TECHNICAL ASSIGNMENT THREE
PENN STATE AE SENIOR THESIS

PENN STATE MILTON S. HERSHEY MEDICAL CENTER
CHILDREN'S HOSPITAL
HERSHEY, PA 17033

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EXECUTIVE SUMMARY

Technical Assignment Three investigates key areas pertaining to the Penn State Hershey Medical Center Children's Hospital Project that could be potential candidates for research. Key areas explored include: value engineering, alternative methods, and schedule acceleration methods. An interview was conducted with key project players to identify major areas of constructability issues. The report concludes with identifying additional problems based on personal exposure with the project as well as technical analysis methods describing how an analysis could be carried out.

The first section of the report involves an investigation in the top three constructability issues the project team are facing. The first challenge identified involves the drilling and grouting of micropiles. This became an issue as the geotechnical report claimed average depths required to reach bedrock were 55 feet; however, the drillers were hitting +/-100 feet in more than half the micropiles which caused productivity and schedule issues. The second issue identified pertained to the project site poor soil conditions. This became an issue to many activities as the soil risked losing structural carrying capacity when exposed to heavy rains. The third issue identified pertained to the demolishing of existing grade beams. This became an issue due to their critical location being next to patient rooms; dust and noise control was very problematic to resolve.

The second section involves an exploration of schedule acceleration scenarios. The critical paths of the project were identified as well as understanding the risks of any delays associated with the critical activities. The Children's Hospital most critical item is the erection of the structural steel system as it is the opening gate to all other trades to put work in place. Next major risks to project completion date were identified. Schedule acceleration methods were identified next ensuring a plan is set in place in the case any delays occur. Finally costs and techniques were discussed and the major techniques involve increasing crews, working overtime, and possibilities of prefabrication.

The final interview involved an exploration in Value Engineering ideas implemented on the project. Surprisingly the owner stressed out that no value engineering will be implemented on the project as the design process was heavily driven by the budget. Three 3rd party estimators were on-board during the design phase ensuring project costs would not exceed the budget.

Upon evaluating the constructability challenges, schedule acceleration methods, and value engineering topics, seven additional problematic features were identified. The top four problems were then further analyzed as potential research topics. The problems addressed include: construction traffic flow, façade erection, MEP systems overhead installation, and the possibility of re-sequencing the structural steel erection.

REPORT CONTENTS

CONSTRUCTABILITY CHALLENGES

Since The Children's Hospital at the Penn State Hershey Medical Center is still in the early stages of the construction process, many of the constructability challenges have not been encountered yet. However, it is not uncommon to have construction issues early on in the project as it is typically very difficult to start-up a project. Through personal experiences interning on the Children's Hospital project and numerous interviews with the L.F. Driscoll team, many challenges have been experienced of which three will be discussed in this report.

Micropile Drilling

As discussed in Technical Report one, the foundation system for the Children's Hospital project is designed to be a deep foundation system due to the depth associated with bedrock. The project consists of 430 micropiles spread across the entire site. Subsurface Geotechnical Investigations noted that the average lengths of the micropiles to be around 55 LF. Due to this theoretical value, the micropile and shoring subcontractor planned to have one drilling and one grouting crew on-site.

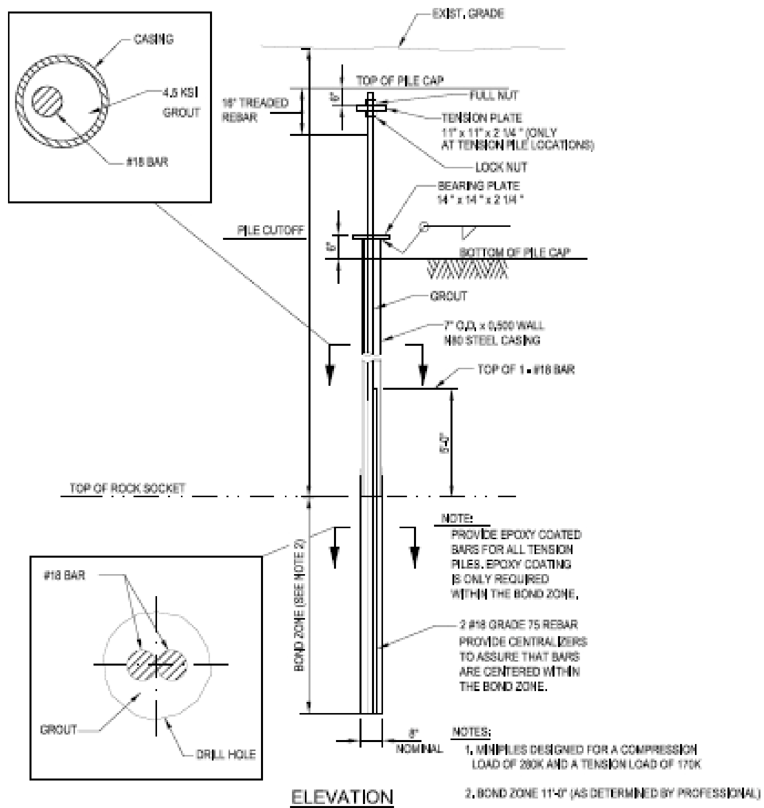

IMAGE 1: Micropile Elevation Detail

Having interned on this project and monitored micropile productivity on a daily basis, on average 1-hour was required to completely drill an entire pile to bedrock. With an 8-hour work day, it was possible to complete 6-10 piles per day depending on the depth of the piles. Some days were less productive due to primary focus on grouting, testing strength of piles, or simply drill rig breakdown.

The biggest unanticipated challenge the construction team faced with the micropile drilling was when they commenced on the west side of the project site. Since the Geotechnical investigation conducted only 21 test borings, actual depths of bedrock were not exactly predicted. Numerous micropiles were amazingly exceeding the 55 LF average and were averaging over 100 LF and a maximum of 129 LF. Those outrageous numbers raised many risks including estimated costs, reduced daily productivity, and most importantly falling behind schedule milestone dates.

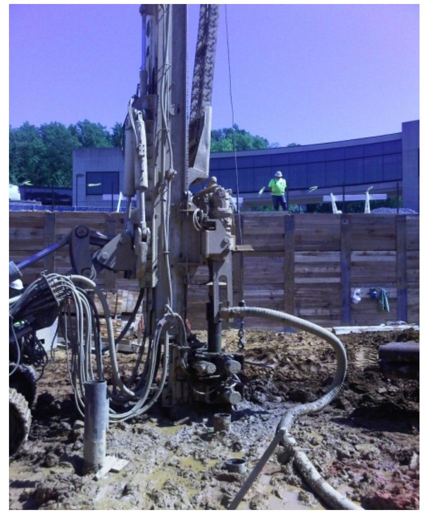

IMAGE 2: Micropile Drill Rig

Initially, the subcontractor requested to work overtime and on weekends to be back on track with the schedule. However, that solution seemed to not work out that well as labor costs were being too costly to the owner in an effort to play catch-up. At that point, L.F. Driscoll requested that a second drilling crew need to be brought on board to double up the daily productivity since the vast site allowed for extra equipment to be on-board. By doing so, the drilling crews bumped up productivity averaging 15-20 drilled piles per day. As the crew progressed towards the east side of the project site it was very fortunate that bedrock was averaging about 40 LF deep. At that point the project team decided to work overtime to completely finish all drilling activities on-site which in return saved money due to not needing the drill rigs on-site anymore. This technique was effectively used and helped the team be back on track with the schedule. See *Image 1* for micropile elevation detail.

Poor Soil Condition

Geotechnical report investigated the project soil composition and found that the soil primarily contains silt-sized particles (USCS Classification ML). Silty soils hinder the structural stability and strength of the sub-grade when exposed to heavy rains. With approximately 3.8 inches of rainfall per month, Senior Project Manager James Carpenter with L.F. Driscoll saw a major challenge in the project schedule.

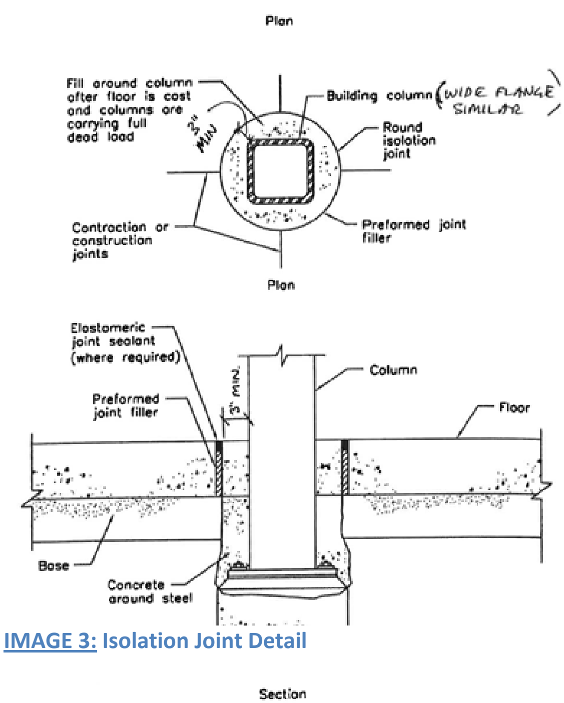

IMAGE 3: Isolation Joint Detail

The most recent detailed project schedule shows the sequence of placing the slab on grade proceed upon completion a number of structural steel bays and decks as the main goal was to get the

CONSTRUCTABILITY CHALLENGES

mechanical room slabs placed as fast as possible. With that plan in mind, Mr. James Carpenter saw from previous experience that heavy rains in cold seasons delay the placement of slabs due to soil complications. During cold climates rainfall causes silty soils to lose shear strength and delay the period of rainwater drying in the soil. Another challenge that Mr. Carpenter saw was during the placement of elevated decks. When placing elevated decks, the slab on grade area would be shaded from the sun which further delays placement of the SOG due to very slow drying processes. The composition of the soil also invokes risks of controlling soil moisture content and compaction.

The project team managed to raise the issue early enough to avoid future complications when structural steel and metal decks have been erected. With proper planning and schedule manipulations, L.F. Driscoll managed to compact and prepare the sub-grade for structural fill. A total thickness of 6 inches of compacted PennDOT 2A stone was placed between the SOG and the underlying sub-grade to reduce stress concentrations by providing a uniform bearing surface. by completing this task prior to structural steel erection, the project team was able to eliminate any challenges with inclement weather that may have affected the soil. To assess this change the Structural Engineer designed a new joint detail that would satisfy placing the SOG prior to steel columns so that the joint doesn't telegraph through the finished floor. See *Image 3* for joint detail.

Grade Beam Demolition

As explained in Technical Report One in the Existing Conditions section, The west side of the Children's Hospital joins with the existing main hospital. With that in mind, careful measures regarding infection control need to be carefully assessed whenever work is being done in the areas where the two buildings adjoin. Any major activity undertaken near the existing operating hospital needs to undertake an Infection Control Risk Assessment plan to reduce the chance of affecting the patients. The Children's Hospital Project requires excavating under an existing part of the existing hospital and changing the existing grade beams that were in ground with a new designed structural steel framing that will hold the new cantilevered section in place. See *Image 4* for grade beams to be demolished.

IMAGE 4: Existing Grade Beams

The risk with this job being done is that the existing concrete grade beams need to be demolished right outside existing patient rooms. The risk associated with this task include: dust control, sound and vibrations, and accidental damage.

Upon developing an ICRA plan that would address the dust control by placing ICRA barriers on the windows and doors of the existing hospital, the project team decided to demolish the grade beams by cutting them into small sections one at a time while supporting the entire section. To minimize the amount of dust flying all over the critical area, it was decided to use a diamond wire saw while lubricating the cutting area to make smooth cuts without dusting off the entire area. To reduce vibration and accidental damages while cutting the grade beams, the project team decided to support the underside of the section being cut so that when completely cut it would be slowly taken down to the ground. By supporting the entire grade beam sections, the crew was confident that the entire beam will not fail at some point and fall to the ground.

Conclusion

Although the mentioned problems may not seem to be truly challenging simply because most jobs have issues like such; however, the mentioned ones were of the top challenges since this project is still in the very early phases of construction. The project team believes that more challenges will arise as they progress through the job and the best solutions will hopefully be developed to tackle down any new challenge.

SCHEDULE ACCELERATION SCENARIOS

CRITICAL PATH OF PROJECT SCHEDULE

The critical path for the Children's Hospital is very similar to many other Hospital Projects. Project start-up is very crucial to keeping the critical activities on time. The critical path relies heavily on the completion of the foundations and the structural steel system. Upon completing excavations, micropile drilling and grouting would be the most critical task to keep the schedule on time. Grade beams, pile caps, foundation walls, and column piers could not commence until micropile drilling and grouting is complete. As discussed earlier, the micropiles posed a very challenging situation requiring a quick solution to be able to finish the remaining substructure making it possible for structural steel to be erected.

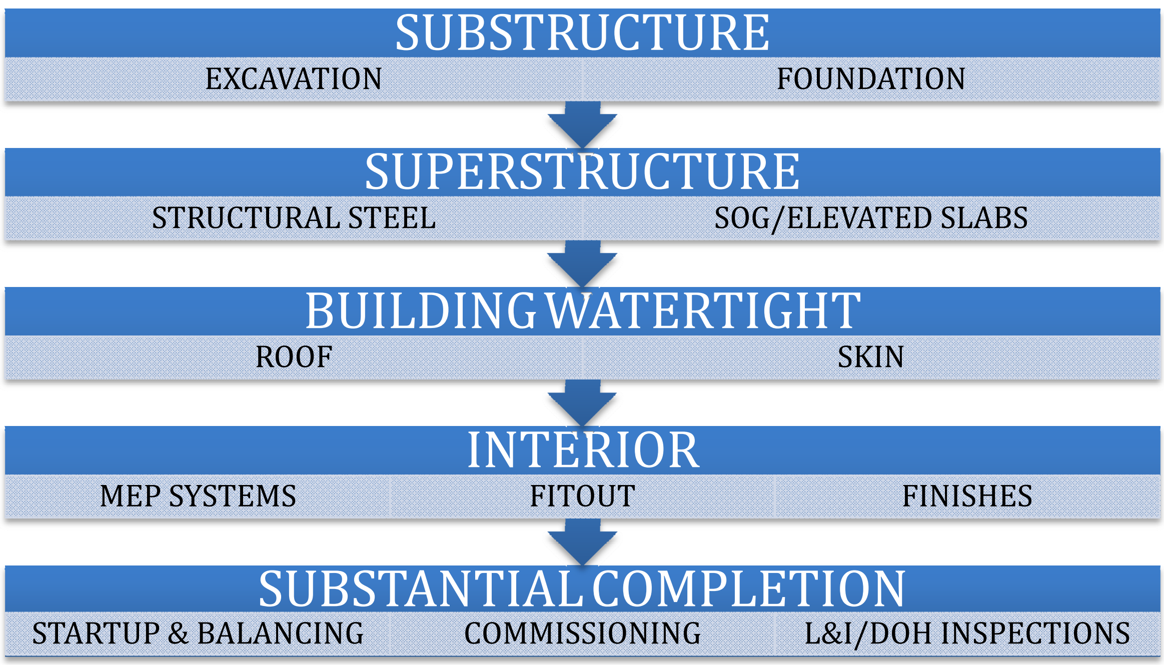

Figure 1 Critical Path Sequence

Following the substructure phase would be the start of the superstructure system. Structural steel crew would start on 8/25/2010 and top-out on 2/1/11. Cast-in-place concrete slabs and roof would follow the structural steel erection. Building watertight is the next major critical path as no interior work can be completed prior to the exterior skin being erected. Interior MEP rough-ins and fit-out would follow next. Finally, startup and balancing, commissioning and inspections take over the final activities prior to project substantial completion.

RISKS TO PROJECT COMPLETION DATE

Every project comes with its risks. The Children's Hospital has many risks associated with it being a state of the art facility. Risks to project completion date include activities from procurement of building materials to actual labor on-site. A major risk during the procurement stage is the procurement of the structural steel package. Other risks include: inclement weather, erection of the structural steel system, pouring slabs, enclosing the building, and MEP rough-ins.

Procurement of the structural steel package is considered the largest share of all other packages. Processing structural steel detailing and erection drawings has been a big challenge to the project. With 2000+ drawings for the project team to process and turn over to the A/E for approval, potential delays will arise if the process is not monitored carefully. Failing to properly monitor this process and expediting it will yield longer lead times for the structural steel to be fabricated.

The Children's Hospital is being built in Hershey, Pa known for its cold winters and wet summers. Although weather impact delays are not specifically accounted for in the project schedule, it is good practice to keep alert of inclement weather. Heavy rains could impact the productivity during the foundation stage as well as placement of concrete slabs. Weather delays would not just delay the project schedule but also contribute to added cost due to decreased productivity.

Erection of the structural steel system poses great risks as well. The project management team allocated approximately 18 weeks to erect the entire structural steel package. One of the risks to completion date is whether the structural steel package has been completely fabricated upon finishing the procurement stage. Another risk the project team has to watch out for is ensuring exact pieces be delivered on-site and on-time without losing sequence. If steel pieces arrive on-site and staged in the wrong sequence, major delays can cause the project dates to fluctuate heavily.

MEP rough-ins at the Children's Hospital also poses great risks to project completion date. The mechanical system of hospitals is not like the typical commercial buildings. Great care and coordination early on in the project need to be made to ensure no clashes exist between the various systems. Any clash of systems discovered during construction can greatly delay the schedule due to the conflicts subcontractors would have trying to secure their space and not dismantle their system. Another risk associated with MEP rough-ins could occur due to spatial conflicts as many different trades will need to rough-in their systems in the same location as everybody else. Coordination for this stage must be well planned ahead of time to minimize schedule delay risks.

KEY AREAS OF SCHEDULE ACCELERATION

In the unfortunate case that the project schedule is delayed. The project team will need to investigate keys areas of possible schedule acceleration. Potential areas and techniques for accelerating the project schedule include: foundation stage, slab pours, and prefabrications.

During the early stages of construction, the project site is not as congested as the later phases. Many acceleration techniques could be implemented early on in the project to make up for any lost time. In an open excavated field, additional crews and equipment could be allocated to the jobsite to make up for lost time and avoid overtime work. During the micropile drilling and grouting stage, L.F. Driscoll may be able to request additional drill rigs to complete the drilling activities quicker. Another area of acceleration could be increasing the formwork and concrete placement crew to be able to form the pile caps, grade beams, and foundation walls quicker. Being able to startup the project with no wasted time helps forecast the project schedule and be able to identify major risks to come up. Being able to work on this project during the summer of 2010, many of the mentioned acceleration methods have been used and successfully made up for lost time.

Another area that could save time on the project is during the slab pours. The project team has their goal set to get the mechanical room decks placed and ready for the slab pours as they would like to get the mechanical equipment in place to enclose the building façade. In the case of schedule delays, the project team can progress with that goal and in addition increase the number of concrete crews working so that the elevated slabs are being placed as the other crews race to get the mechanical room ready.

Finally a major technique that could accelerate the project schedule is by prefabricating certain systems. The limestone and granite façade can be prefabricated to help finish the building enclosure quicker than scheduled. Overhead MEP rough-in can also be prefabricated if schedule time was being delayed. Certain walls of the patient rooms that require intense manpower to get all the medical equipment roughed-in the drywalls can be also prefabricated to help alleviate the project schedule delays. Although prefabrication helps reduce schedule time, the drawback is that it requires long lead times and must be planned out very early prior to starting that activity. The schedule delay must happen long before prefabrication is considered. Advantages of prefabrication include: savings on hard on-site labor, increase in productivity of installing various systems, and helping reduce site material and labor congestions.

COSTS AND TECHNIQUES OF SCHEDULE ACCELERATION

Determining costs of delays and the solutions to counter the delays are difficult to be determined prior to the actual delay. Costs and solutions would be more realistically calculated during the need to implement an acceleration method. It will heavily depend on the type and length of the delay and the techniques the project team will elect to pursue. In some cases where prefabrication is selected as a technique to save time, actual costs will be higher sometime due to the fact of needing to store items in a facility and transport it on truck to the jobsite. However, prefabrication would save a lot of time as welding, cutting, and building on-site will not be required.

Making use of overtime work can be beneficial if used wisely; however, one must note that productivity might be reduced if overtime is abused. In other cases, adding additional crews can be a possible solution but careful planning and coordination need to be made to ensure spatial conflicts are reduced to a minimum so that productivity can increase. In any case of delay, no one solution exists as the project team will need to evaluate a number of solutions and come up with the least cost yet best outcome available.

VALUE ENGINEERING TOPICS

During the interview with the On-Site Project Architect Mr. Carl Romig regarding Value Engineering on the Children's Hospital, he stated that there was no Value Engineering conducted on the final design of the Hospital. The project design was extremely driven by the project budget. Payette Associates designed the building with the budget in consideration to avoid squeezing out money in Value Engineering exercises that may downgrade the quality of the systems designed. However, Mr. Romig claimed that during the design process, specific systems were always analyzed to make sure that the owner will be getting the best systems for the amount of money being paid.

Having worked on the project, the only form of Value Engineering Input that was noticed was during the fit-out of the 5th floor shell space. Since this building is structurally oversized to support 2-3 additional future floors, the owner decided to temporarily fit-out the shell space with offices instead of future patient rooms. By doing so, the owner paid extra money to provide additional offices for the medical center instead of leaving the place as an unused shell space. Although there was extra cost associated with the fit-out rather than simply leaving it as a shell space, it was definitely cost effective because any intent to fit-out this space in the future while the hospital is being operating with patients will be a nightmare to control sound, dust, vibrations, and patient safety. This is the only noticeable form of VE conducted on this project, otherwise there was non due to the strict owner's intent of not squeezing out money out of the quality of the project.

Mr. Romig justified neglecting the Value Engineering exercise because of having three 3rd party estimators during the design phases to ensure the design was not exceeding the budget at any point in time. By doing so, the design team was always aware of the cost fluctuation associated with their different design intents. Upon releasing the project out for bidders, the bids came out within the owner's budget and were very competitive due to the tough economic market. Mr. Romig believes that releasing the project during a tough economic situation definitely helped in receiving competitive bids that were very close to the owner's budget.

Another major reason the Children's Hospital did not undertake Value Engineering practices was due to the disastrous experiences the Hershey Medical Center had with their previous Cancer Institute Building. During the Cancer Institute Project, the Value Engineering practices squeezed out 40% of the project costs which led to many problems later on during construction. Mr. Romig believes that Value Engineering realistically can reduce overall costs by 5%, anything over that would be severely hindering the design intents. Cancer Institute's 40% reduction due to Value

Engineering severely harmed the project budget due to the owner changing their minds on some of the approved VE ideas. Whenever the owner requested to switch back to the original design intents, a change order was required and eventually brought the project over the original budget.

Mr. Carl Romig believes that upon seeing all the disastrous VE and harsh change orders on the Cancer Institute, the owner and the design teams were all very careful when designing the Children's Hospital. Lessons were learned by all parties on the project helping initiate a new project with zero VE and successful budgeting to date.

PROBLEM IDENTIFICATION

Several features in the Construction of the Children's Hospital project have been identified as potential problems for the project team through the opportunity to physically intern on the project as well as studying constructability issues, Value Engineering Topics, Schedule Acceleration Methods, and contacting the project team. The following problems pertaining to the Children's Hospital may essentially contribute to upcoming research topics to be pursued in my thesis research.

Submittal Processing and Monitoring

The contract of the Children's Hospital mandates an electronic tool to submit and monitor submittals. Initially the team utilized the Digital Exchange Server (DES) to upload submittals online so that other parties involved with the project can download and review/approve the subcontractor submittals. The problems associated with this type of method caused lots of tensions between the CM, Architects, and Engineers. Each party had their own monitoring system using Excel Sheets. By doing so, not a single log from any of the parties matched with each other. Conflicts happened when certain parties were exceeding the allowed times to review and send back the submittals to the CM. More than 3000 submittals have been sent out and many of which were late beyond the 21 allowable days. Continuing to manage submittals in this form will cause many delays and might potentially delay fabricators from finishing and transporting the materials to the jobsite on time. Researching different types of electronic submittal exchange softwares will be critical to be able to have a central location that all parties can submit, monitor, and review submittals.

MEP Systems Overhead Installation

MEP systems on the Children's Hospital are fairly complex due to the requirements associated with hospitals. The entire vertical and horizontal MEP systems require intense amount of time to coordinate to avoid any clashes between systems in the field. The project team has been working hard to coordinate the entire MEP systems using 3D Coordination methods rather than the traditional methods. Although using BIM on the project helps identify major conflicts, it was discussed earlier in the Risks to Project Completion Date section that the MEP systems are very complex and pose a great risk of delaying the project schedule due to spatial conflicts with many trades. Methods to coordinate this activity need to be investigated as early as possible to avoid schedule delays.

Waterfall Wall Erection

Erection of the Waterfall Wall, (i.e. east façade) will be the most difficult elevation to erect according to the Architect team. This wall is not a typical standing wall, the Waterfall Wall is slanted at an angle in which the CMU Block-Backup will need to step back a couple of inches as it is erected from ground to roof. The main challenge is to correctly install all the pieces per the given dimensions and angles. However, the biggest challenge stands in the procurement stage of the curtain wall. Every single glass panel will need to be fabricated in different size and angles of curvature. There will almost be no panel of the same shape. The project team will need to look at different means and methods to effectively start fabricating the glass pieces as required per the design as they have long lead times.

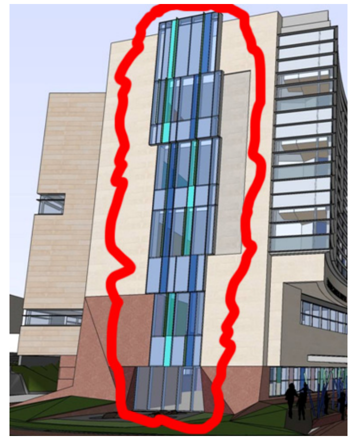

IMAGE 5: Waterfall Wall

5th Floor Fit-out

The Children's Hospital is completely over designed to support 2-3 additional future floors. The shell space on the 5th floor was meant to be additional patient rooms when the 2-3 additional floors have been erected. To avoid leaving a large shell space unused, the owner decided to fit-out the entire shell space with offices for the Medical Center. This decision means that a future expansion of the building will require demolishing the entire office space and refitting with new additional patient rooms as originally planned. The risks and challenges with that will appear during the new future expansion. One of the challenges will be how to tie in the existing medical lines into the 5th floor especially the ones needing to penetrate the floor slabs into each patient room. The entire project team needs to have alternative solutions to efficiently refit the area without having to interfere with the hospital activities on the lower floors. The current decision is to proceed with the current system and in the future will need to drill through the slabs to connect with the existing lines. This will raise issues associated with loud noises in the operating hospital as well as infection control as dust will cause many problems that will require very expensive safety measures. To avoid future problems the project team will need to carefully study this area.

Façade Erection

IMAGE 6: Example of Precast Facade

The entire façade of the building could be a potential problem and delay major milestones such achieving Building Watertight status. The façade of the Children's Hospital contains many different materials and systems. The façade will contain: Granite and Limestone Cladding, Metal Panels, and a Curtain Wall System. Different materials require different complex detailing plans. In addition to different detailing plans, each system has separate subcontractors working on the façade. Spatial conflicts will cause many problems. An alternative way of erection the façade is worth looking at early on in the coordination phase.

Construction Traffic

The Hershey Medical Center campus has many restrictions on the flow of construction traffic. Third party consultants were hired to measure acceptable levels of noise and vibrations when approaching and working on the jobsite. Additionally, the Medical Center prohibits any construction traffic and deliveries between 6:30-8:30am and 3:30-5:30pm Monday through Friday. With so many restrictions associated with the project, it is necessary that the project team carefully plans their deliveries especially during the transportation of the structural steel items as delivery restriction times are not in everybody's best interest. Massive deliveries during allowable times will also need to account for the safety of all pedestrians and regular traffic throughout the medical campus.

Re-sequence Structural Steel Erection

The current structural steel sequencing plan developed by L.F. Driscoll may not be the best possible sequence. Due to this package being on the critical path, many risks of schedule delays might be associated with it. No further construction activity can occur on the building with the current sequence in place. Although the sequence is very well organized and thought of, it would be interesting to see what other alternatives exist to efficiently erect the steel while performing other task as well.

TECHNICAL ANALYSIS METHODS

ANALYSIS #1: Construction Traffic Flow

As discussed earlier in the previous section, Construction Traffic regulations in the Hershey Medical Center pose great risks to the success of the overall project schedule. With many limitations to when and where traffic flow is permitted, a major delay may be caused if deliveries are not carefully planned out. The Children's Hospital project will involve intense truck deliveries during the erection of the structural steel system as well as during building enclosure and finishing. Due to site congestions many materials might not be able to be directly delivered and stored on-site. Another risk can be associated with delayed truck deliveries due to all major highway exits to Hershey exhibiting major traffic during the day. Out of sequence deliveries can cause major delays as the project site would not be able to accommodate multiple trucks on-site which could further delay construction activities.

In order to begin this analysis and provide a very concise schedule for deliveries, an investigation on the different vendors delivering materials will need to be conducted. It is necessary to identify the most critical and heavy deliveries sent to the project site in order to effectively develop a schedule of delivery and logistics.

Hershey Medical Center owns a vast amount of free land that could be utilized for temporary delivery storage. By contacting the Office of Physical Plant at Penn State Hershey, it will be very helpful to determine the possibility of having an off-site space for temporary delivery staging area. Upon approving an off-site space that trucks can stage the delivered materials, a detailed schedule can be developed to determine how many trucks enter and leave the site at any given time aiming at maximizing deliveries to utilize the crane or hoists to set the materials in place. A Short Interval Project Schedule (SIPS) can be utilized to efficiently deliver as many materials on site as possible in a safe and efficient time sequence.

ANALYSIS #2: Façade Erection

As seen in the previous section, the exterior façade of the Children's Hospital places the project schedule at stake. The façade consists of different materials and systems such as: Limestone and Granite Cladding, Curtain Wall, and Metal Panels. Each system has its own connection details and specific means and methods of erection. Multiple subcontractors working on different façade systems pose a great risk at productivity and spatial conflicts which in return delays the project heavily. It would be worth a while studying alternative methods of erection as the Building Water Tight milestone heavily depends on the 100% enclosure of the building.

To perform this analysis, the first item to be looked at is the Contractor erection plans. By investigating the Contractor erection plans, it will be possible to identify the major draw backs of the chosen methods. Alternative means and methods as well as systems may be proposed upon a thorough investigation of the current plans. One potential study can be initiated by determining areas of major spatial conflicts. It is necessary to identify how different crews will be working side by side on two different systems without losing productivity. Upon determining the critical areas, a Short Interval Project Schedule (SIPS) can be developed to coordinate the work of each crew. It will be interesting to see how crews can work in different areas of the façade leaving room for each other to work while rotating the area of work of each crew on a daily or weekly basis. Upon performing this analysis results may possibly show that this method provides higher productivity and quality of work compared to the traditional method of having everybody working at the same time in spatially conflicting situations.

Prefabricating the exterior façade system may be a potential alternative to physically erecting the entire skin on site. Although prefabricating a system in an off-site facility has been proven to accelerate a schedule, careful planning and long lead times need to be accounted for. A prefab system needs to be elected as the method of construction very early in the project to make up for the long lead times. A possible analysis may consist of determining how to splice the exterior skin into pieces of allowable weights for highway transportation as well as crane picking. An analysis may also compare the two different durations and costs associated with each erection method to effectively decide whether the new proposed system has a positive or negative impact on the success of the project. Research on projects that utilized this method would definitely help approach a more realistic outcome.

ANALYSIS #3: MEP Systems Overhead Installation

As in all Healthcare facilities, the MEP systems provide an intense amount of frustrations from coordination to actual on-site construction due to below conservative ceiling plenum space. In the case of the Children's Hospital, 3D modeling of the entire MEP system is the method used to coordinate the entire system. The use of BIM on this project has very quickly proven how much easier it is to coordinate the MEP systems ahead of construction to very accurately locate points of system clashes and being able to make the adjustments virtually instead of on the field. By using BIM the project team has been convinced that this time consuming tool would actually avoid field clashing which could potentially delay the productivity of the crews as well as reduce costs of rework on-site.

Although, the coordination process has been working out very well for all the parties involved; it would be very worth the time and effort to determine whether it is possible to take the 3D models to the next level i.e. Prefabrication. Prefabrication allows the project team to erect sections of the MEP system in an off-site facility that would be delivered to the project site and simply be connected like a puzzle. This approach improves quality and safety, as well as reducing manpower peak demands and schedules. The early approach of coordinating MEP systems in 3D provides a level of certainty and accuracy, allowing workers to construct these systems ahead of time in an off-site facility avoiding site congestions and conflicts with other crews.

An analysis to determine the ability to prefabricate the MEP systems would require investigating the level of accuracy of the BIM models utilized for coordination. Case studies will be considered to avoid mistakes of previous projects and try to successfully improve the process of prefabrication. It will be very interesting to determine how much time and money can be saved by prefabricating the overhead corridor MEP systems. Due to the Children's Hospital still undergoing the initial stages of construction, proposing the idea of prefabricating the MEP systems can become a very successful approach upon reviewing the results of this type of analysis.

ANALYSIS #4: Re-sequence Structural Steel Erection

The Structural Steel erection is one of the most important phases in the construction of the Children's Hospital. The erection of steel is on the critical path as no other activities can commence prior to the erection. As seen in Technical Report One, L.F. Driscoll has developed a very smooth and well thought of erection sequence. Although the sequence might be effective as it works out in the schedule, any cause of delay would heavily impact the work of other subcontractors on board.

The current plan seems to be like monopolizing the construction activities as most subcontractors would need to wait for the completion of the structural steel to be able to put work in place. An interesting analysis would be to determine if any other sequence would allow more subcontractors putting work in place at the same time of steel erection. To carry out this analysis, it will be essential to see what type of activities having a finish-to-start relationship with structural steel. Upon reviewing all the activities with that type of relationship, it will be possible to re-sequence the structural steel erection to be able to start the subsequent activities. Activities of interest to this analysis include: deck placement, slab pours, and erection of the skin. The analysis will focus on the mentioned areas to determine whether or not additional work can be ongoing with the steel erection; hence, illuminating the finish-to-start relationship and saving on schedule time.