

Waynesburg Central High School



Technical Assignment #3

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Executive Summary

Construction is an industry that is totally costume in nature, no two buildings are the same, and therefore every building has different constructability challenges that need to be addressed to make any project successful. Waynesburg Central High School is no different; there are several project specific items that needed to be addressed. Precast concrete was used as the primary structural system at Waynesburg Central High School. Precast concrete is not the primary method of construction in western Pennsylvania causing several constructability issues. As a result of this potential schedule delays had to be handled; precast concrete also produced a lack of productivity due to unfamiliarity with the product and increased congestion on the site. Foundations at Waynesburg Central High School created a particular challenge with bed rock being encountered 4 feet before expected, for constructability and value engineering reasons the foundations were reengineered. Mine grouting is an activity that is not common on many projects but was necessary on the Central Greene School District site.

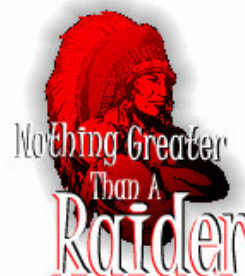


Figure 2: Waynesburg Central High School mascot

Schedule is always important on a project and with there being 12 phases on the Waynesburg Central High School project, each schedule duration is paramount. Each of the three issues listed above, precast concrete, foundations and mine grouting were looked at to see what schedule implications they had. Precast concrete had a long lead time because of a performance specification and also caused for congestion on the site impeding work flow. Changes to the foundation eliminated a few weeks worth of excavation. Mine grouting was split out of as a separate project as to not impede work of other trades.

A similar approach was taken for value engineering were each of the three items were analyzed to see what the effective negatives and positives related to value for each was to the owner. Precast concrete is a system that saves money by being erected quickly, this is a system that would have been further analyzed by the construction manager should they have been present earlier. Foundations at Waynesburg Central High School resulted in savings because or the reduction in material excavated as well as reduction in material installed.

Construction projects are not defined by being problem free but rather by how effectively problems are handled. Waynesburg Central High School had problems like every other project and has managed to address them adequately enough to complete each phase on time. Contractor performance or improper system installation have been handled and delivered to the owner as desired.

Since construction projects always have some problems, this leaves room for research to be done that may be able to help the industry perform better as a whole. Waynesburg Central High School had some issues that deserve further analysis. Site logistics, contractor performance, precast concrete verse structural steel and LEED certification are all areas that can be investigated further to attain a better understanding of the potential in the construction industry.

Constructability Challenges

Every Construction project is unique requiring different methods of construction to be utilized in order to maximize efficiency. Waynesburg Central High School is no different there were parts of this project that were not typical in the region, and others that were typical to the region and not present in most other regions. These are all things that need to be taken into account when creating a schedule or doing estimating, how these challenges are handled ultimately decides the success of a construction project. Several of the constructability challenges are addressed in this section.

Precast Concrete

Precast Concrete was the largest constructability challenge faced on Waynesburg Central High School. There are several reasons that caused precast concrete to be the greatest challenge, many of which relate to other areas that will be elaborated on further in later sections. A precast concrete structural system was chosen to be used rather than a typical steel structure. Precast concrete is not standard practice in western Pennsylvania which caused some confusion during the erection as well as the procedures that need to commence thereafter. Precast concrete requires more fabrication time than that of a typical steel structure, meaning that plans need to be ready for submission earlier than the normal time frame. Due to the structural nature of precast concrete, bracing need to be left in place for an extended period of time causing congestion on the worksite. These are some of the challenges to utilizing precast concrete on Waynesburg Central High School.

Waynesburg Central High School called for a performance specification on the precast concrete structural system, meaning shop drawings needed to be fabricated and approved before any of the members could be fabricated. This process caused further delay in the procedures at Waynesburg Central High School because you now need to wait after contracts are awarded to start the structural design. The project is not very large and proportional to the building there was very little excavation that needed to be complete before the structure was erected. Once the precast concrete is designed it then takes time to fabricate the pieces and at many fabrication which can take varying amounts of time depending on the number of projects being fabricated at the same time.



Figure 2: Precast concrete at building G



Figure 3: Precast concrete at building F

Congestion on a construction site is something that is to be avoided at all cost; it lowers productivity and also creates an environment that is less safe. Precast concrete did not alleviate any congestion on the site but actually caused increased congestion because of the dead men that needed to stay in place till the structure was stabilized. The dead men pictured in figure 2 and figure 3, show the amount of congestion caused. Scaffolding had to be built around the dead men in

order for the masons to lay the block, which was completed before any of the dead men were removed. The dead men did not allow for easy movement through the building and only left the middle corridor for transportation.

At Waynesburg Central High School the precast concrete structural system was not structurally sound on its own until the roof joists and decking was placed. Once the joists and roof decking was placed the dead men that caused congestion on the project were then able to be removed, by this time the masonry work was almost complete and walls now impeded work flow. Open web steel joists and metal decking act as bracing for the wall which eliminates lateral movement. Once the deck is in and all joints are grouted the precast structural system is stable and finished. Precast concrete is a system that was chosen to achieve a particular aesthetically pleasing effect that resulted in a drastically different approach to construction on Waynesburg Central High School.

Foundations

On any construction project the most critical phase to ensure completion on time is the excavation and getting the building out of the ground, this is where the most unknowns lie. At Waynesburg Central High School the project was no different except for the actual implementation of the drawings. Plans and specifications for Waynesburg Central High School called for spread footings 7' to 8' deep. During the excavation rock was



Figure 4: Excavation on building G

encountered at a depth of 3 feet. All geotechnical reports showed that rock did not exist till much deeper and that is why the foundations were originally designed at 7' to 8'. Another geotechnical report was done to find the bearing capacity of the soils at a depth of 3' to 4'. When the bearing capacities came back the foundations were then redesigned and elevated to the shallower depth. By having the engineers take another look at soil conditions and ultimately redesign the foundations it saved the excavator from having to hammer 4' or more of rock and saved an estimated two weeks.

Mine Grouting



Figure 5: Mine grouting

Western Pennsylvania has several regions that were mined in the past and the site of Central Greene School District has some underground mines that needed to be stabilized. This part of the package was actually opted to be taken out and completed under a separate contract. For constructability reasons mine grouting needed to be taken as a factor. Mine subsidence is something that could cause serious damage to a building. Mines need to be stabilized to ensure that differential settlement does not occur in the foundation. Differential settlement can cause serious problem in a building and to the structural stability. Mines on the site at Waynesburg Central High School were stabilized before other construction began to ensure the structural integrity of the building. In the section titled Schedule Acceleration Scenarios explains the reason that the mine grouting was removed from the contract before bid.

Schedule Acceleration Scenarios

Construction is an industry driven by deadlines, in order to meet these deadlines in a reasonable fashion schedules are created. All schedules have areas that are more critical than others. On the Waynesburg Central High School project there are a few areas of construction where it is more critical that the construction of these areas complete on time, as to not hold up the turnover date. As with most projects the first area of concern is getting the project out of the ground on time. After the project is out of the ground the next part that is crucial for on-time completion is the erection of the structural system (in this case precast concrete). The enclosure of the building is important to ensure that all finishing work has enough time to complete their work.

Waynesburg Central High School is not a typical construction project because of its number of phases and its multiple turnover dates. This results in different critical paths for each of the phases, since a schedule is created individually for each. The scenario described in the paragraph above explains the typical sequence encountered in a phase at Waynesburg Central High School. Some phases however have no excavation, structural work or building enclosure, since it is a renovation project the existing building is already enclosed meaning the enclosure simply needs to be maintained throughout the course of construction. Many of the critical areas that resulted in time savings or could have potentially with a different method resulted in time savings are covered.

Precast Concrete

Precast concrete on most construction projects is very quick to install resulting in shortened durations due to less work on site. In the case of Waynesburg Central High School the use of precast



Figure 6: Precast concrete erection

concrete for a structural system caused for a longer schedule and less productive worksite. Since the precast concrete was simply a performance spec this caused for an allowance of time to be left in the schedule for the manufacturer to produce shop drawings that were then submitted for approval. Pieces of the precast concrete system then began to be manufactured. Pieces were stored at the manufacturer's site until the delivery date at

which time they were delivered by tractor trailer. Precast concrete members were erected directly from the truck by a 40-ton mobile crane. The process for erecting precast structural concrete in and of itself is

quick and efficient, but the fact that it was a performance specification that then needed to be designed caused for extra time in the schedule.

Productivity allows for work to commence at a rate set fourth by the schedule, the schedule assumes a pace that is reasonable and a jobsite that has minimal obstructions. The procedure in which the precast concrete members were erected required that dead men be placed every 10 feet for structural stability. The dead men created a workspace that impeded the workspace and subsequently did not allow for some of the trades to work in the space. Fortunately on the Waynesburg Central High School project this did not in the end inhibit the turnover date. Through foreman meetings and some adjustment in the sequence of trades in building G and building F the spaces were completed as desired.

Foundations

Reducing the depth of the foundations created less material to be excavated which always leads to a time savings. In excavation the amount of time it takes to remove a given quantity of material is directly correlated to the properties of that material. In the case at Waynesburg Central High School the material that was encountered was rock, which is one of the most challenging materials to remove. Removing rock requires hammering which is very costly and time consuming. By reducing the depth of the foundation by approximately 4' as much as two weeks of hammering were cut off the excavation process.



Figure 7: Shallow foundations of building F

Mine Grouting

Mine grouting was done on site to help stabilize soil and ensure there would be no subsidence resulting in problems to Waynesburg Central High School. Mine grouting subsequently took place before any other construction began on site. This was accomplished by not including the mine grouting in the package with Waynesburg Central High School. Separating mine grouting allowed this process to begin early resulting in stable site conditions before equipment began excavation.

Value Engineering

Value engineering is a process that projects undergo, not simply to save the owner money, as it is often thought, but to ultimately provide the owner with the most cost effective product that meets or exceeds all expectations in performance and aesthetics. Value engineering is a process best done early on in a project to maximize the potential in savings and quality. Systems are analyzed along with individual products, with cost and quality both being looked at to ultimately obtain the desired result.

Waynesburg Central High School did not have the construction manager involved early enough in the project to have all areas analyzed. Since the construction manager was not involved until just before documents went out for competitive bid they were unable to offer suggestions on some areas that would have resulted in money savings or a better quality. Exploring different options for systems, such as the structural system is often a first step in value engineering.

Precast Concrete

Precast Concrete was chosen as a structural system for Waynesburg Central High School. When speaking with the project manager on Waynesburg Central High School this is an area that could have been further analyzed to ensure the owner knew what the costs of using precast concrete were as well as the schedule implications. This is not an area where value engineering was performed but it was suggested that switching the structural system to a steel frame would be more efficient and also be a lower cost to the owner. Precast concrete was chosen as a structural system for Waynesburg Central

High School by the architect primarily to achieve a specific aesthetic, which is shown in figure 8. Vertical concrete columns and the horizontal concrete lintels were the desired goal of the architect. If this system had been further analyzed it could have been found that the same look could be achieved by utilizing structural steel members and then wrapping the columns with a nonstructural concrete component. With the construction manager coming

on to the project late this could have been an area where the owner could have saved some money and the contractors could have saved some headaches. This is the value of having a construction manager on the project because they understand the process in which systems are installed as well as various ways to achieve the same results all the while saving money.



Figure 8: Finished exterior of new music suites

Foundations

Foundations at Waynesburg Central High School are a great example of value engineering because there was foresight of cost savings. During excavation rock was encountered at a much shallower depth than originally assumed. Since foundations were already designed and planned for a depth 4' deeper, a decision was made to reengineer the foundations and explore the potential savings. When it was determined that the soil encountered was suitable for a foundation to be placed it was decided to decrease the foundation depth by approximately 4'. Reducing the foundation depth eliminated an average of six courses of block saving a large amount in material and labor.

Changes in the foundation did not affect the overall performance of the structure because the soil bearing capacity was checked to

be sure that it was the same as that which it was originally designed. The foundation calculations were all redone to ensure that nothing was being compromised when the height was decreased. The value engineering side of this example is the amount of money that was saved by reducing the depth and maintaining the structural integrity.



Figure 9: Shallow foundations of building G

Mine Grouting

Mine grouting was not something that had much value engineering in the decision to do the work. This task was something that needed to be done and therefore was. The only place where some value may have come in was the breaking out of this activity into an individual contract. By breaking the mine grouting into a separate contract it allowed the grouters to proceed with work before the rest of the project began, this to not interfere with the excavation. Breaking out the mine grouting may have allowed for a lower price also because it was then not under another contractor which would have meant overhead and profit being taken twice resulting in a higher cost to the owner.

Problem Identification

Coordination is paramount on Waynesburg Central High School, with 12 phases and nearly as many different completion dates, coordination must be handled well. With the same prime contractors working on all the phases the scheduling must be done to ensure that any single prime contractor is not in a position where they have too many tasks to complete in multiple phases simultaneously.

Waynesburg Central High School has done this well. There have however been points due to contractor errors when areas could not be worked in because a product was late or the wrong product was delivered or ordered. Waynesburg Central High School is a masonry building with exterior face brick which was tried to be matched for the additions so they would not stand out. There are two additions on Waynesburg Central High School in opposite sides of the building. Each addition had a different completion date and therefore similar activities on each would commence a little over a month apart. Since there was a difference in schedule brick for building F was ordered and delivered separate to the brick for building G. When the brick for building G arrived later it did not match that which was already installed on building F, this is shown in figure 10.

Through a series of meetings the issue was resolved and new brick was fired and delivered to site for installation. This process



Figure 10: Top 3 courses new brick, bottom courses on building F

however took just over a month and as a result did not allow some of the trades to work in building G at the time they were originally scheduled. Contractors worked around this and managed to complete the phase on time. Through a reorganizing of the schedule some contractors were then responsible for extensive work in multiple areas of the building simultaneously. Problem resolution is something that in this situation as well as several others at Waynesburg Central High School has been handled well.

The construction industry today is not the same as what it was in years past; litigation is more common now than ever. Waynesburg Central High School is a publicly funded project and as a result follows state guidelines which require the use of the lowest bidder. Accepting the low bid poses a challenge because they do not always have the interest of the owner in mind, this often results in issues being settled by the legal system. This is not to say that all contractors that do work on public projects are bad contractors, for the most part it is the opposite, there are many quality contractors working at Waynesburg Central High School. However there are a few contractors that do cause problems and do what they can to try to ensure at the end of the project they will have a claim. Handling contractors that do not perform to the expectations of the contract and frequently submit requests for information (RFI)

on areas that are clearly covered in the specifications or the plans to build a case for excessive RFI needed, is handled on a daily basis at Waynesburg Central High School.

Contractor performance needs to be monitored at all times on a construction project. Waynesburg Central High School is no different. Some contractors need to be monitored more closely than others to ensure work is being performed in concordance with plans and specification. A situation arose on the project where shut off valves were not installed in the system where marked on the



Figure 11: Foreign pipe marked in orange

drawings. The construction manager addressed the situation with the contractor who did not feel they were necessary because the equipment the lines were feeding already had shut off valves. Over 20 valves that are clearly marked and called for on the drawings were not placed in the system. The same contractor also had problems with not providing the same product that was approved in a submittal. Public project do not allow foreign piping to be installed, this contractor however installed foreign pipe on the project and when approached about it chose not to remove and replace the pipes with American made material. Figure 11 shows the foreign pipe that was not removed marked with orange spray paint. These are only a few of the problems that have come up due to a lack of performance by contractors and the increasing use of the legal system to settle disputes.

Precast concrete at Waynesburg Central High School caused several problems. One problem that came as a result of the precast concrete was the columns being set in the wrong location. The precast concrete columns were set 4 inches in from where drawings showed. This resulted in several changes being made. With the column set into the building it no longer allowed for the white vertical strip shown in figure 12 to be used to tie brick into as initially designed. Figure 12 shows the base of the precast column and the edge of the concrete slab with a ruler showing the distance to the white groove. Since the groove is only 9 inches from the edge of the concrete slab there is not adequate space to install

concrete masonry units and still be able to tie brick into the groove. Concrete masonry units with face brick were still used as infill between the columns. As a result of the offset a different method of tieback was used at the edges butting a column. The offset in the precast concrete columns not only resulted in the changing connection between brick and column but also effected the connection to the open web joists resting on the beams. Since the bottom cord on open web joists always has extra that does not



Figure 12: Offset precast concrete column

serve a structural purpose these were able to simply be field trimmed. However the resting plates on the top cord were subsequently shop modified and then delivered to site and installed. Precast concrete caused several issues on the Waynesburg Central High School project and could have been further analyzed before selected to ensure this system was the most appropriate system to achieve what the owner desired.

Technical Analysis Methods

Site Logistics

Waynesburg Central High School has 12 phases in the construction sequence. With this many phases the site will be in multiple construction phases at any given time. I will take a look at several of the major phases and create multiple phasing plans during the construction process. These phasing plans will specifically detail the site during one particular phase such as excavation, structural, finishes... These phasing plans will also incorporate the use of areas specific to what is under construction at the time of the phasing plan. I plan to develop site plans for three of the twelve different phases of construction. Creating a series of site logistic plans should help communicate to contractors the space allotted for certain activities and also set concretely the times in which each area will be in which phase of construction since there are so many phases under construction at one time.

Contractor Performance

Contractor performance and communication between contractors is a critical part of any construction project. A potential point to study is to do research on several very successful projects by using survey to gain information on the types of programs implemented to encourage contractors to meet or exceed the performance requirements. An area that would be of particular interest to research would be the effectiveness of different forms of contracts and the bid award system. Since Waynesburg Central High School is a publicly funded project requiring the low bidder is awarded the contract. This in some cases allows for contractors that do not perform to the standards prescribed repetitively be awarded various contracts because it is awarded strictly on the low bid. The goal in analyzing and conducting surveys would be to determine if awarding contracts based on low bid is actually a cost effective approach, or if the low bidder results in a lack of productivity and more communication.

Structural System

Precast concrete allows for numerous options to be investigated for the thesis project. On Waynesburg Central High School precast concrete was the source of many problems. One option for a topic would be to explore a different structural system as a whole to see if it would be more cost effective. Since precast concrete was chosen primarily to attain an aesthetic appeal I could do some research to see if it would be possible to attain the same look by utilizing a structural steel system with some sort of concrete façade. I would also like to analyze what constructability issues could have been avoided by switching to structural steel. I will create a price comparison for the precast concrete structural system and the structural steel system by getting the actual price of the precast concrete system, then deriving a detailed estimate for the proposed structural steel system. Constructability issues of precast concrete will be looked at by correspondence with industry professionals. Since structural steel is the primary system in western Pennsylvania. Industry members will be a good source for any potential issues with implementing a structural steel system. Waynesburg Central High School is a single story building and there are only two small additions that have structural work on them totaling less than 25,000 square feet. A potential problem with doing an analysis such as this would be that the

structural system for the additions would have to be redesigned. Since the area is not very large and the building is only one story I feel that this would be possible. The goal to comparing precast concrete and structural steel would primarily result in a value engineering analysis, I would also create a report on the related constructability issues.

LEED Analysis

Central Greene School District did not set out to gain any LEED certification on the Waynesburg Central High School project. This is a point were I could do some research and see the necessary changes that would be made to attain a LEED certification. I will do this by first analyzing the feasibility of attaining different points, I will do this through a variety of methods one of which would be correspondence with professionals in the region that have completed LEED certified projects in the past. Another way I will determine feasibility of various LEED points is by doing research for the region as a whole to discover the options of things such as the availability to recycle materials. Recycling is a point of particular interest because Waynesburg Central High School is not an urban location so points like recycling and the public transportation may not be possible to attain. Part of the LEED analysis could easily incorporate one of my breadth topics by redesigning a portion of the mechanical system if necessary to attain a LEED point. After a thorough analysis of each possible LEED accreditation point the goal is to create a simple spread sheet to explain those points that are feasible and those that are unattainable.



Figure 13: LEED certified logo