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Construction Management
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New Moon Area High School/ District Administration Offices

8353 University Boulevard, Moon Township, PA 15108

Technical Assignment Three | 12/1/2009

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& District Administration Offices

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STRUCTURAL SYSTEMS

Foundation:

Grade beams and columns bear on (299) caissons ranging from 24”-54” in diameter, at depths of 13’-40’.

Superstructure:

The ground floor is supported by grade beams spanned by a 21” ribbed, structural slab-on-grade. Floors 1-2 rest on 3-1/2” light weight concrete on 3”, 18 gauge metal decking. The buildings main support comes from a structural steel system made of varying W-shapes and the lateral loads are carried through masonry shear walls.

MEP SYSTEMS

HVAC:

Classroom climates are provided by (130) in-ceiling heat pumps, (11) 100% outside air units with heat recovery, (3) natural gas boilers, and (2) fluid cooling units. Other space heating and cooling is supplied by a combination of (12) variable and constant volume AHU’s, and (15) cabinet heaters.

Electrical:

(2) 5000A, 480Y/277V 3Φ, 4-wire Service feeders are provided by Duquesne Light. The service is then dropped to 208Y/120 by (6) transformers within the building. Back-up power is supplied by a 17 minute UPS and a 250 kW diesel powered generator.

Fire Supression:

The building utilizes a combination of wet and preaction systems.

ARCHITECTURE

The New Moon Area High School will feature a tan brick exterior with stone and red brick accenting, along with the occasional use of a glass curtain wall system. The building is of a split-level design, only allowing for only two of the three stories to be seen from the road. The High School is designed for the community spaces to be most accessible from the main entrance, where the auditorium and gymnasium are on the first floor, and the bulk of the classrooms are on the second floor. The ground floor consists of the cafeteria, natatorium and district administration offices. Overall, the building will accommodate 1,260 students and 172 staff members.


Main Entrance

PROJECT TEAM

Owner:
Moon Area School District

Architect & MEP:
Eckles Architecture & Engineering, Inc.

Building Electrical Engineer:
Tower Engineering

Structural Engineer:
Barber & Hoffman, Inc.

Civil Engineer:
Michael Baker Jr., Inc.

General Contractor:
Nello Construcition Company

CM Agent:
N. John Cunzolo Associates, Inc.

GENERAL BUILDING DATA

Size:
291,387 square feet

Occupancy Class:
Group E - Educational

Cost:
$63,682,117

Dates of Construction:
January 2009 - November 2010

Delivery Method:
Design-Bid-Build w/CM Agent

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Executive Summary

Technical assignment three takes a look into the challenges of building the New Moon Area High School and District Administration Office and helps to develop ideas for future research. This paper focuses mainly upon the challenges of the construction, schedule acceleration and value engineering as described by the project team.

Constructability challenges such as the installation of the concrete wall, structural slabs and fireproofing are address first. The second section moves on to discuss any ideas that the project team has used or may use in the future to accelerate the overall project schedule. The interview of the project team concludes with a short list of value engineering ideas that have been utilized up to this point in the construction. This list is not very extensive because it appears that VE was not a major part of the preconstruction period of the building.

Finally, a list of technical analysis topics was developed based upon the constructability challenges described by the project team and other observations made while examining the project documents throughout the process of completing previous assignments. The analysis topics include: 3D coordination and 4D scheduling, LEED consideration, structural system simplification, and substitution of window systems.

Constructability Challenges

The construction of the New Moon Area High School & District Administration Offices is a rather large project and as one would expect there have been many challenges in constructing the new facility. This section of the report will address the top three constructability challenges as described by the design and construction teams. Please keep in mind that the construction is still taking place on the building's superstructure therefore at this point all issues have involved sitework, foundations, and structure.

Concrete Foundation Wall Construction

As a result of the buildings split-level design there is a foundation wall that separates the ground floor of Areas C&E from the soil under the first floor, shown below in *Figure 1*. As designed, the wall could not be backfilled until the steel on the ground floor was set and plumbed and the first floor slab-on-deck was placed. This was a problem because the grade beams under the first floor of Areas C&E tie into the wall and could not be completed until the wall was backfilled. This also prevented the first floor slabs from being placed, which further delayed the installation of the load bearing masonry walls that surround the gymnasium and auditorium. Overall, the any delay in the installation of the wall would have quickly put the entire project behind schedule.

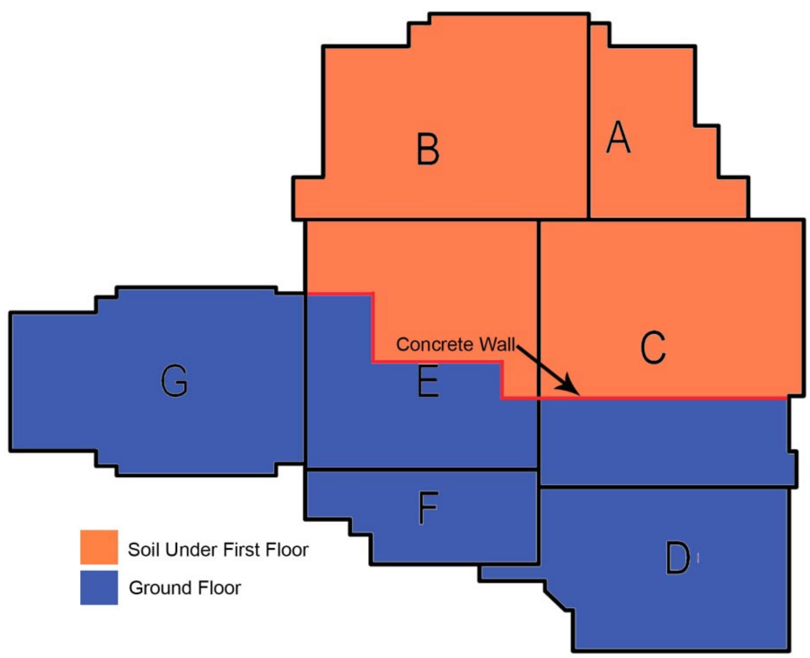

Figure 1: Concrete Wall Location

The solution developed by the general contractor was to divide the structure into two separate buildings. Areas A&B and Areas D, F&G were constructed as two standalone structures while the ground floor of Areas C&E were being completed. This allowed for Areas A&B to be constructed all the way to the roof before the concrete wall was ready to be backfilled and for Areas D, F&G to be constructed ahead of Areas C&E. If the general contractor would have waited for work to be complete on the wall the project would have been several months behind schedule.

Structural Slab Installation

The location of the new high school is an area where the school district previously had athletic fields and sports facilities. Soils reports indicate that the land was previously filled with unsuitable soil classified as "mine spoils" which was fine for a baseball field but will not work for a three story building. Therefore, the structural engineer designed a stout system of caissons, grade beams and structural ribbed slabs to ensure that the building is properly footed on a sturdy base. The structural slabs were designed to be placed under the first floor of Areas A-C&E because there was a risk for settlement in these areas. It came to the attention of the general contractor that the structural slabs required the use of cardboard void forms. During the summer when the slabs were to be placed the weather was often rainy and there was a concern that the cardboard forms would be ruined in the event of a storm. In an effort to prevent delays and the need for rework on the forms and rebar the general contractor looked for other means of installing the first floor structural slab-on-grade.

Figure 2: Precast Floor Planks

Figure 3: Grouted joints

The final solution to the problem was to use precast planks for the first floor slab in Areas A-C&E. The precast planks eliminated the risk associated with any rework that could be caused by a rain storm. Also, faster installation of the planks allowed for this section of the schedule to be accelerated. As shown in *Figure 2* above, the planks were simply installed spanning the grade beams that were a part of the original design involving the structural slabs. As the planks were installed the joints between them were grouted, *Figure 3*, and once an entire area is complete a topping slab with be applied to all of the planks to ensure a smooth finish in achieved.

Fireproofing Installation

Combinations of the building being constructed in two separate parts and impending winter weather have created a challenging scenario for the installation of the sprayed on fireproofing. In order for the fireproofing to properly adhere to the steel it must be completely dry and the temperature must be at least 40 degrees for 24 hours before and after the application. This has forced the general contractor to focus their initial efforts on spraying the beams and columns and the exterior of the building allowing for studs and sheathing to be applied immediately following. Once the studs and sheathing were applied they were used to form temporary enclosures that could be heated for the application of the interior fireproofing.

Schedule Acceleration

The construction of the high school in under a strict time constraint in order to have the building ready for the second half of the 2010-2011 school year. If this project is not completed on time it will force the district to continue use of the old high school preventing that facility from undergoing its scheduled renovations. *Figure 4* below represents the critical path of the project. As shown, the critical path is typical of most construction projects, starting with the excavation and ending with the interior finishes. In the event that the project becomes delayed or is forced behind schedule the following acceleration ideas have been developed by the project team.

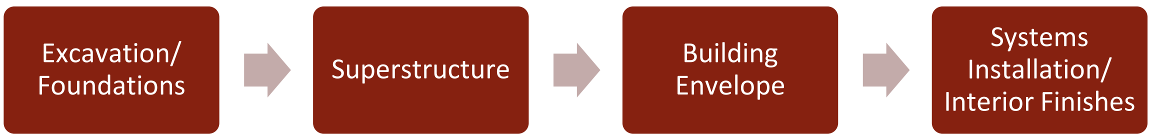

Figure 4: Project Critical Path

Precast Planking Installation

As a result of adjusting the project schedule due to the issues caused by the installation and backfill of the concrete wall in Areas C&E the installation of the precast planking also served as a way to gain sometime in the project schedule. The time delay caused by the backfilling of the concrete wall forced the installation of the grade beams on the east end of the first floor to be delayed. Therefore, by implementing the use of the precast planks this time can be recouped once the grade beams are installed. The relatively quick installation of the precast will is substantially shorter than the original structural ribbed slabs. This wall also done with little associated changes in cost, in fact the precast planks may result in a credit to the owner.

Interior Masonry Construction

When the decision was made to divide the structure into two areas until the completion of the concrete wall the general contractor had to develop a way to ensure that it would not result in a schedule slip. Along with the installation of the precast planking the decision was made to begin construction on the interior load bearing walls in lieu of the exterior masonry veneer. The interior masonry is used to support multiple sections of the building's roof and is a key component on the path to achieving a water tight building. This was done at no additional cost to the general contractor it simply involved reworking the schedule of the mason.

Accelerated Roofing Schedule

The installation of the roof in Areas A&B was handled much like the installation of the interior masonry walls. The roofers were brought into these areas four months before the initial schedule indicated they were to begin work. This was to ensure that the maximum amount of work could take place in the areas where steel has been completed while work continues on the structure in Areas C&E. The roof was simply left incomplete at the east side of Areas A&B to ensure that it can be proper adhered to the roof over Areas C&E upon their completion. This was done at no additional cost to the owner or the general contractor.

Value Engineering Topics

Through conversations with members of the project team it has be repeatedly mentioned that value engineering was not used extensively on this project. One person mentioned the alternates that the owner had built into the bidding as a possible source for value engineering but unfortunately that is a simple case of cost cutting. The alternates are selected base upon what the owner can afford to purchase while staying within their budget. A few of the more reasonable ideas presented throughout the interviews are represented in the paragraphs below. Also, please understand that cost data was not attainable for any of the mentioned scenarios.

Overhead Utilities

The initial plan with the utility companies called for all new utilities to be brought on-site through underground duct banks to a buried vault near the south entrance of the building. However, it was quickly discovered that brining overhead lines to the new building would be far less expensive and much easier to install. With the blessing form the local authorities this plan was put into action.

Reuse of Existing Furniture and Equipment

During the final stages of design it was brought to the attention of the school district that much of the furniture, tech. ed. equipment and kitchen equipment in the current high school was recently purchased and in almost new condition. After much debate the decision was made to eliminate these items from the contract for the new high school and instead bring these items to the new building during the move-in period. This resulted in a savings of tens of thousands of dollars to the school district.

Precast planks

Although the final cost impacts of the installation of the precast planks have yet to be tabulated it is believed that this will save both time and money. The planks can be installed much faster than the original structural slabs and they also require much less manpower to install. Both of these outcomes should result in a cost savings to the owner.

Problem Identification

Along with the constructability issues and other concerns mentioned above, there are several more areas of concern spread throughout other elements of the project. These additional challenges vary in degree of scope and size, but they will all require a fair amount of analysis and attention in order to ensure they do not negatively impact the final outcome of the project. After speaking with the project team and analyzing the construction documents the following topics represent current or future areas of concern.

- ***Foundation Design:*** The design of the foundation system is very complex including caissons, grade beams and structural ribbed slabs. Could this be done more easily by bringing fill onto the site and improving the bearing conditions or exploring alternate designs?
- ***Complex Structural Steel Design:*** While performing the structural estimate it came to my attention that the design called for hundreds of different steel shapes to be installed in the building. Would it be more economical to standardize some of the structure even if it means overdesigning?
- ***Structural Masonry:*** The project contains many loading bearing masonry walls. Through conversations will the contractors it was mentioned many times that some these walls were very difficult to construct due to the occurrence of many large penetrations in some areas. Would it be more economical and efficient to substitute these areas with steel frame construction?
- ***LEED Consideration:*** Many of the elements in the new high school were selected with sustainability in mind, yet the notion of constructing a LEED rated building was quickly dismissed in the early stages of design. Would it be possible to achieve a LEED rating with little or no additional costs to the owner?
- ***3D Coordination:*** Through conversation with the project team it was mentioned numerous times that the coordination efforts have been time consuming and difficult. Also, there have already been several field conflicts that were not recognized during coordination and the installation of mechanical equipment has not yet begun. Could the project have utilized the 3D models developed by the architect and engineers to prevent field clashes and save money?
- ***Site Utilization:*** With the building footprint in place the site became very small forcing many of the contractors to utilize offsite warehouses for the storage of many materials that would normally be kept onsite. Also, the site design calls for the installation of a 30' high retaining wall to add more area for parking. Would it be possible for the building to be repositioned in order to create more space and eliminate the need for the costly retaining wall?
- ***Window Installation:*** The windows selected for this project cannot be installed until after the masonry veneer has been applied to the building. This has proven to be a problem since the veneer has been delayed in parts of the building and the general contractor has been forced to create temporary barriers in these locations. Would it be possible to save time, money and possibly even energy by designing a new window system that can be installed before the brick is in place?

At this time most of the concern focuses around the installation of the building structure, building envelope and any preconstruction activities that proved to be difficult. Again, as previously mentioned this is due to the current physical state of the project. It was only recently that the first two areas of the building were topped out with steel and the area of the building surrounding the retaining wall has yet to get off the ground. Therefore, the focus of my analyses will be centered on the early stages of the project in order to ensure that I can obtain adequate information and feedback for comparison with my results.

Technical Analysis Methods

Upon review of the constructability issues and problematic features of the project, four construction management related topics have been selected for future analysis.

3D Coordination and 4D scheduling

The use of the 3D model is an analysis that I would like to pursue further. Since the model was only used for design purposes it would be interesting to learn what results can be obtained by using the model for clash detection and also using it to create a 4D sequencing model. This has the potential to yield results that would help the project team with future installations. Also, the use of the 4D sequencing could provide results that would have better prepared the team for the installation of the concrete wall that has caused to building to be constructed in two parts.

This analysis would require research into best practices for creating a set of models that can be easily utilized for coordination and scheduling purposes. A possible source of information will be the recently developed BIM Execution plan that was created by the CIC research group here at Penn State. My research could be focused on developing a project specific BIM Execution plan for use on the New Moon Area High School and District Administration Offices.

LEED Consideration

As is the case with most building types these days, LEED is quickly becoming a hot topic in school construction. With the introduction of LEED v3 came upgrades to many of the LEED categories offered by the USBGC, including LEED for Schools. This semester I have been involved in a class that has taken a deeper look into how LEED is utilized and many of the common misconceptions associated with the cost of construction a LEED building. Since the new high school was designed with a small amount of sustainability in mind it is the perfect candidate to show the public how a building can acquire a reasonable level of LEED certification without incurring additional costs.

Research for this topic would first involve meeting with the architect and engineers to discuss what LEED credits may already be designed into the building and where changes can be made to obtain other points. I will also need to develop an execution plan to show what level of LEED can be achieved and the exact steps that would need to be taken to reach that goal.

Structural System Simplification

With the complexity of the structural steel system and the concerns with the installation of the load bearing masonry walls this would be a good area to focus the breadth of my research. Taking a closer look at how the steel system can be simplified or the loading bearing masonry can be substituted with another material could have significant cost and schedule implications as well. This would make it the perfect construction management analysis to include in my breadth.

For the substitution of the load bearing masonry walls research would need to be done to find out why this material was selected and was purposes it serves within the buildings frame. Walls that are meant to handle shear will be more difficult and costly to efficiently replace with alternate materials. Simplifying the steel frame of the building may prove to be a harder challenge. With the large size of the building it may be beneficial to examine the possibility of designing structure that consists of repeating modules. This is also an area of research that can be included in the development of the 4D model to help create a more efficient steel sequence.

Substitution of Window Systems

The current Traco window and curtain wall systems that have been specified by the architect cannot be installed until after the brick veneer is in place. This has resulted in the general contractor having to spend time and money creating temporary enclosures in area that need to remain dry. The delay in the installation of the brick veneer has also pushed back the installation of the windows resulting in a delay in achieving a watertight status on the project.

Substitution of the current window system will require a better understanding of why the original system was selected. Whether this system was selected for architectural or performance characteristics will determine how a comparable system is selected as a replacement. This research should include, but not be limited to an investigation into the thermal properties of the windows and the effects they may have on the LEED analysis.