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Technical Assignment Three

Penn State AE Senior Thesis

New Indian Valley High School

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Executive Summary

The objective of ***Technical Assignment Three*** is to allow for the identification of the areas of the project that would good potential candidates for research, alternative methods, value engineering and schedule compression. These areas will lay the foundation for the final thesis proposal at the end of the semester and make up the bulk of next semesters activities. This project consists of approximately 250,000 SF of construction that will house 1,300 new students in the coming months. Areas of focus contained within this report include the constructability challenges, schedule acceleration and value engineering scenarios from the perspective of the project manager. At the conclusion of the report a thorough problem identification section allows the student to make observations along with potential analysis methods for upcoming research.

The tops three construction challenges facing the New Indian Valley High School include excavation/soil nail wall installation, geothermal mechanical system installation and auditorium scaffolding structure implementation. Each issue provides unique construction scenarios for the project team to discuss and decided on. The critical path of construction starts at the site work and continues through the superstructure outward until the water-tight milestone is achieved. At that time MEP rough-ins he started followed by MEP installations and finishes, concluding with building closeout. Many schedule acceleration options were explored and implemented including more strenuous scheduling and work re-sequencing. Value engineering alternatives were explored that were both accepted and denied based on the owner's expectations for the school. These options are further detailed out to include construction costs along with potential savings.

Analysis of the constructability challenges, schedule scenarios and value engineering topics along with the project management interview with Jim Myers, of Reynolds Construction Management, several features were identified as potential problematic areas on the New Indian Valley High School Project. Several of the identified problem areas are further discussed in the four construction management analysis methods that include: **Building Orientation/Re-Design Excavation Effects, Re-Sequencing Phasing Breakdown/BIM Implementation, Substitution of Geothermal Mechanical System and Sustainable techniques.** Each of the methods discussed provide insight to possible research topics for the spring thesis proposal.

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Constructability Challenges

The New Indian Valley High School presented its own unique construction challenges. Three constructability scenarios were discussed with Project Manager Jim Myers of Reynolds Construction. Three main issues with construction were: 1. Excavation and Retaining wall, 2. Geothermal wells and delays and 3. Auditorium ceiling finishes and installations.

Excavation and Retaining Wall

The site of the new high school was to be positioned north of the current high school on a sloping ridge line which was included in the school district's property. The sloping ridge line required massive excavation into the hill. This particular project requires a long retaining wall along the north face of the site to provide the necessary bracing from the earth above. The retaining wall is to be a soil nail retaining wall that extends deep back into the ridge for support with the installation of steel elements creating soil masses that give the wall support from the load being withheld.

Excavation of site

Benefits of soil nail walls include quick installation with little equipment, factors which can greatly affect cost. Disturbance of settlement of adjacent buildings can also be avoided with the use of soil nail walls. This allows for construction of both elements at the same time while the south side of the site prepares for the structure the north is completing the wall.

Geothermal Mechanic System Installation

The most troublesome constructability issue turned out to be the drilling of the two fields at the southwest of the site. Delays arose when unforeseen site conditions caused numerous problematic scenarios and eventual rerouting of loops. A major value engineering decision was made when the additions of two additional well loops were added, and their depths raised 50 feet to accommodate the unforeseen conditions. The conditions caused use of previously allotted contingency, but changes to original designs kept them at a minimum. The school, previously scheduled to open in August 2010, would now wait until January 2011 to become occupied; which was not foreign to the school board. A few years earlier the school district consolidated local elementary schools into a newly constructed elementary school after the New Year and the process went smoothly. Mid-year moves also allow for the transfer of Indian Valley Middle School occupants to the current high school, and current high school occupants to migrate to their new home over a school break period.

Auditorium Ceiling Finishes/Installation

A unique problem solving method was used to install the ceiling and finishes of the auditorium. Instead of many trades being congested with scissor lifts working on the high ceilings, scaffolding was placed throughout the area of the auditorium floor and around the tunneled entrances to provide the support system of a work space high above the auditorium floor. This method proved to be much safer and more efficient allowing trades to be more spread out without the need for many scissor lifts. This also allowed for compensation of lost time.

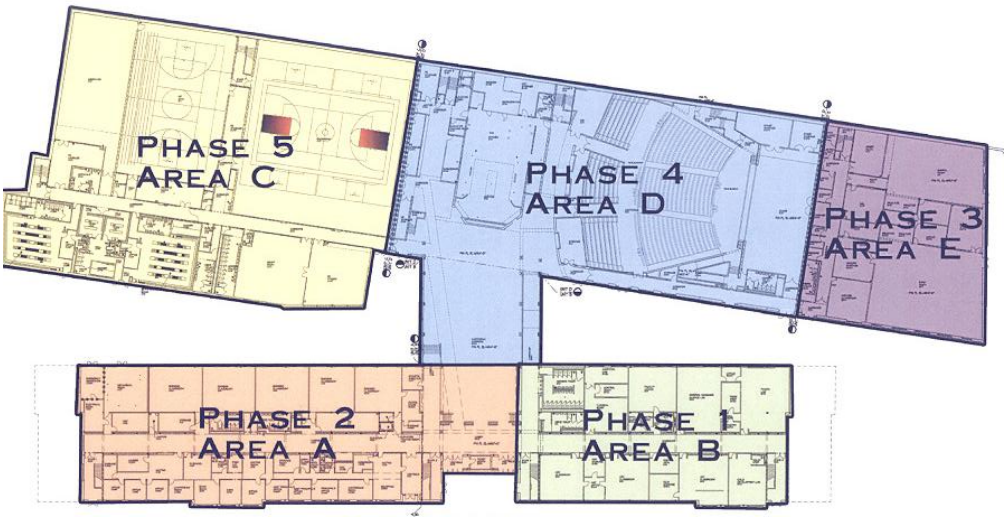
View from outside auditorium through tunnel

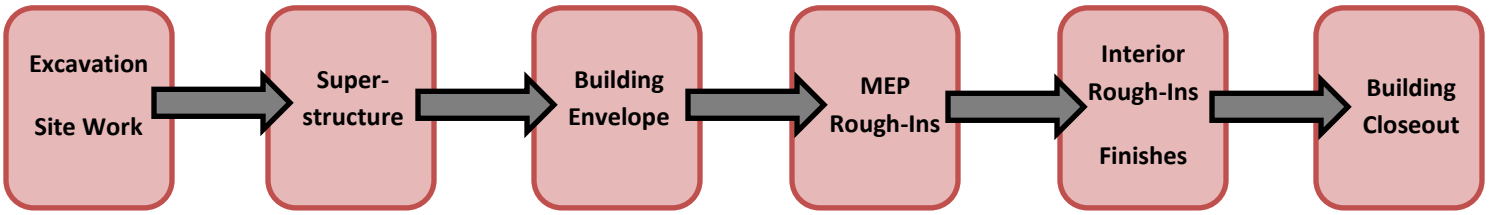
View from auditorium floor

Schedule Acceleration Scenarios

Project Critical Path

Critical paths that are followed allow for a steady flow throughout the project. The critical path directly determines whether the project is early, late or on time. The first step on the critical path for the New Indian Valley High School is the development of site work and excavation processes. This phase is required for allowing the project to emerge from the ground in a timely efficient manner so that it does not disrupt the rest of the critical path and carries a substantial amount of risk. The superstructure follows, and it moves outward to the edge of the building where face brick facades along with the windows, doors and roof systems complete the building's water-tight milestone in conjunction with a five phase sequencing plan seen below. Upon achieving water-tight status MEP rough-ins commence that precede the interior's rough-ins and finishes. The critical path is concluded by building closeout , which is now scheduled to be completed in December 2010.





Critical Path Illustration Scenario

Acceleration Techniques

Project acceleration techniques explored on the New Indian Valley High School Project included the soil nail retention wall that would allow for the placement of the wall at the north edge of the site, while construction at the south end of the site could start on the superstructure in building Area B. Implementing a scaffolding floor system in the auditorium allowed for easy trade coordination without heavy and potentially dangerous congestion in the form of scissor lifts. Other potential scheduling acceleration scenarios explored were decreasing duration of masonry brick veneer placed on the exterior facades. This resulted in a more aggressive and strenuous schedule. Another possible technique that generated interest was to place multiple elevations of masonry veneers at a time. This would require more materials in the form of scaffolding and extra crews to coordinate.

Flexibility in the project delivery was realized when substantial delays developed due to unforeseen well drilling conditions for the geothermal system. The school district was flexible with the idea of moving in late, mid-year, January 2011, instead of August 2010.

Value Engineering Topics

On February 21, 2008, members of the construction team under Reynolds Construction Management, presented the Mifflin County School Board with a 90% Construction Document Estimate which included several value engineering options. The construction team discovered many scenarios in which the school board could save money and/or disperse the saved funds in other areas of construction. In all, approximately $919,000 of potential savings were found. The school board could also use this opportunity to reinvest the money on construction totaling $911,000, providing a net gain. Efficiently saving money was a goal of the small town rural school board and community. Appeasing the community meant presenting something that everyone could be proud of that could stand the test of time.

Changing Floor Material

Terrazzo floors could be found throughout the entire design of the school, however, it was found and later implemented, that if substituting linoleum floors on the upper floors and non-academic areas on the first floor that a savings of $280,000 could be achieved.

Removing Architectural Finish from retaining wall

The site for the new high school was found on a hill with a moderate slope. The site was to be excavated back into the hill, followed by flattening and earth reinforcing site work. At the rear of the construction site a retaining wall drilled deep back into the ridge provides support from the earth behind. Plans called for an aesthetic architectural finish, that if removed could save $172,000. However, the school board did not approve this VE alternative the money was considered well spent and adds an aesthetically pleasing appearance to the rear of the site.

Retaining wall Pre-Finish

Retaining wall Post Finish

Changing Casework Veneer

Throughout the design process, teachers' opinions were heavily considered. Different classes offered by the school required different physical environments to achieve full learning potential. Extensive casework can be found throughout the classrooms of the New Indian Valley High School providing more opportunities to the school's Science and Family & Consumer Science (Home Economics) Departments they previously did not have. Original designs detailed wood veneered casework to be used in most areas; however, changing to a plastic laminate veneer had estimated savings of $42,0(

Family & Consumer Science Room

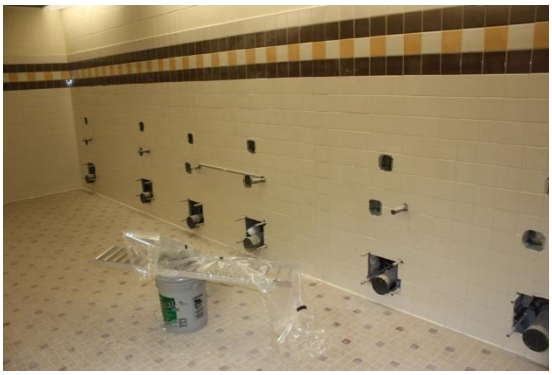
Upgrading Current Athletic Facility Structures

The current outdoor track and field facilities located at the foot of the new construction has also been a recent addition to the Indian Valley High School campus. The track is still in its early years of use and has been without grandstands for multiple seasons. It is proposed that installing grandstands during construction of the new school would take advantage of services that are already on site. Potential grandstands would add $203,000 to the contract value, but would be far less than the amount to install at a later date once construction has finished.

Also proposed is the construction of a pressbox/concession stand combo for the baseball field to go along with the new dugouts. The field has been without all structures since Indian Valley High School was established in 1988. Along with concession stand a concrete path would be added. All additions to the baseball field would total approximately $50,000.

Reducing Ceramic Tile on Restroom, Kitchen and Serving area walls

Cermic tile walls in restrooms will only be placed partially up restroom walls and removed from kitchen and serving area walls. In lieu of the cermaic tiles, the other portions of the walls will be epoxy painted CMUs. Allowing partial cermaic to remain produces a nicer finish at a much less cost. The savings at the Indian Valley High School were estimated at nearly $98,000.



Partial Ceramic Wall Restrooms

Problem Identifications

Analysis of constructability challenges, scheduling acceleration options and value engineering topics in correlation with the interview held with Jim Myers, provided several possible observations indentified by the student. The following topics could potentially be considered a basis for upcoming research.

Excavation/Site Work

The extensive site work and excavation caused by the physical geometry and slope of the construction site raise concern for problems. Extensive amounts of work beginning the critical path of constructon arises many senarios for delays if not successful in take off.

Phasing/Sequencing

Phasing and sequencing of the building gives way to potential problems due to the number of phases and the coordination required to complete the phases of construction correctly. Indian Valley High School currently calls for five different phases of the sequencing of the structure. The more phasing, the more communication and coordination needed to achieve success.

Geothermal Mechanical System

One of few sustainable features of the new school includes a geothermal mechanical system. This area has been indentfied as potentially problematic due to the possibility of unforeseen underground conditions that could disrupt the critical path. A successful start to the project is crucial to a successful completion.

Scope of Masonry Veneer

The masonry brick façade on the exterior of the building raises concern due the shear size of the job. The brick veneer is to be applied extensively around the exterior edges of the building. The water-tight milestone lies on the critical path which relies on the completion of the masonry in a start finish relationship. The schedule proposed could prove to be too daunting of a task.

Building Closeout

Closeout is now scheduled to begin in December 2010. Move in scheduled in January 2011 places added pressure and no margin of error for closeout set to take place right before turnover. Flexibility in project completion cannot be ammended here, which inturn raises conerns.

LEED Certification

LEED certification of the Indian Valley High School was not a high priority item in design. This process has not been pursued to its fullest out of lack of interest, information, financial feasability of the owner and/or rate of investment returns. This project has a higher potential for sustainable design due to the swirling rumors of possible high school consolidation and the need for the structure to serve the

community for a substantial amount of time. Sustainable features would have a significant amout of time to gain return on investments with the potential of substantial returns.

Technical Analysis Methods

Technical Analysis #1: Building Orientation/Re-Design Excavation Effects

Site properties open a door for potential building reorientation/footprint redesign due to the amount of excavation work. The ridge line north of the current high school serves as the new location of the new high school. This ridge line consists of a moderate slope which requires extensive excavation, grading, earth reinforcement and the placement of retaining walls to prepare the site for use. Investigating potential changes in building orientation or footprint size on site could dramatically affect the excavation and lead to different possible scenarios for achieving the equivalent structure size and expectations by altering the original set up

Analysis of the site would need to begin with the same design schematics given to the construction team. Similar to Arch 444, the completion of thorough feasibility studies, environmental conditions reports and knowledge of expectation requirements of the owner, would provide a base to begin the same design process taken two years ago by the project design staff. Close consideration would have to be given to owner's expectations so that this potential change would not compromise the product. A true benefit would be discovered if the implementation of a new building orientation and shape could be developed that encompassed all owner requirements at a cheaper costs and more effective schedule. This very detailed analysis has potential to be considered in an architectural breadth for the upcoming spring semester to see if any true benefit could be attained.

Technical Analysis #2: Re-Sequencing Phasing Breakdown/BIM Implementation

Re-sequencing the phasing breakdown or the implementation of BIM on the project could consolidate trade crews and allow for faster production of the school. Currently a non-BIM five phased project design is used to construct the project. This type of phasing calls for extensive communication and coordination between trades.

Performing re-sequencing would require research to be performed on resource/material availability to ensure work can be completed simultaneously without disrupting critical path activities.

Since Building Information Modeling (BIM) was a main topic of discussion at this year's PACE Roundtable discussions investigation into different pros and cons associated with the New Indian Valley High School and how it can be adapted to a budget for efficient results could be explored. The analysis of whether or not BIM and/or re-sequencing construction can improve communication, coordination and understanding among trades would have to show a substantial gain between implementation and costs to prove beneficial. A valid point brought up at the PACE conference included the fact that not all tradesmen would be privy to BIM technologies and could potentially be counter-productive and could acquire additional costs and potential problems.

Technical Analysis #3: Substitution of Geothermal Mechanical System

The New Indian Valley High School design incorporates a new geothermal mechanical system that has caused problems on the site with unforeseen underground conditions. A newer/sustainable technology, geothermal mechanical systems incur greater upfront costs in return for long lasting energy returns in the form of lower energy costs. However, this system caused a major delay in the project and potential investigations could be conducted to determine the cost of the overall system along with damages from delays to determine if a more traditional system would have been more cost effective.

This analysis would have to provide an estimate of potential geothermal energy use to traditional use along with the investigation of the total cost of geothermal construction on the project. After a detailed estimate of all items costs associated with both mechanical systems is produced, a more accurate depiction of a mechanical system substitution could be identified.

Technical Analysis #4: Sustainable techniques

LEED certification was not a driving concern of the design team of the new school nor was a certification achieved. The utilization of few sustainable ideas and concepts provides an opportunity into further investigations of such designs. Analysis could reveal potential financial returns of investment of opportunities not explored. Design features such as photovoltaic panel arrays and wind harnessing techniques were not considered in original design. A geothermal mechanical system, motion sensitive lighting in classrooms and ivanny block wall construction were all sustainable ideas included in the construction.

Analysis into sustainable techniques would need to include a thorough investigation into financial feasibility of the community. Rate of return associated with each potential sustainable change and cost versus the cost and future life-cycle of their “unsustainable” counterparts would become the most beneficial statistic in analysis of sustainable concepts. It would be fulfilling to determine how far away the project design was from LEED certification rating and what changes would be required to achieve one, including the additional costs.