Technical Assignment Three
Construction Management
December 1, 2009

Upper Dublin High School

Upper Dublin School District
Fort Washington, PA

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The purpose of Technical Report 3 is to identify various constructability issues associated with this project, as well as strategies to prevent them and money and time saving techniques. The challenges/issues mentioned above will be used for further research and analysis during the upcoming semester.

Constructability Challenges

This section of the technical report will be used to identify to tope three major constructability issues associate with this project. These include the topics of safety on and around the jobsite, the installation of the geothermal wells, and construction time constraints.

Schedule Acceleration Scenarios

This section is dedicated to identifying the critical path of the project and how each area of construction relates to one another. Also included in this section is the identification of areas of construction that can be used to accelerate the schedule. These areas will be looked at from a variety of dimensions, such as how they affect the critical path, and the associated cost to implement these strategies. Due to the time constraints on the project, it may be necessary to accelerate the schedule to meet the deadlines if any delays occur during construction.

Value Engineering

This section will be used to identify areas of Value Engineering used on this project. Since the project is striving for LEED Silver, systems with higher efficiency and up-front costs were used. This made it difficult to use Value Engineering techniques on the project without negatively affecting the performance and green value of the building.

Problem Identification

Throughout this section of the report, several problematic areas of the project will be identified for further technical analysis. These topics will be based on the information gathered in the first three sections of the report. Each problem will be identified as well as possible areas of research to create a better solution for that particular topic.

Technical Analysis Methods

The final section of this report will be used to discuss the technical analysis methods that can be used to research and find a better answer to the problems stated in the Problem Identification section of the report. These items will be used as a basis of research for Senior Thesis next semester.

The New Upper Dublin High School is a very large (368,000 sf) high school construction project located on the site of the existing school. This project will take four years to fully complete and will be performed in phases. During this whole period of construction, the students will still need a place for them to continue their schooling. For these reasons, among others, there are many constructability issues that the site team needs to overcome to complete the project successfully. This section takes a look at the most important constructability issues that will/have been dealt with on this project.

Safety of Students/Faculty

The most important issue that the construction team must deal with is safety. This is always the most important concern on any construction project. This is most prevalent with the craftsmen involved with the construction of the project and any people working on the construction site. Well, this particular project adds an extra level of concern because of the fact that the project site will also host the students and faculty of the Upper Dublin High School. This is the major reason why the construction of this high school is being completed in phases. Only a small section of the existing high school will be demolished at a time, while the new high school will be built in its place. As the new section of the high school is completed, students and faculty will be able to utilize that space, while another section of the existing high school is demolished. This will give continued access to the students and faculty of all the needed space to provide the necessary level of education. Phasing Diagrams and Site Layout Plans can be found in the previous **Technical Report 2**.

To combat the possibility of injuries to any bystanders, a safety plan has been created, as is typical for any construction project. This includes proper placement of site fencing, construction and demolition periods, and first aid. Due to the nature of the project working in a north to south flow, it is possible to place site fencing around the entire construction site while separating it from the existing high school even though they are on the same site. As phases of the project are completed and new phases begin, the site fences will be adjusted accordingly. This will reduce the possibility of students and faculty stepping on the job site and getting injured.

Demolition posses concerns for safety, but for noise and vibration as well. This will greatly decrease the effectiveness of learning abilities due to the created distraction. This area of the construction process will be completed during times of lower school usage, such as during the summer months while students and faculty are away. This gives the construction team time to demolish the building and clean up the site, as well as secure the remaining part of the existing high school for further use.

Finally, most importantly for the safety of the construction team, a clean site is absolutely necessary. Much attention will be placed on the condition of the job site, because as more and more clutter builds up on the site the possibility of an injury increases. These are the main strategies to make sure that the students, faculty, and construction workers are safe at all times during the construction process.

Construction of the Geothermal Wells

One of the major construction concerns is the installation of the geothermal wells. Although this is a fairly simple construction process, it is extremely important to install it correctly the first time. **Figure 1**, below, shows a typical detail for a geothermal well on this project. As you can see, the depth of the well reaches 400 feet into the earth. The site of the well field is located about 100 yards away from the high school building. If there are any leaks in the wells, or the well is installed incorrectly this can create a very expensive fix on the already expensive up front cost of the geothermal system. Although this will save money for the school in the long run compared to using other typical systems such as gas boilers, adding to the cost of installation will create a much longer time period for the return on investment.

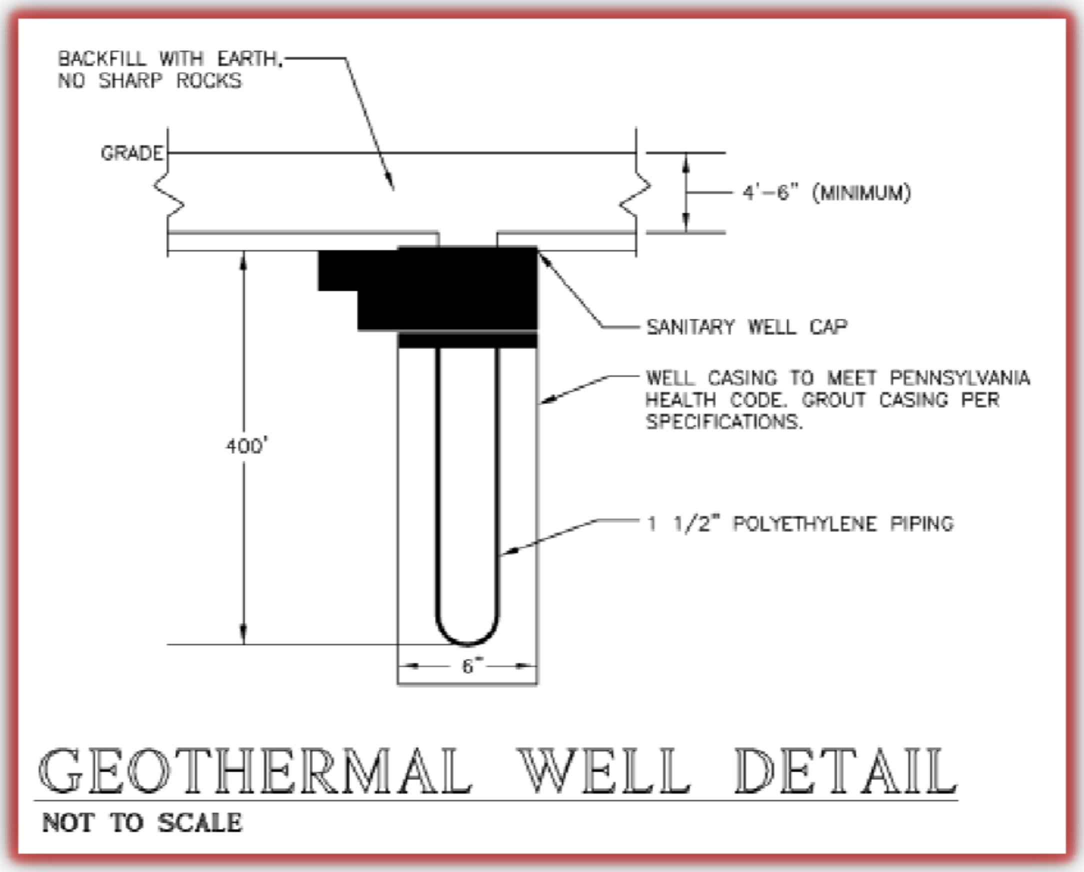

Figure 1: Geothermal Well Detail

This system has already been installed, and was installed successfully. This was completed with the use of a very dependable construction team and an excellent set of plans. This was one of the first areas of construction to be completed. This was due to the fact that by doing this first any problems can be fixed before the piping from the geothermal wells was connected to the new building.

Construction Time Constraints

Since there needs to be a constant flow of existing building demolition and new building completion, time constraint for the project are very high. The construction crew needs to ensure that the students and faculty of the Upper Dublin High School have constant access to all the resources they need. The first part of construction to be completed consists of the gymnasium and natatorium of the high school. This is scheduled to be completed at the beginning of December. This is absolutely necessary because these spaces will need to be utilized for the upcoming basketball and swimming seasons. This causes major concern for the construction team to complete this part of the project on time without any major setbacks. There is a lot that has to come together in a short amount of time to ensure proper working order of this section of the high school. Not only does the structure and interior finishes have to be complete, but the mechanical and alarm systems for this section of the building as well. Also, the exterior parking and entrances for this section of the building, as well as moving the site fencing to allow proper access must be performed. This has and is being completed through multiple processes. A well-thought out construction schedule and earlier commissioning tests on the mechanical systems are only a few of the many strategies being utilized by the construction team to ensure this phase of construction is completed by the proper finish date.

The critical path of the schedule largely relies on several major areas of construction. When looking into techniques that can be used to accelerate the construction schedule the areas in the following paragraphs were looked into. Many items were considered to establish if the acceleration technique was a viable solution to the problem, such as cost of implementation, possible key activities that can be accelerated, and how this will affect the critical path of the schedule.

Critical Path

The following activities represent the critical path of construction. Each section also provides a brief refresher of what this area entails:

- **Demolition** - The construction of the new Upper Dublin High School is located on the site of the existing high school. Therefore, the demolition of the old structure is needed to make way for the new one. Since this job will take approximately four years to complete, the construction of the new school will be done in multiple phases. The first phase (Phase IA) will begin with the demolition and asbestos abatement of the bus garage and a partial section of the old high school located in approximately the north corner of the site. This will make way for the construction of the new gymnasium and natatorium. In a similar manner, all new phases of demolition and construction will work continuously from the northern to the southern corner of the site. It is very important to make sure that the demolition of a certain phase is completed on time. This is because no other structural work can take place if the existing building stands in its place. Also, there are only certain times that the demolition can take place, due to noise, vibration, and safety constraints.

- **Structural** - The structural system of this building consists of a steel frame with load-bearing CMU block walls. Most of the structural steel contained in this building is dedicated to the floor and roof frame construction, but there are also many W-series structural steel columns located throughout the building. The structural steel members that support most of the second floor (40 pounds per square foot classroom live load) are W18x35 I beams spanning approximately 30 feet with 6 foot spacing. Typical floor assemblies are made up of one of two different assemblies. Floor construction type F-1 is 1.5 inch, 20 gage composite decking and 4.5 inches NW concrete topping with 6x6 W2.1xW2.1 WWF. This provides a total floor thickness of 6 inches. Floor construction type F-2 is 2 inch, 18 gage composite decking and 3.25 inches LW concrete topping with 6x6 W1.4xW1.4 WWF. This provides a total floor thickness of 5.25 inches. These floor types are based on the loading in that particular area of the building. In order to ensure that construction stays on the right pace, it is important that the assembly of the structural system flows in a smooth manner. This is the base in which all other construction activities will take place.

- **Mechanical** - One of the more interesting features of the new high school is the geothermal heat pump system. Since the Earth holds a fairly constant temperature of around 55 degree Fahrenheit all year round, this geothermal system will provide very high energy efficient heating and cooling throughout the year. This system contains a total of 320 wells at a depth of 400 feet. The wells are separated into 20 different circuits for a total of 16 wells per circuit. Each well is made from 1.5 inch SDR 11 Polyethylene pipe and connected to a 4 inch supply and return main branch of the same material. The fluid mixture is made up of a Glycol/Water mixture of 20 percent Propylene Glycol mixture with a flow rate of 3800 GPM. The mechanical system also contains 11 Innovent brand Energy Recovery Units (ERU). These units help add to the efficiency of the building with the use of the enthalpy wheel. As the conditioned air leaves the building, it passes through the enthalpy wheel and, in turn, heats or cools the wheel membrane depending on the season. This wheel is constantly spinning. As it reaches the top of the unit, where the supply air flows through, the temperature of the membrane is then passed on to the incoming air. This natural process reduces the load on the building, by allowing the outside air to enter the system at a temperature closer to the indoor conditions than it would have been otherwise. As you can see, the New Upper Dublin High School has a fairly complex mechanical system. Since parts of the new building will be utilized before the completion of the entire project, it is important to ensure that the mechanical system for that area is working properly early in the construction process. Any delays in the mechanical system will delay the use of the building for its occupants.

- **Finishes** - Due to the size of this building and the fact that some of the new high school will be used before the entire building is complete, the interior mechanical and electrical systems must be split into zones. This will allow the finished section of the building to be maintained before the full completion. Since the building will be completed in phases, certain areas of the building will have higher priority than the others. The finish sequence is very important, because an unfinished building cannot be used by the public. The finish sequence for each phase will go as follows:

    - The Energy and Heat Recovery Units (ERU and HRU) with be set in place.
    - All interior wall frames will be constructed.
    - All rough-in MEP work will be completed.
    - This will begin with the installation of the ductwork, followed by the fire suppression and plumbing.
    - Finally, all electrical and telecommunication lines can be run.
    - All exterior walls will be insulated.
    - Drywall will be applied to all applicable surfaces, and the ceiling grid will be put into place.
    - The painting sequence can now begin.
    - All MEP terminations can be completed.
    - The final floor material will be put into place.

Activities that can be Accelerated

There are a few activities on the schedule that can be accelerated if the need occurs on the project.

- **MEP and Building Controls** – Once the structural system is in place, it is possible for the MEP and Building Control Systems contractors to start their work. If it calls for it, more employees can be called in or overtime can be used to accelerate this process. Once all the MEP rough in work is complete, this gives way to the building finishes.
- **Commissioning** – Commissioning can be a very long process, especially if there are errors in the installation of the mechanical systems. By bringing the commissioning agent on the site earlier in the process, they can catch errors before it is too late, causing extra work to occur. They can provide testing throughout every step of the process to ensure proper working order of the mechanical systems.
- **Phasing** – When the time nears that one phase of a project must be complete, craftsmen can slow work down on other phases of the project while helping to complete the necessary phase of the project. Although this may cause another phase to slow down progress, this will ensure that the phase in question is completed by the needed date. This will reduce the cost of hiring extra employees or for current employees to work overtime.

Affect to the Critical Path

Using the acceleration techniques listed above can create big difference to the critical path. This is possible by completing some necessary activities earlier to make way for dependant activities to start. Also, increasing the workload on a particular area of a project allows for more work to be completed in the same amount of time. All of these techniques would have a positive impact to the critical path of the schedule.

Cost of Implementation

The cost of implementing these acceleration techniques could have a negative impact on the project. By hiring extra men to work on the project or utilizing overtime to complete certain tasks will cause extra costs to occur for the project. This may not be a very good solution depending on the budget. Since this is a publicly funded project, there is only a certain amount of money available to use for the project.

There wasn't a very large amount of value engineering that occurred on this project. Some of the areas that had potential for value engineering were in certain types of finishes inside the building. The design of the building also created a sort of value engineering technique. The shape of the main building is symmetrical about the central axis. This leads to easier construction method by removing the hassle of a very complicated design. This can reduce the possibility of excessive structural system construction, saving both time and money.

The reason that a lot of value engineering wasn't incorporated into this design was due to the high sustainability goals of the project. Since this project is striving for a minimum LEED Silver, a lot of thought had to be put into the building systems, structure, site layout, etc. to ensure that the project met the expected level of efficiency of the project. Sometime with value engineering, cheaper systems will be utilized in order to save up front costs, but this doesn't always mean that the systems will have the same efficiency as a little more expensive up front costing systems. This is true of the geothermal wells used to heat and cool the building. There a much cheaper systems available to use, but they are not necessarily as efficient as the geothermal wells. They have a high up front cost, but save a lot of money down the road by utilizing the almost constant year round temperature of the underlying Earth.

The value engineering techniques did not detract from the goals of the owner, because they helped keep the project under the budget, while not taking away from any of the sustainability goals on the project. This was extremely important to both the other and the local community that helped to pay for this project through tax money, among other sources.

The purpose for this section of Technical Report 3 is to identify several problematic areas with the design and construction of the Upper Dublin High School. These problematic areas can or will be used along with technical analysis methods to help create a more effective solution to the problem. This can be possible by decreasing costs, or implementing more efficient technologies or construction processes at approximately the same cost. The following topics are seen as possible problematic areas with the design and construction of this project.

- **Geothermal System** – This system is a great way to reduce energy costs in a building, but has a much higher up front cost than typical systems. There are many other options out there for sustainable systems, such as solar or wind power. Looking into other energy efficient building systems and comparing the return on investment of these products to the current geothermal systems might present a better system that could have been used on the project. This will also provide an analysis for future project to use. Also, looking at how these systems compare to typical, less efficient systems with much cheaper up front costs can also be looked into.
- **Exterior Insulation** – The exterior insulation used on this building is a 2-ply system of 3" urethane foam. The insulation was moved to the outside of the building to reduce the occurrence of moisture entering the building through the air gaps in the concrete block. This is a great method to enhance the insulation value of the building, but there are other techniques available. These can be looked into for this project. An example of this insulation can be found in **Figure 2**, below.

Figure 2: Exterior Insulation

- **Roof/Building Envelope** – Since this building is looking for LEED Silver, a major part of that involves energy reduction. Due to the large size of this project (368,000 sf), there is a lot of surface area from the roof and building envelope. The current system can be analyzed and compared to other methods used in the industry today. The exterior wall system on this project is mostly a 2-ply insulation system over concrete block with masonry façade. The roof system contains either flat "white" roofs, or curved metal roofing.
- **Water Reduction** – Another topic that can be helpful for this project is in the area of water use reduction. There is a lot of surface area contained on the roof of this large building. This can be utilized to collect the vast amount of rainwater that will land on the roof. This water can then be used for purposes such as irrigation and in toilets. There is a lot of irrigation that needs to take place on this property, because there are a number of athletic fields on the site along with the plants/shrubbery around the building.
- **Interior Finishes** – Interior finishes are a great place to look for savings. An expensive finishing product can sometime be replaced with a similar product for a much cheaper price. This leads to the possibility of creating large amounts of savings due to the amount of interior finishing products required on this project.
- **Construction Phasing** – The construction phasing is a very important part of any project, especially this one. It is crucial that the phases are well though out to allow for the correct completion of certain parts of the building at certain times. The phasing techniques of this project can be looked into, and any other possible solutions can be analyzed.
- **Exterior Finish** – The exterior finish of this building is a brick and stone masonry façade. Although this is a typical construction method used around the area, there are other options available that can be much cheaper and labor intensive. A lot of the masonry construction must also take place during the winter months, which may delay the project timeline. Other exterior finishing systems can be analyzed. An example of the finished exterior can be found in **Figure 3**, below.

Figure 3: Exterior View

The following technical analysis methods will be used to analyze and correct the problems/challenges I have identified in the previous section.

1. **Technical Analysis Method I** – *Mechanical Systems* – This technical analysis method will be used to determine the value of using the geothermal system on this project compared to other energy efficient mechanical systems. Also, these will be compared to the much cheaper up front cost of typical, less efficient systems. To perform this analysis correctly, consultation will be needed with the mechanical engineer on the project, as well as the LEED coordinator. This is necessary to find out the impacts of using a different mechanical system on the project, as well as the impact it will have with LEED certification and efficiency. Although it is not a viable solution to change the entire mechanical system now, this information can be used on future projects in the Upper Dublin School District. The analysis made can also be used to supplement the existing mechanical system.
2. **Technical Analysis Method II** – *Roof/Building Envelope* – This technical analysis method will be used to determine the impact of the current roof and building envelope systems used, compared to other possible systems. This will take a look at the materials used, as well as the insulation techniques. In order to do this analysis properly, consultation must occur with the structural engineer. This is because any changes made to the building envelope can impact the strength of the structural system. Also, the LEED coordinator must be consulted to discuss the impacts of changing the building envelope in terms of energy savings. Comparisons can then be made between the current systems and other available systems. As was stated in Technical Analysis Method I, it is not a feasible solution to change the building envelope now, because the building is already well along its way of being constructed. Instead, these methods can be used in future project of the Upper Dublin School District.
3. **Technical Analysis Method III** – *Water Reduction* – This technical analysis method will be used to determine how and how much water can be reduced in the school and around the site. There is a large amount of roof area that can be used to capture water for use in irrigation and fixtures such as toilets and dishwashers. Independent research is probably the best way to complete this task. Manufacturers of any products found to collect and distribute to rainwater can be consulted. Also, individuals that have either installed or used the product can be consulted as well to get their opinion, which may be less biased than the opinion of the actual manufacturer.
4. **Technical Analysis Method IV** – *Interior and Exterior Finishes* – This technical analysis can look at the impact of the current interior and exterior finishing systems on the building. This can be looked at from the standpoint of cost, and execution of the product. If a different product cannot be used as the finishing system, it may be possible to instead change the installation technique or procedure to save time costs on the project. This will also need consultation of the structural engineer and the architect. The owner may also need to be interviewed for his thoughts, because changing the appearance of the building can have a negative impact on the school district and the local community. The structural engineer will advise structural concerns, while the architect will provide advice in the area of building design.