December 1, 2009

TECHNICAL ASSIGNMENT THREE

PENN STATE AE SENIOR THESIS

EPRISCOPAL HIGH SCHOOL
CENTENNIAL GYMNASIUM
ADDITIONS & ALTERATIONS

ALEXANDRIA, VA

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1855

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TECHNICAL ASSIGNMENT THREE

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EXECUTIVE SUMMARY

Technical Assignment Three is intended to identify areas of the project that are good candidates for research, alternative methods, value engineering and schedule compression for the Episcopal High School Centennial Gymnasium Addition/Renovation. This project includes a 60,000 SF new gymnasium addition as well as 39,000 SF of renovation work to the existing gymnasium and wrestling facilities. The largest challenge associated with this project is that the proposed site is located in between two existing structures (both of which are included in the renovation work) on an active private high school campus. The surrounding facilities, including the structures to be renovated, must remain open and functional for the athletic department during different phases of construction.

The top three ***constructability issues*** identified on this project are building alignment between two existing structures, new construction/renovation phase sequencing and the presence of active utility lines within the proposed building pad. Each issue presents different challenges that must be addressed by the project team. The critical path of the project is slated to run through the superstructure, water-tight milestone, hardwood floor installation and finally gymnasium finishes. Achieving a climate controlled space is critical to the success of the project. Several ***schedule acceleration scenarios*** are indentified and include extended work hours, increased crew sizes and re-sequenced work flow. ***Value engineering topics*** that were accepted or denied on the project are described and include construction methods and material selection ideas that maintain the expected quality of the project at a lower cost.

Through the in-depth analysis of the constructability challenges, schedule acceleration scenarios and value engineering topics along with the Project Management interview with Dave Mesich, Marybeth Athanas and Bryan Quinn of DAVIS Construction, several features were identified as potential problematic areas on the Centennial Gymnasium project. Several of the identified problem areas are further discussed in the four construction management analysis activities that include re-sequencing of renovation phases, elimination of site congestion, climate controlled requirements and sustainable techniques. Each of the methods discussed provide insight into possible research topics for the spring thesis proposal.

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CONSTRUCTABILITY ISSUES

ALIGNMENT OF NEW BUILDING

While the structure for the New Centennial Gymnasium is not complex, the location of the facility presents a very unique challenge. The building is to be constructed in between the existing Centennial Gymnasium and the existing Flippin Field House. When the new structure was designed, the Architect and Engineer assumed that the North façade of existing Centennial and the South façade of Flippin were aligned parallel to one another. The footprint for New Centennial was designed square to align with these structures and attach to the existing walls, as shown in Figure 1. However, when the new building footprint was laid out on the site, the field engineer realized that the existing walls were 4" off parallel and the building would not fit in the required space as designed. This created a situation where the column lines and edge of slabs on the new building did not align with the existing walls of the adjacent structures. Key concerns that arose from this issue include waterproofing details, exterior window alignment with adjacent structures, brick alignment with adjacent structures and column line measurements.

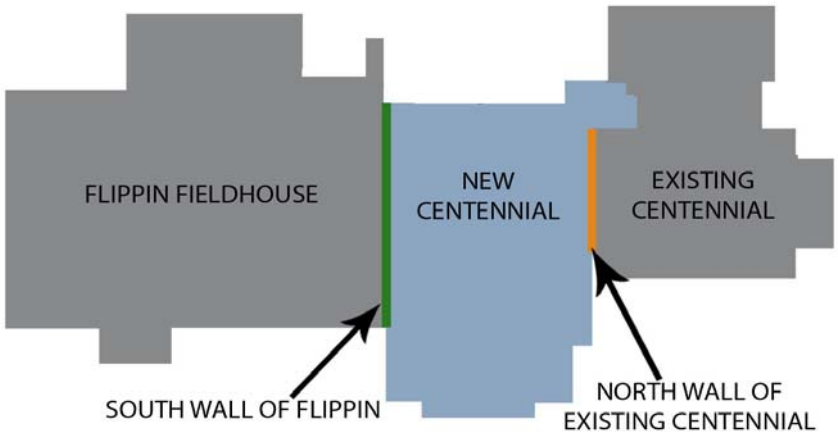

FIGURE 1: Building Alignment Diagram

To resolve the issue, the DAVIS field engineer developed an as-built CAD drawing detailing the coordinates of each of the existing walls. The Architect determined that it was crucial to have the building align with the North Centennial Gym wall due to the glass curtain wall entrance that connects at this location. All of the East/West column lines in the new structure were aligned parallel with the face of the existing Centennial Gym. The East/West positioning of the grid lines were set based on the circular columns, shown in Figure 2, that run along the existing North Centennial Gym wall. These columns were located equidistant from the center of the existing North wall. At the interface between the South wall of Flippin Field House and the new structure, a 4" gap is to be concealed with a brick return at the Northwest corner of the New Centennial building.

FIGURE 2: Circular Columns Along North Wall

PHASING OF NEW CONSTRUCTION/RENOVATION

The complex phasing of the new construction and renovation work creates several constructability issues for the project. In order to construct the new gymnasium but maintain occupancy in the adjacent existing Centennial Gymnasium, temporary egress facilities had to be erected to maintain a safe environment for the students and faculty at EHS. A temporary exterior/interior stair tower and exit had to be erected to provide a second exit from the gymnasium, shown in Figures 3 and 4. Likewise, an emergency exit was installed in the lower level locker room area due to the elimination of the existing exit into the new gymnasium building pad, shown in Figure 5. It was critical to account for these facilities in the general conditions estimate as well as the overall project schedule to ensure that these activities did not delay the overall project nor prohibit EHS from using the gymnasium. These temporary structures will remain in place until March 2010, when the existing Centennial Gymnasium is turned over to DAVIS for renovation work.

FIGURE 3: Temporary Exterior Stair Tower

FIGURE 4: Temporary Interior Stair Tower

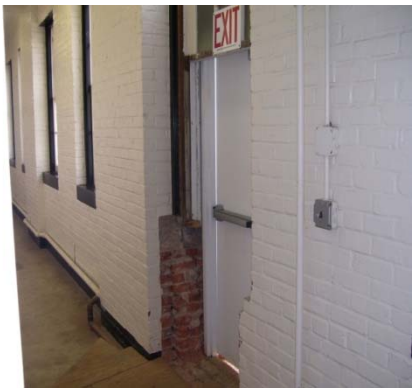

FIGURE 5: Temporary Lower Level Exit

Another issue related to the phasing of the project is the congestion in the relatively small New Centennial building pad. In order to stay on schedule and meet key milestones, the geo-pier installation and building pad excavation had to occur simultaneously for a given amount of time. The geo-pier operation has a relatively large footprint due to the presence of large drills, vibrators and gravel stock piles. Site excavation produced several soil stockpiles throughout the pad, which were not removed in a timely manner. These two activities taking place in a small building pad resulted in several coordination issues and ultimately a loss of three days in the overall schedule due to inefficiency. The site team attempted to control the locations of the soil stockpiles to minimize the impacts on the geo-pier operation; however it proved to be extremely difficult and ultimately contributed to the delay.

The small building pad also restricted the project team to the use one crane for all lifting activities. Due to the proximity of the adjacent buildings, only one tower crane could be located within the building footprint, as shown in Figure 6, and had to be sized to accommodate all lifts for the construction of the facility. These lifts included concrete, steel trusses (10,200 lbs each), roofing material, masonry material and AHU's (8000 lbs.

FIGURE 6: Tower Crane for New Centennial

each). The concrete subcontractor was responsible for the set-up and dismantling of the crane and the rental during the concrete phase. Once all concrete was completed, DAVIS assumed responsibility of the crane rental and determined what trade was able to use the crane at certain times. Since DAVIS did not have money allocated in the general conditions for crane rental, the project team implemented a rental program that charges each trade by the hour when they have to use the crane.

EXISTING SITE UTILITIES

The building pad for the New Centennial Gymnasium is located in between to existing structures on the campus. This area is a main through-way for students/faculty as well as active underground utility lines running to the adjacent structures, as shown below in Figure 7. Among the utilities are major gas, sanitary, storm, water and electrical lines that must remain active throughout construction since the adjacent buildings will be occupied. In order to construct the new facility, the utility lines had to be removed to allow for excavation and foundation work. Prior to these activities, three months of utility relocation had to occur to ensure that the surrounding campus buildings can remain operational during construction. This process was difficult due to the incomplete and inaccurate as-built drawings provided. Utility lines were not located as shown on the plans, or in some instances were not shown at all. Several lines were hit and ruptured during the process, the most crucial of them being the high-pressure gas line break that temporarily shut down the job site.

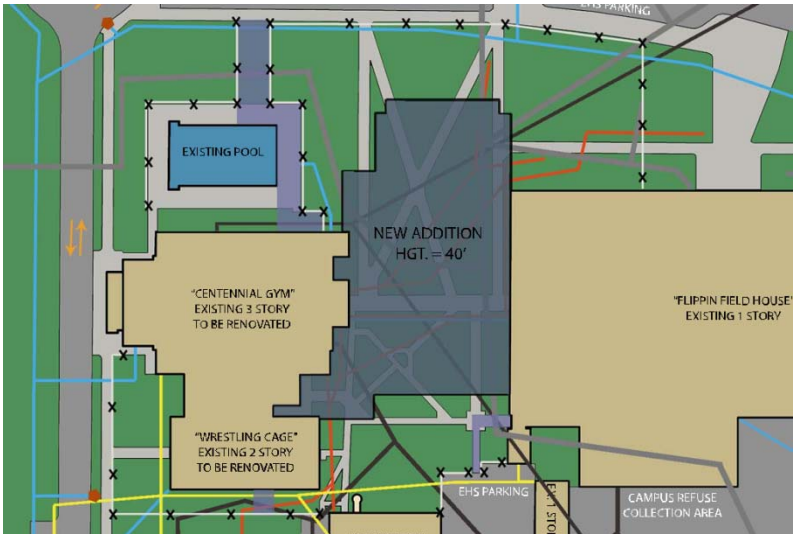

FIGURE 7: Existing Utilities Within Proposed Building Pad Area

To overcome this challenge, a third-party utility locater company was hired to run scans of the entire site to pinpoint locations and depths of all utility lines. A labeling system was established to mark each utility with spray-paint and flags, and all subcontractors on site were informed to not remove or cover the markings. During the excavation and uncovering of the lines, extra caution was implemented to minimize the chances of rupturing the lines. Machines were used to remove the majority of the soils and then hand tools were utilized once the excavation reached within one foot of the measured depth. In hindsight, it would have been beneficial to utilize the utility locater company from the start and remove the risk of encountering unidentified utility lines. The unforeseen challenges with this stage of the project did not impact the overall schedule, but did add unexpected costs with the use of the third-party utility location company.

SCHEDULE ACCELERATION SCENARIOS

PROJECT CRITICAL PATH

The critical path of a project typically runs through the activation of permanent power. Unique to the Episcopal project is the fact that the permanent power was set-up at the beginning of the project, prior to excavation of the building pad. This was done to allow for the removal of existing underground electric lines that ran through the building pad area that needed to be excavated. This is key for the success of the project because no delays will be incurred when equipment start-up and commissioning is taking place.

Currently, this critical path runs through concrete placement, steel truss erection and completing the roof and façade for water-tightness. The biggest risks associated with completing the project on schedule it that the gymnasium area must be climate controlled for one month prior to the installation of the floor. Hardwood flooring material must be stored in the controlled climate for this duration to allow for proper acclimation to the environment. To provide a proper climate controlled area, the HVAC equipment must be delivered, installed, start-up and commissioned with the controls and set-points calibrated. Once the hardwood material has been stored for one month, the installation will take another month. The entire gymnasium finishes, including bleachers, backboard alignment, floor painting, etc. cannot be completed until the floor is installed. To aid in this process, all of the overhead lighting and finish work will be completed prior to the floor installation during the one month storage period. Figure 8 depicts the critical path of the Centennial Gymnasium schedule.

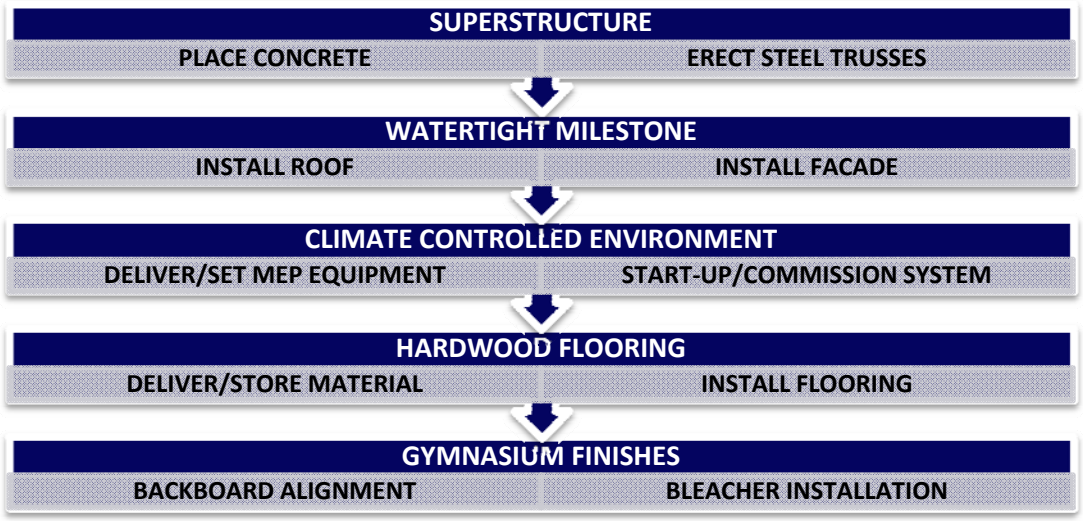

***FIGURE 8*: Project Critical Path for Centennial Gymnasium**

ACCELERATION TECHNIQUES

Discussions with the project management team revealed key schedule acceleration techniques that have been implemented on the project to date. Per the contract schedule, the geo-piers were scheduled to be completed in approximately 15 days, which required 14 piers be installed per day. Within the first week it was determined that this aggressive schedule was not going to be achievable

due to unforeseen coordination issues with underground MEP lines. To meet the contracted deadline, the geo-pier contractor worked six, 10-hour days at no added cost to the project since the durations were included in the original sub-contract. The delay in geo-piers pushed back the mobilization date for the concrete contractor due to the start-finish relationship. DAVIS Construction decided to overlap the end of the geo-piers and start of the concrete to gain time. Quickly, DAVIS and the subcontractors realized that this technique was adding congestion to the site and causing inefficient work. The concrete contractor left the site for a week and began once all geo-pier work was completed. Similar to the acceleration of the geo-piers, the concrete contractor worked six, 10-hour days to recuperate lost time, again at no added cost to the project. Finally, the original contract and phasing plans called for the brick facades to be installed one elevation at a time. In an effort to gain lost time due to weather delays, DAVIS and the masonry subcontractor re-sequenced the work to be on two elevations simultaneously. Extra crews and scaffolding was allotted to meet this new sequencing plan. To date, the added cost is not known for this acceleration in schedule for the masonry operation.

Both Marybeth and Bryan felt that once the project moved to the interior phases there will be few opportunities to accelerate the schedule significantly. Given that achieving climate controlled spaces is on the critical path, the project team feels the accelerating the MEP installation and start-up process may be beneficial. Bryan felt that this would be possible by increasing the amount of hours worked in lieu of increasing crew sizes due to the tight spaces limiting the amount of workers in an area. This acceleration will depend on the availability of materials and equipment on site. Marybeth added that another way to accelerate the climate controlled process is to coordinate the controls and set-points of the equipment early on to minimize delays during start-up/commissioning. Being that this project is going for a LEED certification and has a commissioning agent on the project team, having early meetings and coordination should be obtainable.

VALUE ENGINEERING TOPICS

On December 9, 2008, DAVIS Construction submitted the GMP package to Advanced Project Management with a list of value engineering suggestions. The following are the four largest value engineering items approved by the owner.

RESEQUENCING OF RENOVATION WORK

The original proposed schedule had the renovation work to the existing facilities finishing after the new Centennial Gymnasium was completed. This required the work to extend into the 2010/2011 school year and the athletic department staff to be housed in temporary trailer facilities. Extending the schedule increased the GC's on the project and inconvenienced Episcopal High School.

DAVIS Construction proposed to APM/Episcopal a re-sequencing of the renovation work to allow for multiple turnover and occupancy dates throughout the project schedule, as shown in Figure 9 below. This increased the complexity of the supervision requirements since new construction and renovation work will be performed simultaneously. However, the re-sequencing of the renovations shortened the project schedule and allowed for the overall project to be completed prior to the start of the school year, and therefore eliminating the need for temporary trailers for EHS. This VE item was a $175,000 credit when considering the elimination of GC's and trailers, but more importantly a logistical benefit for the school.

Flippin' Field House: (Renovation)
Turnover to DAVIS: July 1, 2009
Turnover to EHS: July 22, 2009

Existing Wrestling Cage: (Renovation)
Turnover to DAVIS: April 20, 2009
Turnover to EHS: October 9, 2009

Fitness Area/Mechanical Room: (Renovation)
Turnover to DAVIS: October 1, 2009
Turnover to EHS: February 9, 2010

New Gymnasium: (New Construction)
Ground Breaking: June 15, 2009
Turnover to EHS: July 21, 2010

Existing Gymnasium: (Renovation)
Turnover to DAVIS: February 23, 2010
Turnover to EHS: September 3, 2010

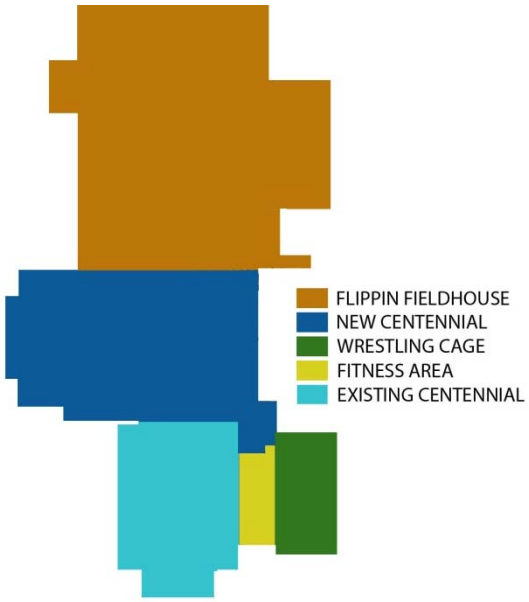

FIGURE 9: Turnover Phase Diagram

REMOVAL OF NAILBOARDS AT METAL ROOFING

DAVIS suggested the removal of all nailboards at the metal roof area that are specified in the construction documents. The Architect believed that due to the span from the roof material to the acoustical decking that a nailboard would be required. However, the metal roof panel fastener could be used to attach directly to the acoustical decking all the way to the top of the roof. This produced a savings of $26,000.

ALTERNATE PRODUCTS/MATERIALS

In order to meet the proposed budget set by EHS and provide high-quality building finishes, DAVIS suggested material and product alternates that maintained quality, aesthetic and performance expectations at a lower cost. The athletic rubber flooring in the fitness/gymnasium areas was suggested to be switched to a comparable manufacturer that provided the same quality material for $70,000 less. Also, DAVIS recommended using Versa-Dek 3.5LS in lieu of the EPIC deck that was specified for the metal roof deck. This alternate provided a $32,000 deduct. Both VE items were aligned with the goals of EHS in that they maintained quality and performance and aided in meeting the proposed project budget.

NEAT CUT FOOTINGS

DAVIS and the concrete subcontractor proposed to neat cut all footings, shown in Figure 10, for the pile caps and grade beams to reduce the amount of excess soil that had to be hauled away and to eliminate the use of formwork for the footing concrete. Typically, footings are excavated with two extra feet on each side to allow space for formwork. This value engineering item reduced the amount of labor and duration for this activity by approximately one half and saved the project $100,000.

FIGURE 10: Neat Cut Footings

VE ITEMS NOT APPROVED

Several value engineering items were proposed to APM and EHS during the GMP process, however not all were approved. The following are a few of the items not implemented on the Centennial Gymnasium project:

- Deduct the fire rating characteristics of the fixed seating padding - $1,200
- Deduct the specified Panelam on bleachers and replace with plywood decking - $1,200
- Install a hydraulic elevator in lieu of the specified machine room-less elevator - $16,100
- Furnish scoreboards by an alternate manufacturer - $13,320

PROBLEM IDENTIFICATION

Through the in-depth analysis of the constructability challenges, schedule acceleration scenarios and value engineering topics along with the Project Manager interview, several features were identified as potential problematic areas on the Centennial Gymnasium project. The following issues may possibly be pursued in upcoming research topics.

RENOVATION SEQUENCING

The proposed sequence has multiple turnover dates with renovation work overlapping new construction activities throughout the entire project schedule. Phased occupancies are planned for the Flippin Field House, Wrestling Cage and Existing Centennial to accommodate the EHS athletic requirements. This scenario creates potential problems with trade coordination, contractor buy-in and delays. For instance, the HVAC contractor will be required to install and complete the Wrestling Cage system at the same time as the underground work is being installed at the new building. There will be several contractors switching between renovation and new construction work which will make coordination and schedule understanding extremely difficult. This phasing plan requires temporary HVAC systems to be installed until all renovation work is complete, as well as inactive fire suppression systems during phased occupancies. Ultimately, the overall project schedule starts with renovation to the Wrestling Cage and ends with renovation in the existing Centennial Gymnasium with new construction in between.

PUBLIC SAFETY

Since this project is located on an active high school campus, several problems exist with ensuring the safety of the students/faculty while maintaining a productive site. Several measures must be in place to separate school and construction activities without sacrificing campus operations. The fact that the two adjacent structures that New Centennial is attached to will be occupied during construction presents a challenge to public safety. Items such as crane swing, emergency egress and vehicular traffic must be considered for all phases of the project schedule.

SITE CONGESTION/CRANE USAGE

The building pad for New Centennial is small and situated between existing structures. There is only one access point to the site with minimal space for storage and layout. Having multiple trades working within the pad presents problems with efficiency and safety. This project has space for one crane and requires multiple trades to coordinate usage and rental expenses. Coordinating trades and crane usage is crucial to minimize delays during construction.

MASONRY SCHEDULE DELAYS

Due to the tight site and overlapping of trades, the masonry operation has the potential to fall behind schedule due to inefficient work. This trade requires a large space for material storage and scaffolding erection, both of which will be difficult on the New Centennial site. The GMP schedule shows an

aggressive duration for masonry work, which is one of the main activities on the critical path to the water-tight milestone. It will be difficult for the masonry subcontractor to meet the proposed schedule.

WATER-TIGHT MILESTONE

The major milestone for the New Centennial Gymnasium is meeting the water-tight date. This is identified as a potential problem because it requires all exterior masonry walls, windows, doors and roof to be completed in order to allow for HVAC equipment start-up. Extensive trade coordination is required to install all of the required components, many of which must utilize the same scaffolding system. This milestone is on the critical path and crucial for the overall success of the project.

HVAC START-UP/COMMISIONING

Following the water-tight milestone, it is critical that the HVAC system is start-up on time to provide a climate controlled space for the hardwood floor installation in the gymnasium. This is listed as a potential problem area due to the difficulties with the controls and set-points of the equipment. A one month climate controlled duration is required to have the hardwood material acclimated before installation can occur. If this deadline is not met, problems will arise with delays to the overall schedule.

LEED CERTIFICATION

The LEED Certification process is identified as a problem because the sustainable features of the project are not being pursued to the fullest potential. Whether it is lack of interest, information or time, the owner and project team have not investigated all of the techniques that can make the Centennial Gymnasium project sustainably beneficial to Episcopal High School and the environment. This project is ideal to pursue a high level of sustainable features since EHS will own and operate the facility for at least 50 years.

TECHNICAL ANALYSIS METHODS

TECHNICAL ANALYSIS METHOD #1: RESEQUENCING OF RENOVATION PHASES

As described in the previous section, the renovation work on the Centennial Gymnasium is spread throughout the entire project duration, with multiple phased occupancies. This plan has required several contractors to mobilize, demobilize and remobilize multiple times due to gaps in the schedule and has created uncertainty pertaining to responsibilities and coordination in each area. Also, the phased occupancies require several systems, such as HVAC and fire suppression, to be either temporarily connected or out-of-service during initial turnovers due to incomplete renovation work that tie into later activities.

The analysis will include an in-depth re-structuring of the project schedule to group similar activities in the Wrestling Cage and existing Centennial Gymnasium. Currently, these two areas are to be completed at the beginning and the end of the overall project schedule respectively. It is proposed that they be completed simultaneously at the beginning of the project, primarily over the summer months, to minimize the impact on school functions and allow subcontractors to perform similar activities at the same time. This will eliminate the phased occupancies and temporary HVAC/fire suppression systems. Also, this will require less public egress measures described in the *Constructability Challenges* section. The new Centennial Gymnasium can be constructed as originally scheduled because the excavation, foundation and superstructure activities will not affect the renovation work in the other areas. It is believed that this re-structuring will reduce the overall schedule and turn-over the renovated areas earlier in the project.

To perform this analysis, research will need to be performed on resource leveling and material availability to ensure that all renovation work can be completed simultaneously. Close consideration will be taken to ensure that all EHS athletic functions are not inconvenienced. If a reduction in overall schedule is determined, the savings in general conditions and management fees will be calculated to further prove the benefit to the owner. The Project Manager at DAVIS will serve as the primary contact for this analysis since she is responsible for creating and updating the actual project schedule.

TECHNICAL ANALYSIS METHOD #2: ELIMINATION OF SITE CONGESTION

Site congestion is a major concern identified on this project. This issue has impacted several trades and caused delays in excavation, geo-pier installation and masonry work to date. The lack of material storage and lay-down space has caused contractors to work inefficiently and unsafely. More than once, a trade had to demobilize until the site cleared up to allow for productive work.

This analysis will include careful considerations of activity durations and sequences to determine the most efficient progression of work. Several activities on the original project schedule had unrealistic durations and overlaps that made it impossible for the contractor to meet expectations. These problem areas will be identified and techniques will be suggested to eliminate the issues and ensure a logical schedule.

Another analysis will be to explore pre-fabricated systems that may be applicable on the Centennial Gymnasium project to reduce the amount of on-site material storage and labor durations. One system that will be analyzed is precast brick panels. This trade was chosen due to the extensive amount of on-site labor required for the masonry operations. The project has already experienced delays due to this trade. Areas that will need to be researched include production capabilities, erection sequences and durations, quality control issues with interfaces and aesthetic requirements of the Architect and EHS. Also, the availability of the crane will need to be considered to ensure that the panels will be able to be erected efficiently. This analysis can provide the opportunity for a structural breadth study to determine the required connection and loading details for the panels and impacts they will have on the superstructure. It is believed that this technique will reduce the amount of site congestion and eliminate the encountered delays between different trades.

TECHNICAL ANALYSIS METHOD #3: CLIMATE CONTROLLED REQUIREMENTS

The requirement to have the gymnasium space climate controlled for one month prior to the hardwood floor installation is a critical element of the overall project success. This milestone relies on several different activities to be met. All of the exterior walls and fenestrations must be enclosed along with the roof structure. HVAC equipment must be delivered and installed with all controls and set-points calibrated to allow for system start-up. The gymnasium floor installation and finishes depends on these activities being completed and anchors the critical path of the project.

This analysis will include an exploration of techniques available to accelerate the schedule to ensure climate controlled status is provided for the gymnasium to allow the hardwood flooring to be installed on time. One possible solution would be to isolate the gymnasium space and temporarily control the climate with HVAC equipment from the adjacent existing buildings. This would require additional mechanical analysis to determine loading and equipment requirements and could serve as a potential mechanical breadth study. Accelerating this portion of the project would ensure that the gymnasium floor is installed and all necessary finish work, i.e. bleachers, backboard alignment, etc. is completed on time.

TECHNICAL ANALYSIS METHOD #4: SUSTAINABLE TECHNIQUES

The Centennial Gymnasium project is slated to achieve LEED Certification upon completion. However, the project has utilized very few sustainable techniques that could provide a financial benefit to Episcopal High School. Features such as photovoltaic roof panels were identified as possibilities by EHS in the initial design phases of the project, but eliminated from scope due to financial restrictions.

This analysis will include an in-depth investigation into the financial feasibility of installing a PV array on either the existing Flippin' Field House roof or the new Centennial Gymnasium roof. Research will be performed to determine the optimal array layout and equipment size. Also, a life-cycle feasibility study will be performed to allocate for grants and incentives that may make the use of the PV technologies financially attractive for Episcopal High School. This study will require the use of materials and programs used in the Sustainability Design graduate course and may serve as the MAE breadth topic for the spring thesis research.