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CARDEROCK SPRINGS ELEMENTARY SCHOOL

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CONSTRUCTION MANAGEMENT

TECHNICAL REPORT 3

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A. EXECUTIVE SUMMARY

This technical report begins to identify areas of the project to research for the final thesis proposal. Areas that will be further investigated and researched will be the relation of critical industry issues to the project, value engineering solutions, schedule acceleration, constructability challenges, and cost implications of any change. Some of the topics found within this paper reflect upon the outcome of an interview held with the project team, while others were observations through work as an intern on the project.

Ideas that will be elaborated upon in this report came from a visit in which I interviewed Dave Gauthier, Bryan Bailey, and Kristin DiStefano who are the superintendent, project manager, and project engineer respectively. During this interview they identified key areas which the schedule was able to be accelerated. This was primarily accomplished through coordination of the change and thought out sequencing of construction which allowed for better utilization of open areas on site. The projects critical path is generally described in the following order; foundations and site work, steel, masonry, watertight enclosure, and finally finishes and closeout.

Certain activities caused constructability challenges to the project. One such challenge was the coordination of subcontractors to complete foundation walls and footings that had an unbalanced fill condition. The main challenges had to deal with closely managing coordination of different trades to complete the wall. Other issues arose with a late change order to the curtainwall system and delays in receiving final utility approval of both the temporary and permanent site power plans.

Value engineering was primarily done in design phases. Montgomery County Public School is an experienced owner and has a clear idea of their building requirements. The major system installed was the closed loop geothermal well system. This allows the district to save money on their electric bill and also contributes to the sustainable LEED aspects of the project that the district has committed to achieve in their new buildings.

The last section of the report elaborates upon how challenges can be addressed through analysis of different construction management methods. One challenge addressed is a possible phasing of different sections of the building to become watertight and allow finishes to proceed. Also discussed is the possibility of changing the enclosure and façade to precast panels which will have different schedule and cost impacts. MEP coordination issues were also analyzed as well as problems that arose from damaged pieces of steel from improper storage of construction materials.

B. Constructability Challenges

Split Level Footings and Foundation Walls:

One very challenging piece of work to install were split level foundations and walls located near the south west part of the building. This work required a lot of coordination to complete. In total, five trades needed to access this area to finish the foundations and the foundation wall. The challenge comes from the design of the split elevation at this part of the building. At this location there will be a main level on grade which will walk out to a slab on deck. The figures below illustrate some of the details.

First, excavation was completed to make way for the footings. After the footing was completed a foundation wall was installed. After this, masonry foundation wall can be started in certain sections. Between these activities, the wall must be waterproofed and the plumber must install the foundation drainage system. Last, the wall must be backfilled.

Close coordination was integral to complete this activity successfully. Meetings were held bi-weekly during this time to make sure each trade was ready to complete their work on time. This was important to keep to schedule and ensured that the trades were ready to move to the area when it was their turn. The meetings also allowed the construction team to brainstorm alternative solutions and methods to benefit the project.

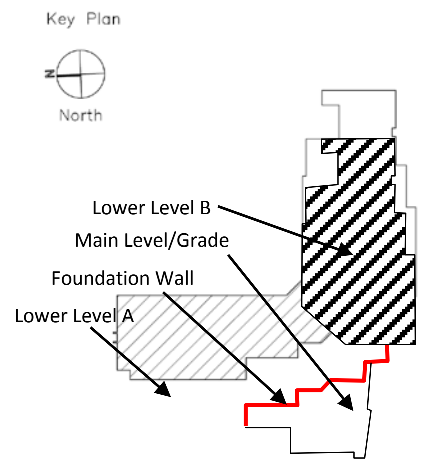

Figure 1 - Building Foundation Outline

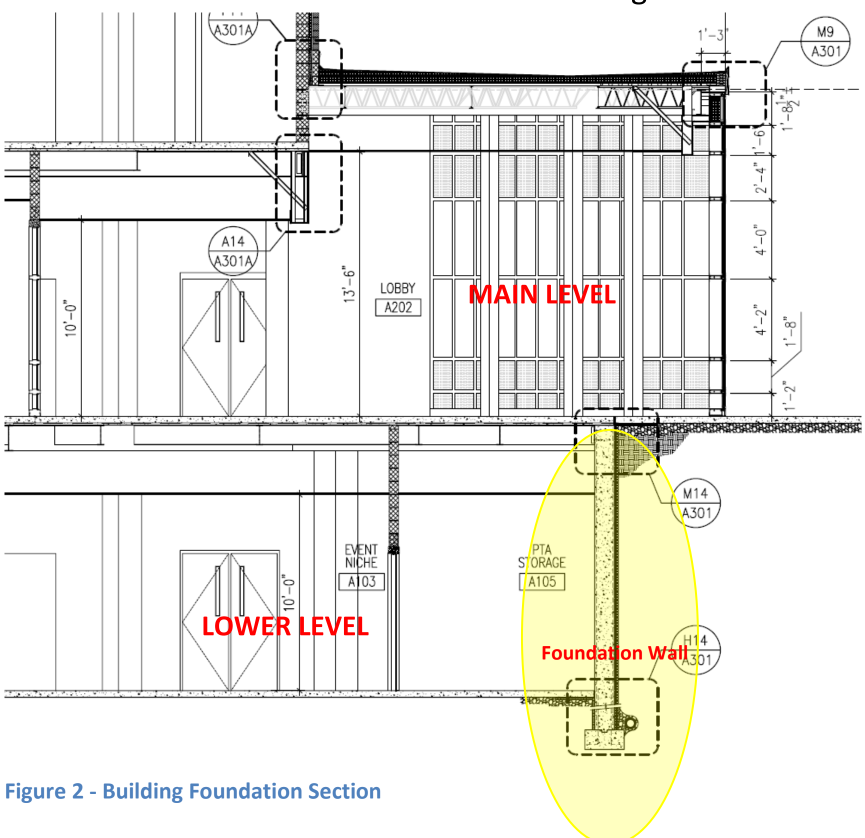

Figure 2 - Building Foundation Section

Acoustical Roof Deck:

The gymnasium and multi-purpose room had acoustical roof decking installed over them. Designers called for a better noise dampening decking since Energy Recovery Units will be placed on the roof of these large areas to assist in heating, cooling and ventilation. The critical issue with the decking was that they cannot get wet. Acoustical deck can be installed in two ways. An acoustical batt can be installed by the factory or installed on site by the roofer. On this job, the bid packages were grouped as such that the steel erector was responsible for the purchase of all decking and elected to have the acoustical material installed by the factory. Since the batt is a cellulose material it can present problems with mold and bacterial growths if not protected from moisture.

Coordination of the installation of the deck and the bituminous roofing materials between the steel contractor and roof contractor was critical. Adding to the challenge of keeping the decking dry was a rainy forecast when the deck was scheduled to be installed. In order to complete this work without ruining the decking, the weather forecast was closely monitored for dry openings to complete the work without risk of rain. This activity required about seven days of work between both trades for each area. Once the decking was installed, the roofer immediately moved to those areas to install the water proof roof system. When there was inclement weather, the decking was covered with tarps to keep dry.

Curtainwall, Permanent Power, and Finishes (Currently being installed on project):

The most critical challenge on the project will be making the building watertight for final finishes to begin. Adding to the challenge are the coming winter months and the anticipated inclement weather the winter months bring with them. Humidity and temperature affect many final finishes and they cannot begin until the building is watertight which can affect the critical path of the schedule. An unexpected delay was a late curtain wall change order by the owner that pushed back the date of watertight enclosure.

Another challenge to the finish work is the delay of the permanent power installation to the site which has been caused by the utility company. Preferably during this time period the Construction Manager, HESS Construction + Engineering Services, would like to remove the temporary electrical boxes and use the main building power. Also, delay of the power is affecting the electricians ability to start-up and test the equipment they installed to date.

The primary challenge of these interrelated activities will be the installation of the curtainwall system. Temporary weatherproof enclosures are to be built in areas where curtainwall is to be installed. This will pressure the critical path and delay installation of interior finishes. Temperature and humidity will also have to monitored which limits what types of finishes can be installed. Temporary heating solutions will be installed which allow some finish work to begin despite delays with curtainwall.

Permanent building power will also play a role in the ability to start finishes. When power comes online, there will be better access to electrical outlets for power equipment and tools. Generators will not be able to be used since exhaust and carbon monoxide will present a health risk to the workers on site. The exhaust can also negatively impact the finishes since they can absorb toxins which can later present health risks to building occupants. The temporary power boxes will also have to be removed from the floor in order for those finishes to be completed. However, this is out of the control of the project team since the utility company has control over this activity.

During the winter months, a close eye will be kept on the progression of the curtainwall system, which will ultimately affect when certain areas of the building will be able to receive finishes. Temporary heat will be utilized to assist with temperature control. The superintendent will sequence areas and move trades into areas that are ready to receive finishes. Meetings will be held regularly with foremen to create plans to optimize productivity to complete the project successfully with top quality workmanship.

C. Schedule Acceleration and Risk Scenarios

The critical path of schedule follows a typical sequence for a standard steel superstructure and shall foundations. Early in the project foundations and building pad were critical to prep for steel to be erected. Also during this time, sitework pertaining to the installation of the underground storm management system was important to ensure that site access roads would be available to contractors during erection of steel and building enclosure. Once steel was completed an area the masonry enclosure would begin. Interior MEP rough-in began during this stage too. Once masonry is complete in a section windows and curtainwall can be installed. When the building is watertight, final finish work can begin inside. This leads into quality inspections, equipment start-up and final closeout.

As is the case with all new building construction, the foundations and preparation of the building pad are always on the critical path. On this project, this was a key area in which the schedule was accelerated. Also during this phase, sitework was accelerated to prepare temporary access roads, preliminary grading, and to install large underground storm structures.

The goal during this stage of the project was to maximize productivity without adding cost to the project. To achieve this goal, sequencing of the trades was closely coordinated by the superintendent to accelerate the schedule. Also, all contractors bought into the idea of gaining extra time which could help them later in the project if issues were to arise. Without the trade contractors accepting the plan, accelerating the schedule would not have been possible during the early stages.

An example of schedule acceleration was with the foundations by taking advantage of the opportunity to move to open areas on the site. This meant that the contractors would not always follow the exact schedule sequence. Since no schedule is ever perfect, updating the schedule frequently and taking advantage of the current site conditions was utilized. Weekly schedules were completed by the superintendent detailing the work to be completed to be distributed in the foremen meeting. Foremen assisted by estimating time periods to complete their work. Also during this time the look ahead schedule could be scrutinized and improved to benefit the construction team. Overall, this proved very useful and allowed the contractors to complete the foundations and preliminary sitework ahead of schedule. Gaining time early in the project benefitted the project as a whole reeling in the final completion date.

Early acceleration was very important to help minimize risks to complete the projects. As was discussed in the previous section, watertight enclosure activities pose the biggest risk to the critical path and successful completion of the building. The construction manager will closely coordinate upcoming enclosure activities to ensure they do not impact the completion date. The successful early completion of the foundations will help to provide a cushion for these activities. However, finishing the enclosure of the building in winter months is not ideal due to the greater impact inclement weather can have on a project.

D. Value Engineering

Geothermal Wells and Heat Pump HCAV System:

Montgomery County Public Schools is the 16th largest school district in the entire country and are a very experienced owner of their educational facilities. Their mission is to provide world class education. To do so, they must build and maintain high quality schools for the children of the district to achieve their full potential. Since they operate many facilities, saving money in the budget is always in the best interests of the district.

On this project the largest implementation of value was the selection of a closed loop water geothermal well system to provide primary heating and cooling to the facility. This type of system has higher first costs compared to traditional systems using Air Handling Units, Cooling Towers, and Boilers as the primary source of heating, ventilation, and air conditioning. However despite this, a long term economical analysis proves that this is cost effective solution to lower energy bills and reduces the schools consumption of electric. Due to the high demand of electricity in the United States as a whole, this benefits the school district financially and shows their commitment to sustainable design.

Another great advantage of this type of system is the reduction of the space necessary to house mechanical equipment. This creates two benefits for the school. First, they can utilize the space for educational purposes . Next, there is a reduction of large equipment which often gets crammed into tight mechanical spaces making maintenance of this system easier for technicians. Also, the system relies on smaller heat pumps located throughout the building to provide the heating and cooling. The maintenance cost ends up being cheaper since these parts are easier to order and stock.

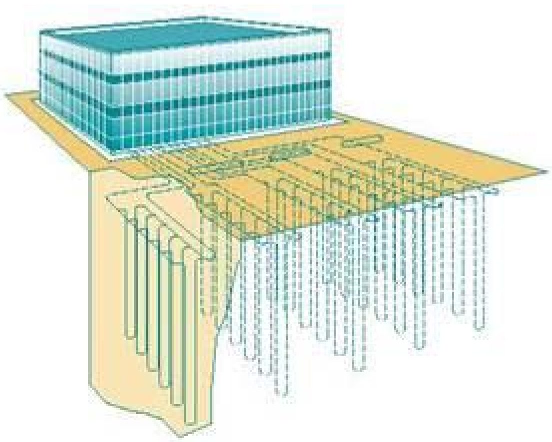

Figure 3 - Geothermal Schematic Drawing

Source: http://wiki.aia.org/Wiki%20Pictures/_w/closed-loop%20vertical%20geothermal%20field_jpg.jpg

Electrical and Lighting Systems:

Carderock Springs Elementary School is attempting to achieve a LEED Silver rating in the LEED for Schools rating system. Many systems chosen not only support the sustainable design program, but also add value to the owner. One of these systems is an intelligent electrical building monitoring system. This type of system has higher first costs for the owner, but over time trends that are developed can save the school district money.

This system consists of a central monitoring system allowing the facility manager and energy department to monitor building electric usage. Such a system allows them to identify faulty equipment and better understand why electricity is being consumed and if it is vital to the facility. An example of this could be a water pump motor that is running inefficiently. The system will alert the technician of the excess consumption and will lead to them troubleshooting the reason a motor may not be working correctly.

In addition to monitoring electrical consumption, the building is outfitted with light sensors in the classrooms. They will be able to sense occupancy and turn off if a classroom or a space is not occupied and switch off the lights. The lights are also specified to be energy efficient fluorescent lighting fixtures.

Plumbing Fixtures:

The fixtures in this building are specified to be low flow fixtures. This includes bathroom lavatories, water closets, and urinals. This will help to reduce water consumption at this facility. In addition to low flow fixtures, motion sensing devices will ensure that excess water is not wasted from a faucet that could be left running. These fixtures will help lower overall water consumption reducing the cost of utility bills and will also allow this facility to be more environmentally sustainable.

E. Problem Identification

Enclosure and Curtainwall:

Over the course of the project, unforeseen issues arose with the progression of the watertight enclosure of the project and delay of the curtainwall construction. One issue was a lack of details showing how a hollow metal frame door will connect to an aluminum curtainwall system. This problem has a couple of implications. One has to deal with the architectural aesthetics of the building. Two different types of materials from different manufacturers are difficult to match together if not planned for in initial design stages. Another issue relates to the support of the curtainwall system and warranty implications.

Curtainwall systems are designed to be independently supported from other building systems with tie-ins to hollow steel tubing. Adding a metal door to the base of the curtainwall upsets the independent design of the system. Also, the manufacturer will not warrant the system if it is tied into other building systems that it was not designed to support or be supported by. This created design issues for engineers and architects who need time to explore how the systems will be supported.

MEP Coordination:

An elementary school is not an overly complicated building to coordinate, however over the course of the project there were some areas where time and money could have been saved in the coordination process. The delivery method of this project was a GMP with a CM-at-Risk. This method calls for the construction manager, HESS, to hold nearly all of the subcontracts to complete the project. The exception was commissioning contracts that the district chose to contract independent of the new building contract.

The main problems related to problems with sharing information and different file formats. It complicated the drafting and correction of conflicts that arose in the coordination meetings. This led to delays in receiving a final set of coordinated drawings that would be used for construction.

Masonry:

Masonry is an extremely labor intensive trade requiring all of the work to be laid by man. This introduces issues with quality while maintaining production. In this area of the country, labor is readily available. However not all labor has equal skill sets. The masonry labor force on this project lacked enough quality personnel with the skills to lay out and start the first courses. This led to some delay in the scheduled sequence of activities.

Another issue arose from a complex façade. The façade of this building had many different colors, types of bricks, and patterns to be used in different areas of the building façade. In some areas, the mortar colors and patterns were not the correct type that was designed by the architect. Adding to the problem is the fact that once the mortar has dried, it is a very expensive fix to demolish incorrect work. Usually these situations give way to cheaper fixes which are not equal to the original design intent.

Steel:

Throughout the course of steel erection, issues occurred where steel galvanization and lighter steel members were bent and damaged while in storage. The primary causes were a tight lay down area and improper storage techniques by the contractor. Steel members that were not protected properly rubbed and hit each other, chipping the protective coating of the steel. Smaller members such as the masonry hung plates were also bent in this process. This led to the mason being unable to lay blocks on the plates since they were not level. The levelness of the surface impacts the appearance and quality of the workmanship.

Temporary and Permanent Power:

The project experienced delays with both installation of temporary site power and permanent power for the building. Although these delays are generally unpreventable since the utility company controls the approval and installation. A proactive approach can limit the risk of delay. Issues arose from slow turnaround time of drawings which are needed to submit to the utility company. Although different members on the project had contacts within the utility company, the utility company follows a review queue based on the date of submission. Therefore submitting early and often is the best way to achieve final approval of a temporary or permanent electrical power.

F. Technical Analysis Methods

Enclosure and Curtainwall:

An area that can be explored is the phasing of watertight milestones in certain areas of the building. This analysis can be done by analyzing the schedule and understanding the constraints on the activities. Primary areas to investigate will be the submittal and final approval of the curtainwall system. The possibility of submitting different sections of curtainwall in different packages could also assist to make this a feasible idea. Also, temporary weatherproof partitions will have to be explored to make this idea feasible. Another area that will relate to the feasibility of this study would be communication lines necessary from the subcontractor to construction manager to the architect.

Ultimately the phased watertight enclosure of different areas could allow finish work to begin sooner. The ability to start work sooner could lead to a decrease in the schedule and generate cost and time savings. The cost relation for the addition of the temporary watertight partitions compared to the savings will have to analyzed. If the labor and cost of the partitions cost more than the general conditions this will not be feasible. Despite this, if cost breaks even and creates opportunities to finish early it could benefit the contractor due to the minimization of risk to damage clauses that could occur if there is a time delay in final delivery.

MEP Coordination:

The creation of standard guidelines for file formats could be created to help assist the coordination process. This would allow for better productivity of all construction team members and save time. Over the course of the coordination process there was excess time troubleshooting technical issues not relating to the actual construction, but with file errors and compatibility issues. A standard would help to dismiss these issues and allow for better use of time. Since Hess holds all subcontracts, they could add this into the contract requiring MEP trades to adhere to specific file sharing standards.

Another available option to explore could be the use of in-house building modeling and collision detection. The exposure to risk will have to be analyzed if the CM chooses to lead this process. This option is however a double edged sword. The possibility of saving time in the coordination could save the project team money since their time can be diverted to other tasks. Outsourcing modeling is also another option. There are drafting companies overseas that recreate models cheaper than what can be contracted in the United States. Pursuing this option would require the CM to possess a person with the ability to analyze the model in the format in which it is created. This would transfer the risk from the CM to another company via contract. The CM, Hess, would then have to manage the communication between contractors to ensure that all members understand the construction drawings.

Masonry:

Figure 4 - Masonry Facade

This picture shows the complexity of the façade. Pictured are 3 different brick types. Overall the project has 7 different brick type which introduces the need for an intense quality control program to ensure they are installed in the correct location with correct pattern. Precast would be a solution help to improve overall quality control.

An analysis of alternative enclosure and envelope systems would be interesting to explore since this project was enclosure is primarily masonry. Since masonry is labor intensive and completed 100% by manpower, quality issues can arise with installation of this system. The investigation into precast architectural façade would be interesting to assess feasibility of such a system and whether or not it would have cost or schedule implications on the project. The availability of the system in the area will also have to be investigated since it is a LEED project and materials must be procured within specific distances from the school to meet project goals.

Preliminary research into this system would have to be explored to ensure that it can meet the projects architectural aesthetic goals. Preliminary design meetings would have to be held between owner and architect to determine if this could be a feasible substitute for traditional masonry construction. The different types of styles of finishes and materials will have to be analyzed to ensure the owner is receiving a product that can meet their requirements for the desired architecture design of the building.

Using precast would have various impacts on the project that could be investigated. The two obvious areas to explore will be cost and schedule. A detailed cost analysis would have to be completed to compare the two systems to make sure a precast system will fall within the project budget. If used, productivity rates will need to be identified for both methods to understand schedule impacts. Precast will require different crew types who will need to be specialized in rigging and crane operation.

Using precast on the exterior will not eliminate all masonry. The interior walls of the building are built using concrete masonry units. Designers chose CMU since they have good properties for blocking sound transmissions through walls. Disruption of classes from ambient noises was closely monitored by designers to ensure that education will not be disrupted from noises outside of the classroom environment.

The use of precast will also impact the ways the site can be utilized. First, a precast system will require less labor which will decrease need for vehicle parking and decrease the manpower required for the project. However, there will still need to be protected areas to store the panels before they are erected. Care will need to be taken as not to damage panels while in transit and storage since it will be a final finish and can affect the aesthetics. The use of precast will also eliminate storage space that is typically used for CMU, sand piles and mortar mixers on the project. Overall the decrease of manpower and storage space could allow other trades to be more productive. Outside the building there is the potential to complete additional sitework in areas that were needed for lay down.

Steel:

The main issue relating to steel was the timing of deliveries and the availability of space to store deliveries. First, the sequencing of steel packages can be investigated to determine the nominal amount of steel that can be stored on site so that only necessary steel will be on site. Materials that sit on site for excess periods of time are at a high risk to be damaged by high vehicular, man, and machinery traffic. Decreasing time from storage to final product is always the best solution to preserve the quality of construction materials.

Another issue that can be developed is the engineering of different structural systems. One system is the support of masonry above windows through the use of hung plates. These plates were especially vulnerable to damage since they are very small compared to other steel members. A large column easily damages a ¾” thick steel plate. These plates were also attached to the beams by the steel fabricator prior to delivery making them awkward for storage and transportation.

Areas of research to explore will be alternative methods to support masonry above openings. The relation between different topics discussed can also be explored. The impact of changing to precast would have on the structural system as a whole will have to be analyzed in detail. It could also impact the curtainwall system. Connections and building envelope issues would have to be investigated to determine if greater risk to moisture infiltration could negatively affect other proposed ideas. Also there is labor and time associated with flashing, sealing, and caulking of connections when two different systems meet together.

Figure 5 - Hung Plates