KRISTOPHER J. BRICE

Construction Management
Faculty Consultant: Dr. Magent

New Moon Area High School/ District Administration Offices

8353 University Boulevard, Moon Township, PA 15108

Final Report | April 7, 2010

8353 University Boulevard, Moon Township, PA

New Moon Area High School

& District Administration Offices

Kristopher J. Brice | *Construction Management*

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.

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

Table of Contents

Acknowledgements

I would like to thank the following people for their support and guidance throughout the completion of my senior thesis project.

Eckles Construction Services, Inc.
Kenneth Holsopple
John Pappas
Brian Fulkerson

Eckles Architecture & Engineering, Inc.
Cassandra Renninger
Susan Cooper

Moon Area School District
Dr. Donna K. Milanovich

Nello Construction
Jerry Falso

The Pennsylvania State University
Bob Holland
Dr. Christopher Magent
Dr. Richard Behr
M. Kevin Parfitt
Craig Dubler

Barber & Hoffman Consulting Engineers
James Pospisil

Mabey Bridge & Shore, Inc.
James Porreca

Hranec Corporation
Mike Reese

W.G. Tomko, Inc.
Rich Miller

SlenderWall
Frederic Beck

. . . And most of all, I would like to THANK my family (especially my wife) and friends!

Executive Summary

The following document contains information pertaining to the design and construction of the New Moon Area High School and District Administration Offices, Located in Moon Township, PA. In the first section, one will find information concerning the client, project delivery method, project team, overall construction schedule, and site layout. The next section provides a brief description of each of the building's systems, creating an overview of how the building is constructed.

Analysis One: BIM Planning with Multiple Primes

The first analysis is intended to help define how Building Information Modeling (BIM) can be incorporated in a traditional project delivery method that includes the use of multiple prime contracts. Throughout the past decade, the use of BIM has slowly started to become an industry standard. As Pennsylvania's required contracting approach, the multiple prime delivery is often one of the last to adopt current construction technology. Although the integration of the two will require overcoming many challenges in the way project specifications and contracts are written, these will be greatly outweighed by the benefits. Ultimately, the change will not occur overnight and it will take several years for designers and contractors to refine the process. For success to occur, it will be important to start slowly with only a few BIM uses to introduce new contractors to modeling.

Analysis Two: Concrete Foundation Wall Bracing Design (Structural Breadth)

The second analysis incorporates a structural breadth to determine a proper bracing design for the building's concrete foundation wall. Designed as a split-level structure, the ground floor requires the use of a substantial concrete foundation wall that cannot be backfilled until much of the steel structure is in place. This requires that the building be constructed in a disjointed sequence, further prolonging the completion of the superstructure. Through careful calculation it was determined that a bracing system provided by Mabey Bridge & Shore will allow the wall to be backfilled much earlier, saving 37 days in the overall time require to finish the building structure. Overall, the bracing rental and installation will cost the general contractor an additional $27,356, but this can be easily justified by the schedule savings it will provide.

Analysis Three: SlenderWall Precast vs. Traditional Brick Veneer (Building Envelope Breadth/ M.A.E Study)

The third and final analysis involves both a building envelope breadth and an M.A.E. graduate level study, involving course material from AE 542: *Building Enclosure Science and Design*. The analysis is focused around the substitution of a brick veneer cavity wall system for a precast architectural concrete façade. This analysis was considered in order to reduce the project's dependency on the masonry contractor remaining on schedule. The system selected for the analysis was SlenderWall, a non-typical lightweight precast panel that integrates the use of structural metal studs. Careful considerations were made to ensure that the thermal and moisture performance of the SlenderWall panels met that of the original cavity wall design. This included performing analysis of both the heat and moisture flow through the wall system. Final calculations determined that SlenderWall can be applied to the project resulting in a total savings of $277,034 while also reducing the project schedule by 32 days.

Project Background

Client Information

The owner of the New Moon Area High School is the Moon Area School District. The district is located in Moon Township, Pennsylvania, and encompasses approximately 23 square miles. The population in the district is around 25,000, and during the 2005-2006 school year, the school provided services for 3,705 students (2009 Allegheny County Performance Audit). Below is the school's mission statement taken directly from the district's website (www.masd.k12.pa.us). Along with this mission statement, the district takes great pride in its mascot, the Tiger. The phrase "Tiger Pride" is used to describe the attitude of the district and the surrounding community.

"Moon Area School District, in partnership with the community, is dedicated to educating every individual in a respectful, safe, enriching environment through comprehensive programs that inspire excellence, lifelong learning and responsibility."

The core values of this mission statement demonstrate the reasons the district is currently in the middle of a four year plan to revitalize its facilities. The high school is being built to better serve the needs of the community and students. The current high school is very much outdated and suffering from a stint of reoccurring issues that are currently being dealt with. The School Board hopes that the new facilities will draw more attention to the district and provide students with more opportunities.

At the inception of the idea five years ago, the School Board did not know what they were getting in to. In late 2004, contracts were awarded for the design of a new high school. Sometime in early 2006 the design was completed, and $76 million in contracts were awarded for the construction of the new facilities. However, shortly before the project was to begin, a few new school board members were elected and the board changed majority power. The new school board decided they could make better use of the money by focusing on some other renovations and the construction of a new middle school. The project was terminated. The district spent the next few years discussing how the money could be better spent. After much debate, it was decided that the best course of action involved the construction of a new high school and the renovation of the old high school into a new middle school. In January of 2008, a contract was awarded to Eckles Architecture & Engineering for the design of the new facilities.

As is the case with most school construction, it will be crucial that all deadlines are met and the school is ready to be opened for the second half of the 2010-2011 school year. The district also hopes the high school will become their "show piece", adding the need for a high quality of construction. According to the architect, the school board has very high hopes for the success of this project, and is relying heavily upon the experience of the design and construction teams to ease the minds of the community with a high quality and timely product.

All information for this section of the report was obtained via the school district's website and through conversation with the project team.

Project Delivery System

The high school is being delivered to the district using the traditional design-bid-build method with the addition of a CM Agency. This method was chosen simply because it is a Pennsylvania state law to employ the design-bid-build method on state funded projects. Due to the owner's inexperience, the decision was made by the school board to employ a CM Agent. Figure 1 represents the overall structure of the project with solid lines indicating a contractual agreement, and dashed lines signifying non-binding lines of communication. The diagram does not include all prime contractors and their subcontractors, nor does it include all design consultants.

Project Organizational Chart:

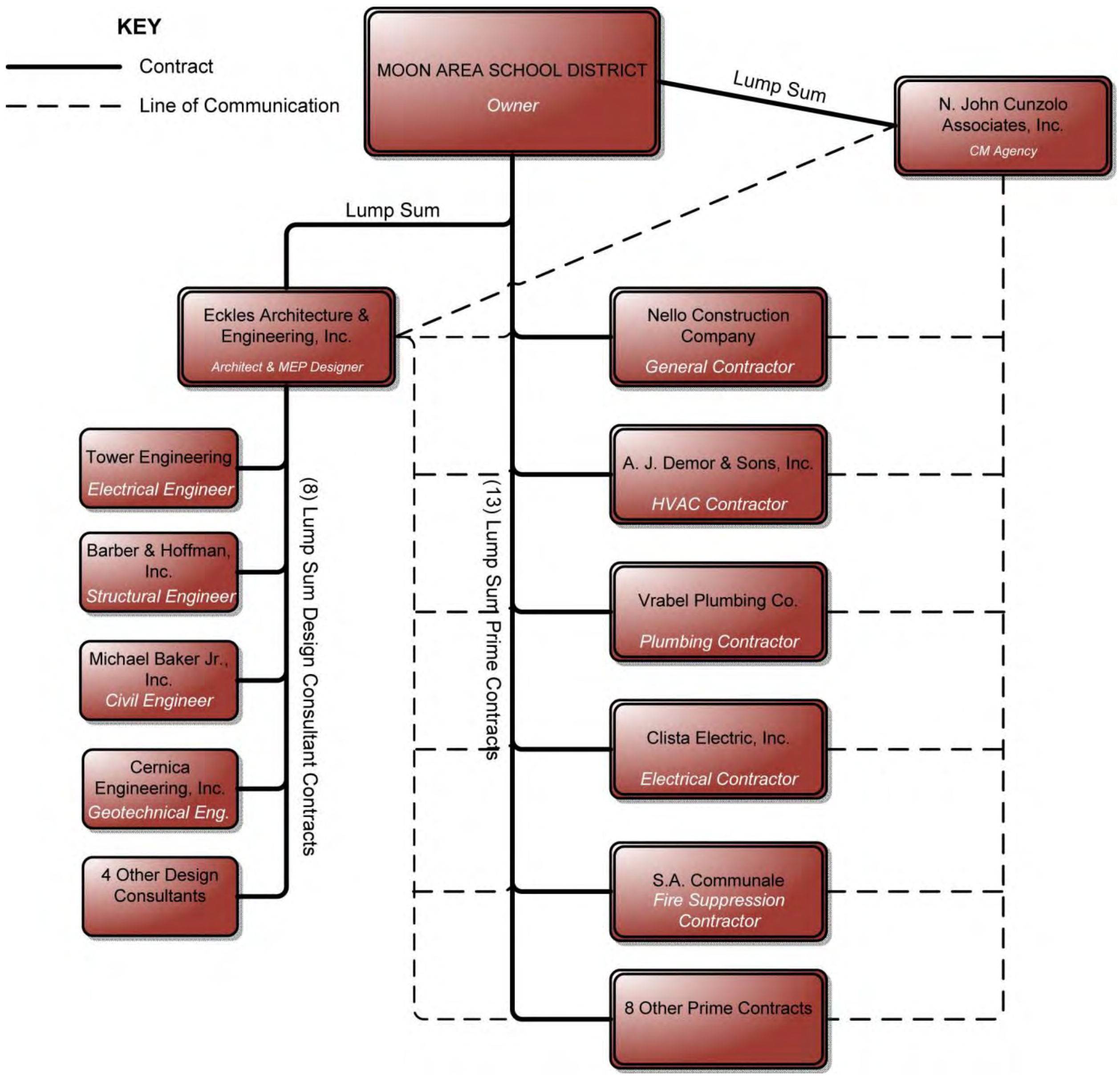


Figure 1: Project Organizational Diagram

As depicted in Figure 1, the construction was divided into (13) lump sum, prime contracts. The contracts were awarded to the lowest bidder in each category. Upon submitting bids, contractors were required to provide a bid bond and proof of liability insurance. Within seven days of being awarded a bid, the contractors were required to furnish payment and performance bonds. This project did not require any additional insurance since it is being performed under an OCIP (Owner Controlled Insurance Program). The program has been purchased by the owner and will cover the insurance of all prime contractors and registered subcontractors. The program provides a way for the owner to ensure that all contractors are properly insured and often results in a cost savings to the owner.

The selection of the architect and CM Agent were done separately from the selection of the construction team. Both the architect and CM Agent were required to submit proposals and present their plans for the high school in front of a selection committee. N. John Cunzolo Associates, Inc. was chosen to perform the CM Agent responsibilities based upon their qualifications and lump sum bid of $2.6 million. The architect, Eckles Architecture & Engineering, Inc. was chosen based upon their design proposal and 7% lump sum fee. The 7% fee is awarded based upon the final building cost. The fee includes the amounts of the lump sum contracts that the architect holds with its (8) consultants. It is important to note that Eckles Architecture & Engineering was selected to be the architect for all phases of the campus renovation.

In the end, the owner made a wise decision to employ the services of a CM Agent on the project. Even though the CM Agent has no contractual control over the prime contractors, they can still serve as a valuable asset to an inexperienced owner. The traditional design-bid-build delivery system is required by law, and was also a wise selection for this project.

Project Summary Schedule

The construction of the New Moon Area High School is the third phase in a four year endeavor to improve the functionality and aesthetics of the district's main campus. The first two phases included the addition of a campus entrance with traffic signaling and the demolition of a previously condemned structure. Construction of the new high school began in the early part of February 2009 and will continue through November 2010. The building must be completed for class use after Christmas break in 2010.

For construction purposes the building has been divided into seven major areas, labeled A-G. As depicted in Figure 2 below, the construction will start in Area C and continue through Area G then jump to Areas A & B. This sequence will begin on the ground floor and continue up through the roof. Areas A & B are on floors one and two, and are not part of the ground floor. The sequencing allows for the ground floor foundations and framing to be put in place before framing begins in Areas A & B, keeping vertical progress consistent throughout the floor plan.

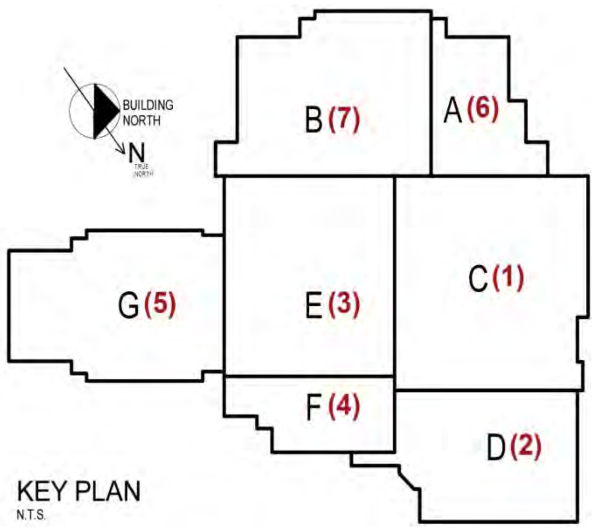
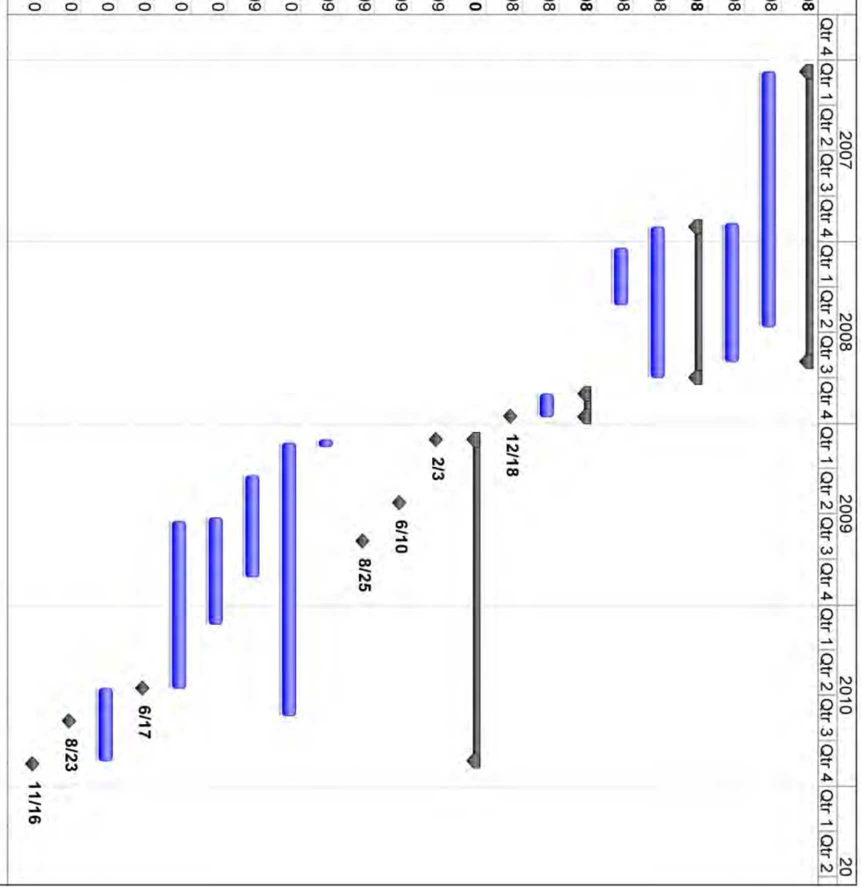


Figure 2: Building Key Plan with Sequencing

Construction in each area uses very logical and simple sequencing. The areas are divided by floors, where each floor is constructed from the bottom-up and the outside-in. On the ground floor, caissons are installed, grade beams are poured and SOG's are placed. Upon completion of the superstructure, MEP work begins, along with the installation of the façades. Once the building reaches a "dry" state, work begins on the interior finishes.

Please see Figure 3: Summary Schedule, on the next page, for a more detailed look at the overall timeline of the project. As is shown by the long duration, the design phase was impeded by many changes from the owner and a few hurdles during the permitting process. The district had a difficult time deciding whether they wanted to build a new high school or middle school, and ultimately decided that a new high school would better serve the needs of the district and the community. For a more detailed look at the overall construction schedule please refer to Appendix A.

ID	Task Name	Duration	Start	Finish
1	**Design**	**417 days**	**Thu 1/25/07**	**Fri 8/29/08**
2	SD and DD	367 days	Thu 1/25/07	Fri 6/20/08
3	Construction Documents	200 days	Mon 11/26/07	Fri 8/29/08
4	**Approvals and Permits**	**217 days**	**Mon 12/3/07**	**Tue 9/30/08**
5	PlanCon	217 days	Mon 12/3/07	Tue 9/30/08
6	Municipal	82 days	Tue 1/15/08	Wed 5/7/08
7	**Bidding**	**34 days**	**Mon 11/3/08**	**Thu 12/18/08**
8	Out to Bid	34 days	Mon 11/3/08	Thu 12/18/08
9	Contracts Awarded	0 days	Thu 12/18/08	Thu 12/18/08
10	**Construction**	**462 days**	**Tue 2/3/09**	**Wed 11/10/10**
11	Notice to Proceed	0 days	Tue 2/3/09	Tue 2/3/09
12	Last Day of Classes Spring	0 days	Wed 6/10/09	Wed 6/10/09
13	First Day of Classes Fall	0 days	Tue 8/25/09	Tue 8/25/09
14	Mobilization	10 days	Tue 2/3/09	Mon 2/16/09
15	Sitework	392 days	Tue 2/10/09	Wed 8/11/10
16	Substructure	146 days	Thu 4/16/09	Thu 11/5/09
17	Superstructure	152 days	Fri 7/10/09	Mon 2/8/10
18	Building Envelope	240 days	Fri 7/17/09	Thu 6/17/10
19	Building Dry	0 days	Thu 6/17/10	Thu 6/17/10
20	Finishes	104 days	Fri 6/18/10	Wed 11/10/10
21	Permanent HVAC/Controls	0 days	Mon 8/23/10	Mon 8/23/10
22	Substantial Completion	0 days	Tue 11/16/10	Tue 11/16/10



Project: Summary Schedule.mpp
Date: Tue 9/29/09

Task, Split, Progress, Milestone, Summary, Project Summary, External Tasks, External Milestone, Deadline

Page 1

Figure 3: Summary Schedule

Site Plan of Existing Conditions

The site of the New Moon Area High School is located at 8353 University Boulevard in Moon Township, Pennsylvania. University Boulevard provides immediate access to many of the major highways surrounding the Pittsburgh area. The high school will be centrally located on the existing 59 acre campus as depicted in Figure 4.

Before construction, the majority of the site was covered by athletic fields. This resulted in the need for very little demolition. Also, the site contained very few major utilities. Most of the campus' main utilities enter by way of either University Boulevard, to the west, or Beaver Grade Road, to the east. Most of the utilities under the site were able to be demolished during the sitework phase.

The project's construction entrance is off of University Boulevard to the south of the existing middle school. This is the area that is most crucial for the general contractor to create a barrier between the active school campus and the construction zone. Due to the immense size of the site there is not a construction fence used around the entire perimeter. However, careful planning has been done to create a barrier between the project and the middle school. During the summer of 2009, the construction forced the closing of the road between the current high school and middle school. Also, during this time a new road was built to the north of the new high school that connects the old middle school and high school. This now splits the site into two parts, with the athletic fields to the north and the high school to the south.

Please refer to Appendix B for a plan of existing site conditions, along with a rendered site plan displaying the final state of the site concluding all phases of the renovation.

Figure 4: Arial View of Moon School District's Campus (www.maps.google.com)

Building Systems Summary

BUILDING SYSTEMS SUMMARY		
Yes	**No**	**Work Scope**
X		Demolition Required
X		Structural Steel Frame
X		Cast in Place Concrete
	X	Precast Concrete
X		Mechanical System
X		Electrical System
X		Masonry
X		Curtain Wall
X		Support of Excavation

Figure 5: Building Systems Summary

Demolition

In order for the new high school to be built, part of the Moon Area campus is to be cleared. The majority of the existing site contains athletic facilities including a baseball field and two sets of tennis courts. Demolition of the baseball field consists of the removal of two CMU dugouts and chain link fencing. The 10' high chain link fence will be removed from around both sets of tennis courts, and the asphalt playing surfaces will be removed and used for fill elsewhere on site. The scoreboards for both the baseball field and tennis courts are to be carefully dismantled and stored for future installation in new locations. Along with the demolition of the sports facilities is the removal of an existing maintenance building. The building's steel frame will be carefully taken apart and sold.

Besides the demolition of site structures, there are several existing utilities that will be removed. There are many utilities buried under the new site due to its central location on campus, falling between three of the school's other facilities. This demolition includes the removal and relocation of gas, storm and electric lines.

Structural Steel Frame

The majority of the structure will be comprised of structural steel members. The beams and girders are made from varying W-shapes, and the columns are a combination of W-shapes and HSS tube steel. The gym, auditorium and pool roof support is provided by LH and DLH long-span steel trusses that bear on reinforced masonry walls. The structures lateral load will be supported by a combination of moment frames and reinforced masonry walls positioned throughout. Finally, each above ground floor will feature a 6½" composite slab (3½", 4,000 psi lightweight concrete on, 3"-18 gauge, galvanized decking).

All structural steel will be installed using two cranes. The main crane will be a 110 ton crawler with a 150 ft. main boom and 45 ft. jib. The secondary crane will be a 60 ton hydraulic crane with a 110 ft. main boom and 35 ft. jib. A site road will be installed around the perimeter of the building allowing the cranes to be relocated as sequences are completed.

Cast-In-Place Concrete

Cast-in-place concrete is being used in a variety of locations both on site and in the structure of the building. The site concrete includes sidewalks, stairs, planters and small slabs. All site concrete was formed using traditional hand-made wooden forms and placed by the direct chute method. The building structure uses concrete caissons, pile caps, grade beams, reinforced concrete walls, slabs on grade and elevated slabs on deck. The caissons, pile caps, and grade beams were all formed using the surrounding earth or wooden forms and were placed using the direct chute method. The reinforced concrete walls were formed using Mod-U-Form, a reusable modular concrete formwork system as shown in Figure 6. All elevated slabs are supported by decking and edged with standard formwork. The structural SOG's were edge-formed by hand and supported underneath by a combination of soil and void forms. The void forms were used to create the ribs in the structural slabs. All concrete walls and slabs were placed using a pump truck.

Figure 6: Mod-U-Form installation

Mechanical System

The high school will feature an air-water heating and cooling system. The building's main heating and cooling is supplied by (130) single zone heat pumps. The heat pumps are supplied with hot and cold water by (3) natural gas boilers and (2) fluid cooling units (cooling towers). Both the boilers and the sumps for the cooling towers are located in the boiler room on the ground floor in Area D. The heat pumps are used to supply heating and cooling to the classroom areas of the building. Fresh air for the classrooms is supplied by (11) rooftop 100% outside air units with heat recovery. All other heating and cooling needs are supplied by combination of RTU's, AHU's and cabinet heaters. The AHU's service the district administration office, pool area and team locker rooms and are located in the mechanical and boiler rooms on the ground floor in Areas D and G. The (3) AHU's that service these areas are a combination of variable and constant volume units. The (9) RTU's within the system service most of the public spaces within the building including the gym, auditorium, cafeteria and library. Like the AHU's, the roof-top-units are a combination of variable and constant volume.

The fire suppression system will use both wet and pre-action systems. The gymnasium will be the only area of the building to utilize the pre-action system. This is often the case in school design because sprinkler heads in a gymnasium can easily be struck by flying objects. Using a pre-action system ensures that there is no accidental discharge in the event a head is broken.

Electrical System

The Moon Area School District's power is supplied by Duquesne Light. The building will be provided with (2) 5,000A, 480Y/277V 3Φ, 4-wire service feeders. These feeders will enter the building from the southeast corner of the ground floor near Area G. Once the service enters the building, the 480Y/277V is distributed through (2) main switchboards. The 208Y/120V power is provided by (6) step-down transformers located throughout the building. The high school is equipped with two back-up systems; a UPS and a diesel powered generator. The UPS is designed to provide 17 minutes of emergency power. The generator and fuel tank are sized to supply 250 kW of 480Y/277V for a period of up to 24 hours.

Masonry

The construction of the high school will feature the use of masonry as a structural element, and for aesthetics. The majority of the building's exterior showcases tan and white utility brick. The utility brick is attached to one of two different wall structures along the perimeter of the building. In some areas the brick is backed by a 12" reinforced CMU wall, and attached with adjustable brick ties. In all other areas the brick is attached to ½" sheeting on 6" structural metal studs. The building uses structurally reinforced CMU walls to help support vertical and lateral loads. Some of the structural masonry walls will utilize Ivany Blocks, as displayed in Figure 7. The Ivany Block system is designed to ensure that the reinforcing bars within the structural masonry walls is properly placed. The blocks are formed to align the placement of both the vertical and lateral steel bars. All masonry will be placed using the assistance of traditional tube and plank scaffolding.

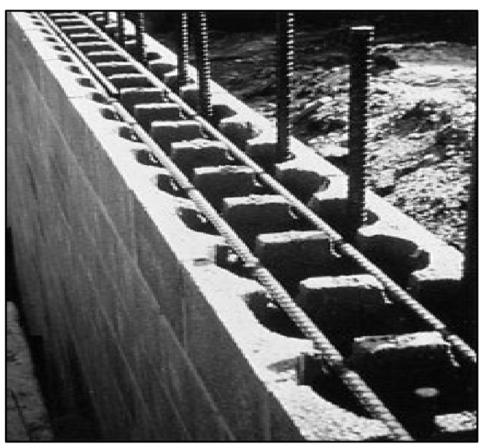


Figure 7: Ivany Block (www.ivanyblock.com)

Curtain Wall

The exterior of the high school will feature 10,600 ft^2 of traditional aluminum framed curtain wall divided amongst several locations. The design of the system is the responsibility of the curtain wall subcontractor, Specified Systems from Canonsburg, PA. The curtain walls will have an array of glazing types, ranging from ¼" clear tempered glass to 1" insulated low "E" panels. The exterior of the curtain walls will also feature a 2' aluminum finned sunscreen, providing shade to all three floors. The curtain wall system selected for the project will be provided by TRACO.

Support of Excavation

Soldier beams and lagging are being used to support the area around where the pool will be installed (Figure 8). The soldier beams were set in previously drilled holes and grouted around the base. The soil was then excavated starting at the deep end of the pool and working outward. Lagging was placed at varying depths to meet the contour of the pool bottom. This system will be kept in place permanently and backfilled as part of the final support system for the pool's structure. Since the water table in this area of the site was recorded to be below the excavation depth of the pool, there are no permanent dewatering techniques being used. In the event of a rain storm, the pool area will be evacuated using a portable, gasoline water pump.

Figure 8: Supported Excavation Surrounding Pool

Introduction to Analyses

The following proposal serves as an outline for the research and analyses that I plan to conduct during the spring of 2010. The three analyses described below are a result of potential complications identified during the design and construction of the New Moon Area High School and District Administration Offices.

Analysis One: BIM Planning with Multiple Primes

The first analysis deals with the use and coordination of a Building Information Modeling through a multiple prime contracting scenario. As a critical industry issue, the use of BIM can be very beneficial if properly executed. Research for this analysis included the development of a strategy for the implementation of several BIM uses through multiple prime contracting. This research was completed with the guidance industry members, AIA literature and current BIM research.

Analysis Two: Concrete Foundation Wall Bracing Design (Structural Breadth)

As a result of the building's split-level design, there is a foundation wall that separates the ground floor of Areas C & E from the soil under the first floor. The installation requirements of the retaining wall have forced the building to be constructed in way that delays the achievement of a watertight structure and extends the overall time required to complete the structure. The goal of this analysis was to select an alternate foundation system or bracing design for this area of the building that would help to accelerate the schedule and result in a more efficient construction sequence.

Analysis Three: SlenderWall Precast vs. Traditional Brick Veneer (Building Envelope Breadth/ M.A.E Study)

The final analysis requires investigation into the use of a precast building façade to replace the current cavity wall design. Since the design of the New Moon Area High School incorporates the use of a large amount of structural masonry and exterior brick, the schedule relies heavily upon the ability of the masonry contractor to stay on schedule. Unfortunately, due to changes in the project schedule, the installation of the brick veneer was delayed. The use of a precast wall system will eliminate the dependence on the masonry contractor and should also improve the overall construction schedule. This analysis will incorporate information gathered from AE 542: *Building Enclosure Science and Design*, to determine if the new design meets the standards of the initial design.

Analysis One: BIM Planning with Multiple Prime Contracts

Background


Figure 9: Main Entrance Model Rendering

With all of the recent advancements in the use of Building Information Modeling, the process for using this technology is continually becoming more complex. In recent years there have been many efforts to better define BIM processes and help make it easier to understand; for example, the research being performed by the Computer Integrated Construction (CIC) Research Program at Penn State. The CIC program aims to enhance the construction industry through the use of computer and media technologies and to help simplify the entire process by developing best practices and industry standards. The results of this research will help expand the future use of Building Information Modeling to many different project types.

Among the potential beneficiaries of this research are the thousands of projects performed every year under a design-bid-build, multiple prime delivery method. The state of Pennsylvania currently employs this delivery method on all government funded work. Although, the state only requires four separate prime contracts (GC, HC, PC, and EC), recent years have seen as many as 20 separate contracts. Although the ever growing number of contracts is intended to provide building owners with a lower project cost, it continues to make coordination efforts more difficult. This is where the opportunity presents itself to begin incorporating the use of BIM into this type of work. With many architects and engineers already utilizing 3D modeling tools to create construction documents, the ground work for BIM implementation is already in place. Figure 9 depicts a rendering of the New Moon Area High School generated using a 3D design model.

Problem/Opportunity Statement

In the case of the New Moon Area High School, the building and some of its systems were modeled using 3-dimensional software, but the models were not made available to the construction team. There is a great potential for this project and others like it in the future to benefit from many of the BIM uses, including scheduling, coordination, and digital fabrication. However, there is no clear process available for making the modeling information available to the contractors.

Objective

The focus of this research will involve the development of a strategy for using BIM on multiple prime projects. The goal is to provide the tools needed to integrate several specific BIM uses into this widely used delivery method by addressing the challenges and benefits of this integration.

Methodology

- Contact Penn State's Computer Integrated Construction Research Program to gain a better understanding of BIM Project Execution Planning and use the guide to identify several BIM uses applicable to the multiple prime delivery method.
- Conduct interviews with the lead architect and engineer to determine how extensively the models were used. Were the models used for MEP coordination? Was clash detection completed between the structural, architectural and mechanical models? Were the models used to help develop an overall project schedule? Were the models used for site coordination?
- Contact contractors that typically work in multiple prime situations and survey them on their views of BIM and its benefits. Do they use BIM? Would they bid differently if it was available? Is there a potential savings to the owner with this information available?
- Develop a strategy for the future use of BIM in the design-bid-build with multiple primes approach.

Required Resources and Tools

- BIM Project Execution Planning Guide
- CIC Research Program team members
- BIM literature
- Design Team
- Construction Team and other industry members

Expectations

Through my research, I expect to conclude that the use of BIM Planning in the multiple prime approaches could have a very positive impact. By making models available to the contractors there is the potential to increase the speed and efficiency, while providing the owner with a better product. However, I expect that there will be many challenges that must first be addressed by industry members.

Analysis

The following sections provide information about the many challenges associated with multiple prime contracting and how the process can benefit from the use of Building Information Modeling. Much of the information for this analysis was gathered from interviews with industry members (designers and contractors) that typically work on multiple prime projects, and/or are currently using 3D modeling software in their daily work. Again, most of the statements and details provided in the following section are directly related to multiple prime contracting and may be true for sectors of the construction industry.

Challenges of Multiple Prime Contracting

In order to accurately develop a strategy for using BIM in multiple prime contracting, there must first be an understanding of the challenges associated with this task. As previously mentioned, the multiple prime delivery can employ the use of any number of contractors. This makes the effort of coordinating construction a laborious task for everyone involved. In the case of the New Moon Area High School, the general contractor was given the title of Lead Contractor. This means that all scheduling and coordination efforts are their responsibility. They are charged with the task of creating the overall project schedule and tracking its progress, while also ensuring that all work is properly coordinated before being put in place. However, as shown in Figure 10, there is no contractual agreement between the general contractor and the other primes. This translates into the general contractor having little or no ability to control schedule overruns and missed coordination items, often resulting in the owner incurring additional costs through change orders, thereby eliminating the cost advantage that multiple prime contracting is intended to provide. Also, in many instances, the general contractor has the smallest stake in the coordination and can be very apathetic when attempting to expedite the process. Coordination blunders are often the biggest fear of an owner, because they generally produce more than one change order. For instance, if casework, with a sink is required to be moved due to the relocation of a wall in a classroom, this will likely result in a change order from both the casework contractor and the plumbing contractor. This can be a hard thing for school boards to understand because in most cases the change orders will be submitted at different times, but will be written with the same description. This leaves the board feeling like they are paying for something twice.

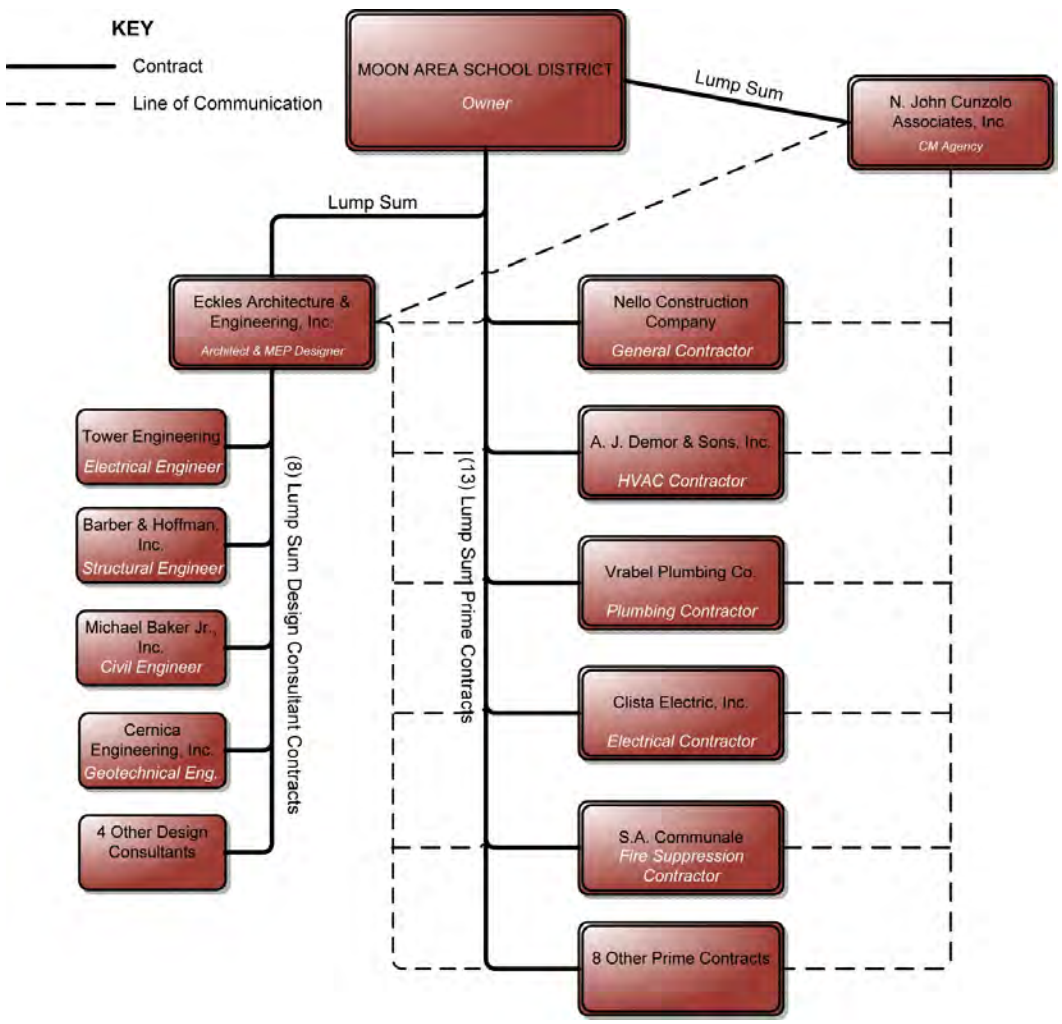


Figure 10: Project Organizational Diagram

Scope definition is another challenge often associated with the application of this contracting method. Even with the most diligent of efforts, designers occasionally fail to accurately define each contractor's scope of work. When this occurs, some contractors are quick to claim they are not responsible for any work not clearly identified, and others are quick to submit a change order for the work. Again, this results in difficulties coordinating construction and eventually results in additional costs to the owner.

Project closeout and warranty information is often a concern towards the end of many multiple prime projects. Items such as excess materials, as-builts, keys and training must be received from each of the prime contractors. In cases where the services of a construction manager are not acquired, it is the responsibility of the owner to track down this information. Oftentimes it can be very difficult for inexperienced owners to make certain they are provided with all of the necessary information before the completion of the project. This can have grave consequences down the road if the owner needs to make a warranty claim. If the warranty is not properly submitted by the contractor and provided to the owner, there is seldom anything that can be done to remedy the situation. Also, in situations where owner training is not provided for one of the building's systems, that system will no longer carry a warranty. The warranty is void in these situations because the owner generally operates the equipment improperly.

It is also important to consider how the multiple prime contractor services are procured for public work in Pennsylvania. All projects performed for the state use a public bidding process with little or no prequalification. In most cases, contractors are only required to provide bid bonds, qualification statements, performance bonds, and certificates of liability. The process allows for almost anyone who can provide the proper information, the right to bid the work. Also, the winning bid is generally based solely upon the amount of the bid. There are only a few circumstances where regulations allow for someone other than the lowest bidder to be awarded the contract. Combining this with the lack of prequalification it can be very difficult to guarantee the capabilities of the contractors prior to when the contracts are awarded. In a situation where projects are trying to utilize the benefits of BIM, this can make the process very difficult.

Although the multiple prime delivery method is used for the purpose of providing the owner with a better overall project cost, it is easy to see how this is not always achieved. It is the intent of this analysis to show how BIM can potentially alleviate some of aforementioned concerns. However, the introduction of BIM will present its own set of challenges that must also be overcome.

BIM Challenges for Designers and Contractors

Like any new technology, the implementation of BIM into a new project scenario creates issues for both designers and contractors. The design-bid-build, multiple prime delivery method may present additional difficulties because of the clear separation between designer and constructor, making the transfer of information more difficult. Also, with an open bidding scenario making who the contactors will be unclear, it is not always known if the winning bidder will have the capabilities to perform the BIM services.

The common denominator among concerns expressed by most designers unfamiliar with BIM collaboration is the associated liability with the document transfer. For years, designers have been able to rely solely on the interpretation of paper construction documents littered with notes indemnifying them from further responsibilities. Several of the designers contacted for this research expressed concerns for the extra liability they would be incurring by releasing digital versions of their 3D design models for interpretation by builders. In situations where designers are not completely familiar with 3D design software, 2D tools would be used to complete constructions documents, making it hard to guarantee the overall accuracy of the building model.

The second most common concern expressed by the design professionals is related directly liability. Many designers worry about using their building models for construction purposes due to ambiguity in the accuracy of their models. Most designers are developing building models for one of two purposes. The most common use of the model is to create images for presentation to the client, such as Figure 11. The second most common use is to aid in the development of construction documents, but as previously stated, this is not the sole method of producing the documents. For instance, a structural designer seldom incorporates the design of connections and exact member lengths into a design model. Instead, the structural steel fabricator is typically responsible for these details. This would make the model difficult to use for purposes of fabrication and cost estimation. In the case of the models developed for the design of the New Moon Area High School, this would be a great concern. Through my attempts to create my own demonstration of 3D coordination, I discovered that all was not what it appeared to be. The mechanical model was never fully developed because the designers determined the software was not capable of performing to their standards. Therefore, the model depicts only a few of the mechanical system elements, and the rest of the design was completed using 2D CAD software. As for the architectural model, I was never able to open the file. Since, the model was only intended for design purposes, it was not carefully monitored and the large file eventually became corrupt. Through conversation with the architect, I was able to gather that the model was not comprehensive and in many cases 2D CAD was used to add detail to the construction documents. My investigations did however find that the structural design model, aside from missing connections, was very complete and easy to manipulate.

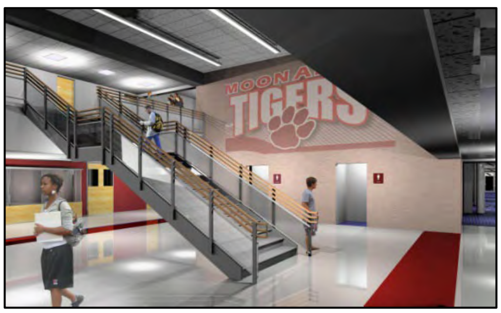


Figure 11: Interior Rendering

Not surprisingly, the contractors hold a completely separate set of concerns. As previously described, multiple prime projects like the New Moon Area High School use a bidding process that allows a diverse grouping of companies to compete for the work. Accordingly, some of the smaller, less advanced companies that are often awarded contracts may not have the capabilities to perform work using standard 3D modeling, let alone complex BIM analyses. Therefore, in order to participate in new BIM projects, they would be required to purchase the proper infrastructure. In most cases this will also require hiring additional employees or providing extensive training to current staff in order to ensure that they can properly use the new equipment and programs.

The second concern comes from many of the mechanical and plumbing contractors that are currently using 3D modeling as part of their everyday operations. The worry is mainly focused around file compatibility and system configurations. Even though they are already using modeling programs, many of them do not have the resources to maintain their software and continue to purchase updates and add-ons that allow for collaboration with the tools architects and engineers are using. Even if there is compatibility in the file formats, some MEP contractors have expressed additional concern over the design elements engineers use to make their models. The specifications of most projects allow for contractors to select their equipment suppliers from a preapproved list. Therefore, the designer's model may not incorporate products from the company that the contractor chooses to use. When considering the size and shape variations between equipment from different suppliers, this error would result in a model that is no longer useful for an analysis such as 3D coordination.

Contract and Specification Requirements

In order to properly address many of the concerns voiced by both the architects and engineers the project specifications and standard contract methods must be altered. This is the area that will help to alleviate concerns over liability and responsibility during design and construction. Also, the contracts and specifications can be used to help define how models will be developed and distributed during each stage of the project.

First, we'll take a look at how the project specifications have the ability to change how the project operates, more specifically during construction coordination. For the New Moon Area High School, details for how to perform the construction coordination are clearly defined in the specifications, *Section 01 3100 – Project Management and Coordination*. This section describes each step of the coordination process in great detail, providing each contractor with a list of specific areas to focus on during coordination. Also, the specs delineate how the coordination will progress, starting with the HVAC Contractor and ending with the Communications Systems Contractor. Figure 12 below describes the coordination process from beginning to end along with the allotted duration for each contractor to complete their portion of the drawings. If the process continues as planned, the total amount of time taken to complete coordination will be 60 days. Also, this traditional method of coordinating systems through the use of 2D drawings often relies heavily upon the experience of the project team and their ability to visualize the spaces mentally to determine areas of conflict. Even with the best of efforts, this process often results in many issues going unnoticed until the time of installation, resulting in additional costs for rework and further coordination.

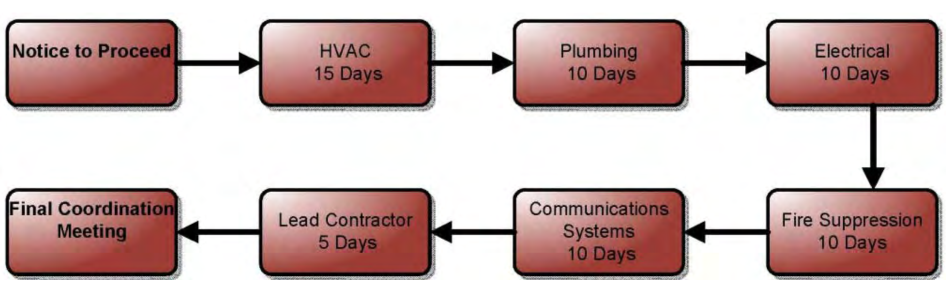


Figure 12: Traditional Coordination Process

If BIM is to be properly executed in a multiple prime setup, the project coordination specifications will need to be addressed. This is an area of the construction process that has the potential to greatly benefit from the use of Building Information Modeling. For instance, with the use of BIM, the previously described coordination process will no longer require the contractors to depend upon the upstream data to complete their work. Rather, each system can be independently modeled and once completed all conflicts can be handled by the project team as a whole. Overall, using BIM for coordination purposes tends to increase the overall accuracy of the process and reduce the number of field conflicts resulting in a savings of both time and money to all parties involved.

The current standard contract for projects like the new high school is the *AIA Document A101-1997: Standard Form of Agreement Between Owner and Contractor.* This is a basic AIA contract provides the owner with a lump sum agreement for each of the prime contractors and guarantees substantial completion on a predetermined date. The contract does not provide any provisions for how the construction should be completed. Similarly, the contract between the architect and owner is based upon the fee for design services and does not include any provisions for how the project should be designed in terms of the use of modeling. Ultimately, this is where the work must be done to enforce the use of BIM throughout the design and construction of a facility.

Fortunately, in an attempt to further develop the use of Integrated Project Delivery (IPD), the AIA developed Document *E202-2008: Building Information Modeling Protocol Exhibit*. Although it was intended for IPD work, E202-2008 can be attached to many of the more traditional AIA contract documents utilized for design-bid-build services. A sample copy of the AIA E202-2008 can be found in Appendix C. The E202 provides detailed descriptions of how models will be used, what file formats are acceptable, what details are required for each model use, and who is responsible for each model during different phases of the project. The traditional version of the E202-2008 contains information describing the level of detail required during each of the major design phases as well as for construction documents. According to the AIA, models will typically be developed to level 300 standards for construction documents and some models will progress to level 400 during the shop drawings phase of construction. Figure 13 below provides an example of the level of detail required for two basic building elements. The E202-2008 also provides provisions for assigning liability throughout the project phases.

Level of Detail ->	100	200	300	400	500
Element					
Interior wall	Not modeled. Cost and other information can be included as an amount per s.f. of floor area.	A generic interior wall, modeled with an assumed nominal thickness. Properties such as cost, STC rating, or U-value may be included as a range.	A specific wall type, modeled with the actual thickness of the assembly. Properties such as cost, STC rating, or U-value can be specified.	Fabrication details are modeled where needed.	The actual installed wall is modeled.
Duct run	Not modeled. Cost and other information can be included as an amount per s.f. of floor area.	A 3-dimensional duct with approximate dimensions.	A 3-dimensional duct with precise engineered dimensions.	A 3-dimensional duct with precise engineered dimensions and fabrication details.	A 3-dimensional representation of the installed duct.

Figure 13: LOD Descriptions (www.aecbytes.com)

Potential BIM Uses and Benefits

The next step in developing a plan for incorporating BIM into a multiple prime contracting scenario is determining which BIM uses are best suited for the project. Most often, the selected BIM uses will be project specific, but for the purposes of this analysis, four uses were selected to be a good starting point for projects similar to the new high school. Through my conversations with contractors and designers, I discovered it is best to begin with a few of the more easily executed BIM uses. This will help to ensure that the first few projects have the best chance at success. Also, it seemed logical to start with uses that are more common and may be familiar to those who already have 3D modeling experience. Figure 14 shows the four selected BIM uses, along with a brief description of the potential benefits of each, as well as a list of resources required, as described by the CIC Research Program.

Selected BIM Use Chart			
Use	**Description**	**Benefits**	**Required Resources**
Design Authoring	A process in which 3D software is used to develop a BIM model based on criteria that is important to the translation of the building's design.	1. Creates efficiencies in design process 2. Shorter and more efficient design reviews 3. Easy to evaluate design options 4. Easier to communicate design to team	1. 3D model manipulation 2. Design review software 3. Interactive review space
Design Review	A process in which a 3D model is used to showcase the design to the stakeholders and evaluate meeting the program and set criteria like layout, sightlines, lighting, security, ergonomics, acoustics, textures and colors, etc.	1. Creates efficiencies in design process 2. Easier to communicate design to team 3. Eliminate costly mock-ups 4. Preview space aesthetics and layout	1. 3D model manipulation 2. Design review software 3. Interactive review space
3D Coordination	A process in which Clash Detection software is utilized during the coordination process to determine field conflicts by comparing 3D models of building	1. Reduce and eliminate field conflicts 2. Visualize construction 3. Increased productivity 4. Reduced construction costs	1. 3D model manipulation 2. Model review application
Digital Fabrication	A process that utilizes machine technology to prefabricate objects directly from a 3D Model. The 3D Model is cut into appropriate sections and is fed into an assembly system for production.	1. Automated component fabrication 2. Minimize tolerances with machine fabrication 3. Maximize fabrication productivity	1. 3D model manipulation 2. Fabrication capabilities

Figure 14: Potential BIM Uses

Design Authoring and Design Review

Design authoring and design review are the two BIM services most likely to be provided by the architect and design engineers in the traditional design-bid-build project delivery. Design authoring is typically the foundation of a well executed BIM model. Many of the other BIM uses rely heavily upon the details and accuracy embedded in the original design models. This will require designers to pay closer attention to the details they are providing within the model in order to ensure that it will be usable for construction purposes. Implementing the use of the AIA E202-2008 contract, as previously described, will help to ensure that all requirements of the design models are accurately portrayed from the beginning of the project. Design review was selected as a use because it is already very commonly used to help architects sell their design to an owner. As was depicted by the previously shown renderings, design review was in fact implemented on the New Moon Area High School.

3D Coordination

As discussed earlier, this is the BIM use that has the potential to have the biggest impact on the multiple prime delivery method. However, it would require changes to the coordination process currently followed by most multiple prime projects. Through speaking with industry members, I have determined that HVAC contractors are most often the most qualified to lead the coordination effort, not the general contractor. In most cases, construction coordination is focused around the equipment being installed by the HVAC contractor because it is usually the biggest and least flexible. Also, from my experience, most HVAC contractors are already using 3D modeling to help develop shop drawings and perform digital fabrication. Overall, they appear to be the most qualified to perform these tasks. This would require additional verbiage within the project specifications to clearly define the new roles of the contractors.

Digital Fabrication

Much like the design authoring and design review uses, digital fabrication was selected for its prevalence throughout the industry. On most projects, digital fabrication will not be used by all contractors. However, the Plumbing Contractor, HVAC Contractor, and steel erector will benefits the most from this BIM use. If design models are completed in formats compatible with the software already used by these contractors, digital fabrication has the potential to greatly reduce lead time on important project elements. In the event that the design model is not directly compatible with the contractor's equipment, it may still be used to aid the contractor in developing their own model that can also be used to help with coordination.

There are many factors involved in the selection of appropriate BIM uses for a specific project. The BIM Execution Planning Guide suggests that each use should be evaluated based upon the resources, competency level, and experience that can be provided by each of the parties involved in the process. For example, if 3D coordination is a responsibility of the architect, engineer, contractors, and subcontractors, each of these parties should be rated on their ability to perform the task. Based upon the overall ratings of the project team, it should then be determined whether or not there is enough experience amongst the group to properly execute. Although a use may seem very beneficial to a project, if too many of the parties involved are not properly prepared or experienced, then the use no longer provides benefits. The four uses selected above are only meant to be a starting point for future projects similar to the New Moon Area High School and may be eliminated or added to in accordance with individual project needs.

Conclusions and Recommendations

Although there are many obstacles to overcome, the marriage of Building Information Modeling and multiple prime contracting is far from impossible. I believe it is important for the advancement of this archaic delivery method that an attempt be made to integrate modern technology. Ultimately, initial attempts to integrate the two will result in confusion and maybe even an additional cost to the owner due to hesitation by contractors. The extra cost makes it even more important for owners to be aware of the potential benefits and be willing to spend the extra money. Ideally, the extra cost will only be incurred on projects that are part of the initial integration of BIM and multiple primes. Like anything else in the construction industry, it may take time for the designers and contractors to refine the process and become comfortable with the integration. As mentioned within the analysis, the two key components for the success of BIM with multiple primes will be the refinement of the AIA E202-2008 for use with a traditional delivery and keeping the BIM uses simple in the beginning. These two steps will help to ensure that the project has the best chance at success. Additionally, time must be taken to rethink how specifications are written and responsibilities are assigned. It will be important to evaluate each project and make certain that the most qualified parties are responsible for managing the BIM process.

Analysis Two: Concrete Foundation Wall Bracing Design (Structural Breadth)

Background

As a result of the building's 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 in Figure 15. As designed, the wall cannot be backfilled until the steel on the ground floor has been set and plumbed, and the first floor slab-on-deck is placed and allowed to come to its 28-day strength of 3,500 psi. This is a problem because the grade beams under the first floor of Areas C&E tie into the wall and cannot be completed until the wall is backfilled. This also prevents the first floor slabs from being placed, which will further delay the installation of the load bearing masonry walls that surround the gymnasium and auditorium. The requirements of the wall have caused the building to be constructed as two separate pieces with a void between as depicted in Figure 16, below.

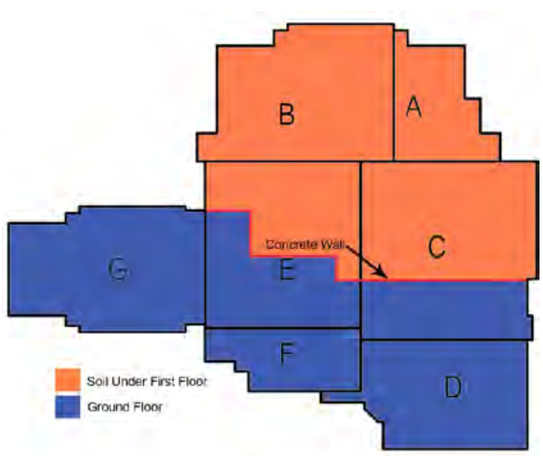


Figure 15: Foundation Wall Location

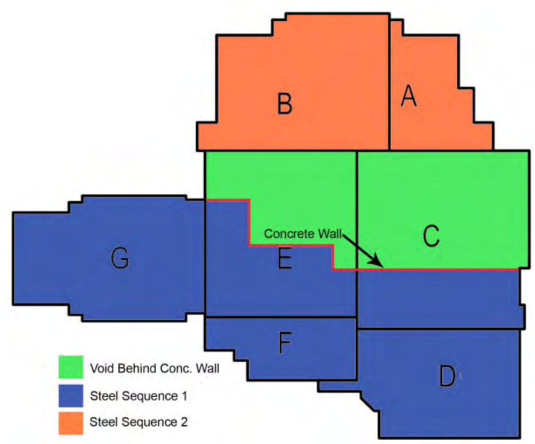


Figure 16: Foundation Wall Backfill Area

Problem/Opportunity Statement

Although it is often more cost efficient not to design foundation walls as retaining structures, it can also be a key factor in developing a construction sequence on large projects. The project team has developed a sequence that adequately deals with the requirements of the wall, but has also resulted in extra expenses for the general contractor to ensure that certain materials are being installed under proper climate conditions.

Objective

The focus of this research is to determine if an alternate wall system or bracing design will allow the first floor of Areas C&E to be completed with the rest of the structure. The goal is to design a new system that will have a much smaller impact on the project schedule and help the building to reach a state of weather resistance at an earlier date.

Methodology

- Contact structural engineer and general contractor to determine possible alternate systems.
- Design alternate system best suited for this situation.
- Analyze constructability of current system vs. alternate system.
- Analyze schedule implications of current system vs. alternate system.
- Analyze cost differences between both systems.

Required Resources and Tools

- Nello Construction
- Barber & Hoffman Consulting Engineers
- Geotechnical reports
- Structural drawings and specifications
- Industry professionals
- Penn State AE faculty

Expectations

The development of an alternate wall system or bracing design should eliminate the need for the building to be constructed in such a disjointed manner by alleviating many of the constructability issues related to the current design. The new design should also result in reduction of the overall schedule of the structure and an advancement of the building dry date. However, it is expected that the new design will result in an increase to the total project cost.

Analysis

The following sections provide a description of the steps taken to achieve the final design results and suggestions. All cost comparisons were developed using previously developed estimates for the buildings structure along with additions from the manufacturer of the selected bracing system online estimating software. Also, the schedules developed for this analysis are based on the original schedule developed by the general contractor at the outset of the project.

Project Team Suggestions

Through conversation with the project manager from Nello Construction, a few initial ideas were developed. First, it was explained from the general contractor's perspective, the only other option would be implementing a bracing system on the wall during the backfilling process. According to the specifications, the general contractor is responsible for the design of any support systems during construction. This means for the wall to be braced, there would need to be sufficient time for the procurement of design services from a third party engineer and the willingness of the general contractor to incur the extra cost. In fact, Nello had entertained this option at the beginning of the project but chose not to pursue due to time constraints. Therefore, the project manager suggested that a bracing design may, in fact, be a feasible solution to this issue.

The conversation with the design engineer from Barber & Hoffman Consulting Engineers offered a more detailed look into the design behind the foundation wall in question. Again, the designer reiterated the idea that in most cases this issue is a responsibility of the general contractor and often times is overlooked due to time constraints. On the other hand, during the initial design, there was an option developed for converting the current wall profile into a self-supporting retaining structure. This design involved the addition of a large amount of concrete into the building's structure in the form of additional caissons and increased grade beam dimensions, along with additional reinforcing. The general profiles of the final design and the alternate design are shown below in Figure 17. Ultimately, it was decided that the additional costs of the retaining wall design outweighed the benefits and it was pursued no further. As was the case with the project manager, the designer suggested that a bracing system would probably be a more practical solution. It was suggested that maybe a system using an angled shoring type of brace similar to that used to support wall forms might be a good starting point for the alternate design.

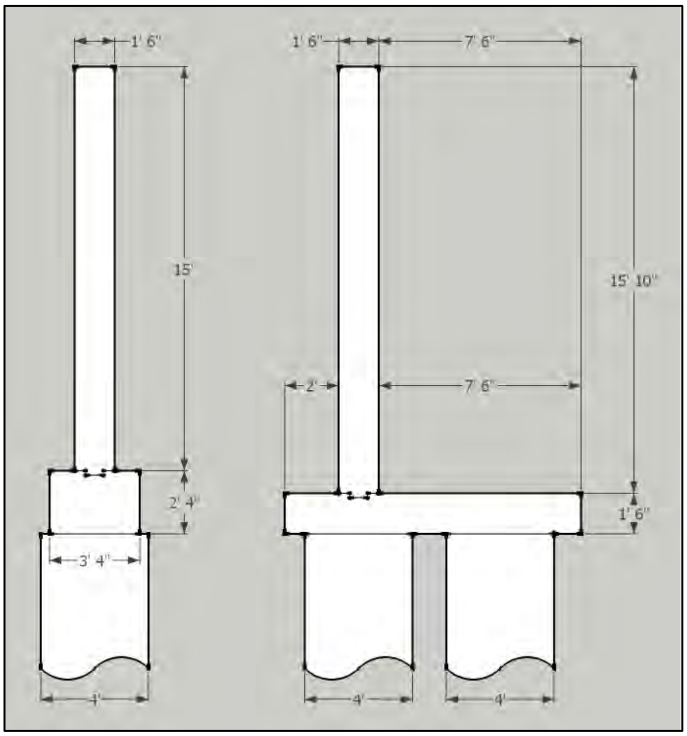


Figure 17: Original Wall Design (left), Retaining Wall Design (Right)

Bracing System Selection

When beginning the search for a supplier for the bracing system, it was important that they be able to fulfill a few initial criteria. First, the supplier needed to be in relatively close proximity to the project site to allow for practicality. Second, they needed to be able to supply a fairly robust bracing system in order to avoid having to install a large number of braces. After much searching, the system proven to be best suited for this job is the System 160 Wall Support System supplied by Mabey Bridge & Shore. Mabey's Pittsburgh office is located only 13 miles from the site of the New Moon Area High School and they claim their System 160 provides the highest strength on the market for formwork support and shoring applications while stilling keeping a reasonable cross-section and profile. Figures 18 and 19, on the next page, were graciously provided by Maybe Bridge & shore. The image on the left displays an elevation drawing of the System 160 design that has been selected for our use and the image on the right shows a recent application of the same system under almost the same conditions found at the New Moon Area High School site. All details of the components required for the installation of the selected prop system can be found in Appendix G.

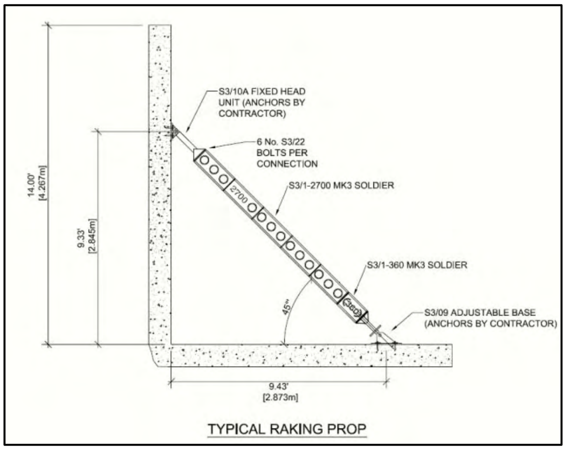


Figure 18: System 160 Elevation (Image supplied by Mabey Bridge & Shore, Inc.)

Figure 19: Recently Complete Mabey Project (Image supplied by Mabey Bridge & Shore, Inc)

Wall Bracing Layout

Before the design of the bracing system could begin, it was necessary to determine the type and quantity of the load(s) that the braces would be required to withstand. For this, calculations were performed to determine whether the movement of the wall was to be governed by overturning or sliding. The results yielded an overturning moment of 24,148'lbs per linear foot of wall. The sliding calculations show that the wall will resist sliding as long as the slab-on-grade is in place prior to the backfilling. This is not an issue because the slab is required to be in place for the mounting of the wall props. Once the required resisting moment was determined, the strength of the props was used to calculate the proper spacing requirements. The final results determined that a brace will be required every 10.3', therefore a spacing of 10' will be used for simplicity. All calculations and assumptions used to determine this loading can be found in Appendix D.

The spacing requirements were then used to determine the total number of braces required to properly support the 436' of concrete wall. The layout diagrams in Appendix F reveal that a total of 44 braces will be used to complete the project, including 23 braces for use in Area E and 21 for Area C. Careful consideration was taken in determining the layouts to ensure that there would be no interference with the construction and any interior walls while the braces are in place. The layout diagrams also depict the required slab modifications for the support of the braces. It was recommended that there be a minimum slab thickness of 12" below the points where the braces will be mechanically fastened. In order to achieve this, a 3 foot wide 12" thick stripe will be added to the slab running parallel to the wall at a distance allowing for the braces to be centered on the thickened area. The 3 foot width was determined to be adequate in order to allow for some adjustment of the 15" long feet at the bottom of each brace. Overall, this will require the addition of 8" of concrete to the original 4" slab-on-grade design.

Schedule and Cost Implications

Once the bracing system has been selected and designed, it must be determined whether or not it will positively affect the project schedule and budget. Remember, the purpose of this analysis was to develop a method for shortening the duration of time required to complete the building structure with the understanding that a certain amount of cost would be incurred. Figure 20 below represents the overall impact that each of the three options will have on the project. The third option is being provided as a comparison although it was determined at the beginning of this analysis that a retaining wall would not be a cost effective alternative. All detailed scheduling information used to obtain the final results can be found in Appendix E.

Concrete Foundation Wall - Alternate Design Comparisons				
Design	**Added Material**	**Overall Cost**	**Cost Difference**	**Schedule Change**
Original wall design w/o bracing	None	$ 201,755.47	$ -	None
Original wall design w/bracing	Mabey System 160 Wall Support System with required accessories and additional concrete to thicken slabs	$ 229,111.76	$ 27,356.29	-37 Days
Wall designed as retaining structure	Increased footing size, added caissons, additional reinforcing steel.	$ 382,367.66	$ 180,612.19	-43 Days

Figure 20: Wall System Comparisons

As displayed above, the alternate options of bracing the wall or redesigning the structure as a retaining wall both provide substantial time savings. However, when comparing the cost of the two options, the decision to design the wall as a standalone retaining structure quickly becomes irrational. Adding an extra $180,612 to the overall cost of the project in order to ease construction would not be an easily sold to the owner. However, the added $27,356 for bracing the wall might be more easily justified when considering the overall times savings it allows. This is a cost that would be absorbed by the general contractor's general conditions budget and should easily be recouped by the 37 day time savings. The time savings should theoretically allow the GC to have a substantial savings in labor costs as the project progresses and comes to completion.

When developing the final schedule and cost data, it was important to remember a few keys elements of both systems. The scheduling of the retaining wall structure had to include extra time for the installation of the additional caissons, footing requirements, and additional wall reinforcing, but did not require waiting for the first floor SOD to cure before backfilling could begin. As reported in the detailed cost estimate on the next page, these additional requirements included the addition of a combined 581 CY of concrete and 46 tons of reinforcing material. On the other hand, separate considerations had to be made when developing the cost and schedule scenario for the installation of the originally designed wall with an added bracing system. First, in order to ensure that the system would be properly supported, time was allowed for the slab-on-grade on the ground floor of Areas C and E to be installed before the Mabey system could be installed. The SOG also required an extra day for installation in both areas to allow time for the installation of the additional concrete required in the 12" thickened areas that will provide additional support at the foot of the braces. Also, both areas of the wall required an additional 3 days of work to allow the braces to be put in place. However, much like the retaining wall design, there is no longer a need to wait for the first floor SOD to be placed and cured once the braces are providing support to the wall. In the end, the only additional materials needed for the bracing system are the braces with proper accessories, and the additional 16 CY of concrete required to thicken the slab areas where the braces will be supported. Figure 21 below provides a detailed breakdown of the final construction costs of the wall associated with each of the alternates and the original design.

Concrete Wall Alternates - Cost Analysis								
Description	**Quantity**	**Unit**	**Bare Material**	**Bare Labor**	**Bare Equipment**	**Bare Total**	**Total O &P**	**Final O & P**
Original Wall Design WITHOUT Bracing								
Caissons (3,000 psi)	286	CY	$ 97.16	$ 10.39	$ 0.41	$ 194.32	$ 123.16	$ 35,223.76
Caisson Reinforcing	11	Tons	$ 1,417.48	$ 712.64	$ -	$ 2,130.12	$ 2,714.43	$ 29,858.73
Grade Beams (4,000 psi)	119	CY	$ 101.97	$ 11.03	$ 4.90	$ 117.90	$ 133.85	$ 15,928.15
Grade Beam Reinforcing	13	Tons	$ 1,345.40	$ 413.96	$ -	$ 1,759.36	$ 2,146.73	$ 27,907.49
Concrete Walls (4,000 psi)	371	CY	$ 101.97	$ 18.07	$ 8.04	$ 128.08	$ 147.86	$ 54,856.06
Wall Reinforcing	16	Tons	$ 1,417.48	$ 497.80	$ -	$ 1,915.28	$ 2,373.83	$ 37,981.28
							TOTAL:	**$ 201,755.47**
Description	**Quantity**	**Unit**	**Bare Material**	**Bare Labor**	**Bare Equipment**	**Bare Total**	**Total O &P**	**Final O & P**
Original Wall Design WITH Bracing								
Caissons (3,000 psi)	286	CY	$ 97.16	$ 10.39	$ 0.41	$ 194.32	$ 123.16	$ 35,223.76
Caisson Reinforcing	11	Tons	$ 1,417.48	$ 712.64	$ -	$ 2,130.12	$ 2,714.43	$ 29,858.73
Grade Beams (4,000 psi)	119	CY	$ 101.97	$ 11.03	$ 4.90	$ 117.90	$ 133.85	$ 15,928.15
Grade Beam Reinforcing	13	Tons	$ 1,345.40	$ 413.96	$ -	$ 1,759.36	$ 2,146.73	$ 27,907.49
Concrete Walls (4,000 psi)	371	CY	$ 101.97	$ 18.07	$ 8.04	$ 128.08	$ 147.86	$ 54,856.06
Wall Reinforcing	16	Tons	$ 1,417.48	$ 497.80	$ -	$ 1,915.28	$ 2,373.83	$ 37,981.28
12" Thickened Slab Concrete	16	CY	$ 101.97	$ 10.75	$ 4.77	$ 117.49	$ 133.25	$ 2,132.00
Bracing System Labor	44	Each		$ 39.63		$ 39.63	$ 43.59	$ 1,918.09
Area C - Mabey System 160 Wall Brace Rental (21 Braces @ 10)	10	Week				$ 1,040.00	$ 1,112.80	$ 11,728.00
Area E - Mabey System 160 Wall Brace Rental (23 Braces @ 9)	9	Week				$ 1,140.00	$ 1,219.80	$ 11,578.20
							TOTAL:	**$ 229,111.76**
Description	**Quantity**	**Unit**	**Bare Material**	**Bare Labor**	**Bare Equipment**	**Bare Total**	**Total O &P**	**Final O & P**
Wall Designed As Stand Alone Retaining Structure								
Caissons (3,000 psi)	572	CY	$ 97.16	$ 10.39	$ 0.41	$ 194.32	$ 123.16	$ 70,447.52
Caisson Reinforcing	22	Tons	$ 1,417.48	$ 712.64	$ -	$ 2,130.12	$ 2,714.43	$ 59,717.46
Grade Beams (4,000 psi)	414	CY	$ 101.97	$ 11.03	$ 4.90	$ 117.90	$ 133.85	$ 55,413.90
Grade Beam Reinforcing	44	Tons	$ 1,345.40	$ 413.96	$ -	$ 1,759.36	$ 2,146.73	$ 94,456.12
Concrete Walls (4,000 psi)	371	CY	$ 101.97	$ 18.07	$ 8.04	$ 128.08	$ 147.86	$ 54,856.06
Wall Reinforcing	20	Tons	$ 1,417.48	$ 497.80	$ -	$ 1,915.28	$ 2,373.83	$ 47,476.60
							TOTAL:	**$ 382,367.66**

Figure 21: Foundation Wall Cost Comparison

Conclusions and Recommendations

The addition of a bracing system for the originally designed concrete wall bordering Area C and E is a feasible solution to the setbacks associated with the wall's design. By adding the Mabey System 160 wall braces, the project team is able to eliminate a significant amount of the time required to complete the building's structure. This time savings will easily translate into a reduction of the overall duration of the project with the structure falling on the schedule's critical path. It also becomes easier to justify the extra expense when one considers the general contractor would only be $739 for every day eliminated from the schedule.

Even with all of the collected information favoring the implementation of an added bracing system, ultimately this decision would need to be made by the general contractor. As previously mentioned, the project specifications state that the GC is responsible for ensuring that concrete wall is properly supported before commencing any backfilling activity. Since this is a design-bid-build project, there is often not much time to make this type of decision. This means that the GC would need to have this decision made before, or immediately upon being awarded the project. However, through speaking with a representative from Mabey Bridge and Shore, it seems as though this process could be handled quickly and efficiently if the decision was made to incorporate a bracing design.

As is the case with many public school projects, the New Moon Area High School is under pressure to be completed in order for classes to begin on a particular date. This case is even more unique considering the building is scheduled for occupancy following the winter break, in the middle of the 2010-2011 school year making it even more critical for the building to be complete on time. Also, in many cases near the end of the project, the school district will request earlier access to the building to ensure that all supplies and owner furnished equipment is in place, and to allow teachers time to learn the features and layout of the new building. Considering the bracing system could allow this to happen at an earlier date makes the case even stronger.

Analysis Three: SlenderWall Precast vs. Traditional Brick Veneer

(Building Envelope Breadth / M.A.E. Study)

Background

As previously discussed there were many limitations forced upon the construction team as a result of the design requirements of the main foundation wall that runs through the heart of the building's structure. One of the trades most affected by construction of the foundation wall was the masonry contractor. The portions of Areas C&E that were delayed due to the foundation backfilling requirements contain a majority of the building's structural masonry in the areas surrounding the gymnasium and auditorium. Unable to perform work in these areas, the masonry contractor was forced to focus initial manpower on other areas of the building and on the installation of the brick veneer. However, once the foundation wall was backfilled and the ground floor of Areas C&E was made available, the brick veneer was abandoned. As a result, the schedule to complete the building façade fell behind. This created further issues because the installation of the windows and curtain wall were delayed, preventing the building from reaching a state of full enclosure. Overall, the process created the need for the general contractor to create temporary enclosures within the building to protect sensitive work until the façade was completed. The left portion of Figure 22 shows an example of one of the required temporary enclosures.

Figure 22: Temporary Enclosures

Problem/Opportunity Statement

Delays in the installation of the brick veneer resulted in additional work and expenses to create temporary enclosures within the building. By looking into the application of precast brick panels in lieu of the current cavity wall design, the dependence on the mason will be eliminated and the overall time required to complete the façade should be reduced.

Objective

The goal of this analysis is to select a precast wall system that will allow for proper sequencing and ensure that the building enclosure remains on schedule. Also, an effort will be made to ensure that the thermal properties of the building's façade are equal to, or better than the current specifications.

Methodology

- Analyze existing wall section for thermal properties.
- Research precast wall systems.
- Select precast system.
- Compare thermal properties of both systems.
- Determine sequencing and cost impacts of selected precast system.

Required Resources and Tools

- Structural Engineer
- Industry professionals
- Scheduling software
- Building envelope literature
- AE 542 materials

Expectations

Through investigation I expect to find many benefits of installing a precast wall system. Although I expect the initial cost of the material to be higher than the current design, the savings in labor may result in a net overall savings to the owner. Also, I expect to find a precast system with comparable thermal properties to the current cavity wall design. Finally, the implementation of a precast façade should eliminate the dependency on the masonry contractor and allow the building's shell to be installed at a much faster rate.

Analysis

The following sections provide a detailed breakdown of the steps taken to determine the feasibility of substituting precast architectural concrete panels for a traditional brick veneer system. Cost and scheduling information used in this analysis was obtained from both the precast manufacturer and the actual project team. Careful consideration was also taken to ensure that the selected precast wall system will provide envelope performance equal to the original cavity wall design.

Precast System Selection

Through research, it was determined that SlenderWall by Easi-Set Industries, a non-traditional precast wall panel system, is best suited for this analysis. Through its non-traditional design, SlenderWall provides many additional benefits when compared to other architectural precast wall systems. As shown in Figure 23, SlenderWall utilizes a thin 2" layer of concrete supported by heavy-gauged stainless steel studs. By incorporating the use of the structural stainless steel studs and reducing the required thickness of the concrete, the average panel weight is reduced significantly when compared to a traditional 6" precast panel. The integration of the stainless steel studs eliminates the need for exterior metal studs to be installed around the building perimeter and allows for additional usable square footage because the studs are now on the outboard side of the floor slabs. As a proven air and vapor Barrier, SlenderWall allows for the elimination of other building materials found in a typical wall section.

Figure 23: Typical SlenderWall Section

Thermal and Moisture Performance

When selecting a precast wall system for use on the New Moon Area High School, it was very important to ensure that the new system would not adversely affect the overall performance of the building façade. As a school building, the new high school will be expected to perform properly for many decades and any change in the thermal properties of the wall could result in a large change in the district's maintenance and utility costs. Figures 24 and 25 below represent the wall sections that were used to compare the SlenderWall system against the original cavity wall design. One can see that the SlenderWall system provides a much thinner wall section. Once the layers of each wall section were established, the next step was to evaluate the insulating properties. Figures 26 and 27 represent the R-Value and heat transfer calculations performed for each wall section.

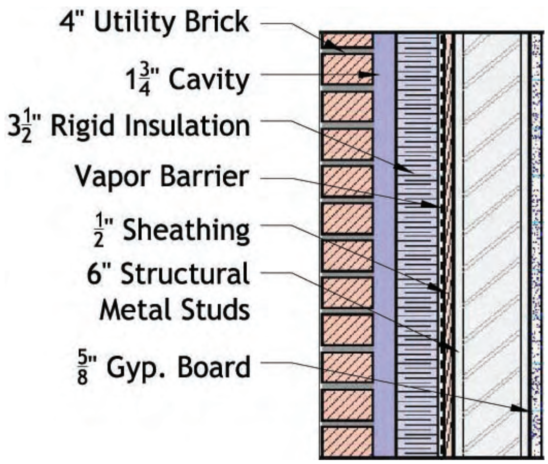


Figure 24: Cavity Wall Section

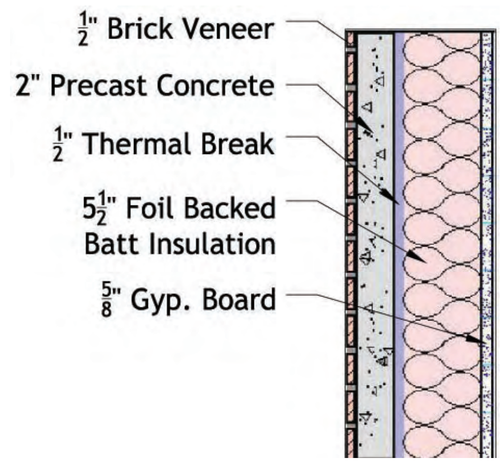


Figure 25: SlenderWall Section

Cavity Wall				
R-Value				
Material	**Thickness (in)** **L**	**R-Value per inch** **°F*ft²*h/Btu-in**	**R-Value** **°F*ft²*h/Btu**	**U-Value** **Btu/°F*ft²*h**
Outside Air Film	-	-	0.17	5.88
Brick (4")	4.000	0.150	0.600	1.67
Cavity (1-3/4")	1.750	-	0.980	1.02
Rigid Insulation (3-1/2")	3.500	5.000	17.500	0.06
Vapor Barrier	0.010	12.000	0.120	8.33
Sheathing (1/2")	0.500	1.280	0.640	1.56
Stud Cavity	6.000	-	0.980	1.02
Gyp. Board (5/8")	0.625	0.730	0.456	2.19
Inside Air Film	-	-	0.640	1.56
		Total:	**22.086**	**0.045**

Heat Transfer			
Summer			
ΣR **°F*ft²*h/Btu**	**ΔT** **°F**	**A** **ft^2**	**Q** **Btu/hr**
22.086	13	48,242	28,395
Winter			
ΣR **°F*ft²*h/Btu**	**ΔT** **°F**	**A** **ft^2**	**Q** **Btu/hr**
22.086	-41	48,242	(89,554)

Figure 26: Cavity Wall Thermal Calculations

SlenderWall				
R-Value				
Material	**Thickness (in)**	**R-Value per inch**	**R-Value**	**U-Value**
	L	**°F*ft²*h/Btu-in**	**°F*ft²*h/Btu**	**Btu/°F*ft²*h**
Outside Air Film	-	-	0.17	5.88
Brick Veneer (1/2")	0.500	0.150	0.075	13.33
Precast Conc. (2")	2.000	2.615	5.230	0.19
Thermal Break (1/2")	0.500	-	0.520	1.92
Batt. Insulation (5-1/2")	5.500	-	15.000	0.07
Gyp. Board (5/8")	0.625	0.730	0.456	2.19
Inside Air Film	-	-	0.640	1.56
		Total:	**22.091**	**0.045**

Heat Transfer			
Summer			
∑R	**ΔT**	**A**	**Q**
°F*ft²*h/Btu	**°F**	**ft^2**	**Btu/hr**
22.091	13	48,242	28,389
Winter			
∑R	**ΔT**	**A**	**Q**
°F*ft²*h/Btu	**°F**	**ft^2**	**Btu/hr**
22.091	-41	48,242	(89,534)

Figure 27: SlenderWall Thermal Calculations

All individual R-Values were obtained using the H.A.M. Toolbox software, and *Mechanical and Electrical Equipment for Buildings*. The heat transfer calculations in the previous figures were calculated using summer temperatures of 75°F indoors and 88°F outdoors and winter temperatures of 70°F indoors and 29°F outdoors.

With a total difference of .005 between the two R-Values it can be assumed that there will be no difference in the overall heat transfer properties of the two sections. For example, the overall heat gain for SlenderWall in the summer is 28,389 Btu/hr, while the cavity wall would see a gain of 28,395 Btu/hr. That being said, it is safe to assume that there will be no increase or decrease in the overall heating and cooling requirements of the building. Therefore, the use of SlenderWall will not have an effect on the current mechanical system.

Further, the H.A.M. toolbox software was used to perform a condensation analysis on the proposed SlenderWall Section. Since the location of the new high school is relatively close to the city, the program's information for Pittsburgh, Pennsylvania was used to perform the test. The results show that the wall will perform very well under normal summer conditions (Figure 28), but in the winter there is the potential for condensation to enter the wall as shown in Figure 29 on the next page. During this time of the year, the vapor will be traveling from the inside of the wall to the outside. This means that careful consideration must be made to ensure that the insulation is not exposed to moisture. This is why foil backed insulation was selected for use in the wall section. The foil face will be towards the exterior, helping to prevent the moisture from entering the batt insulation. Speaking with a representative from the manufacturer, I gathered that there is not usually a concern for condensation in SlenderWall applications, but in the event that the building designers think otherwise, a vapor barrier can be applied to the outside of the studs in the SlenderWall section. The representative stated that the only time there has ever been a concern over condensation was during an application in Northern Canada, where the thermal gradient across the wall was much more extreme. Therefore, the chance for moisture to enter the wall, as displayed in Figure 29, should not be a concern. However, if the architect and MEP engineer feel it necessary, they could choose to use the vapor barrier specified with the original cavity wall design.

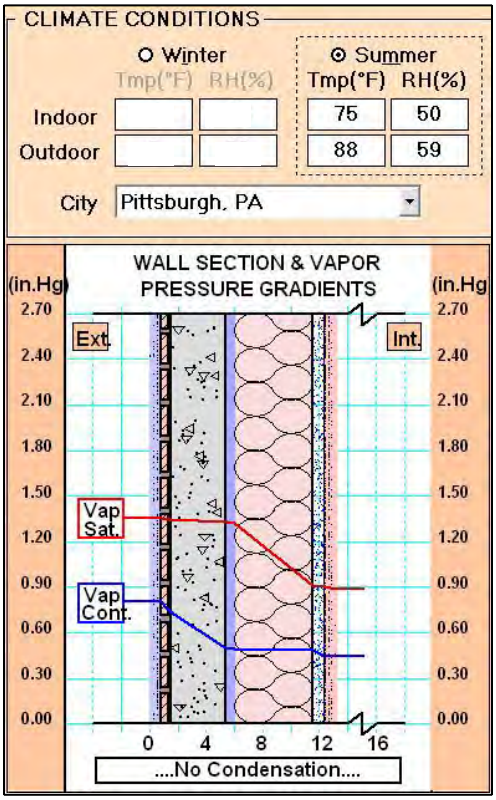


Figure 28: Summer Condensation Analysis

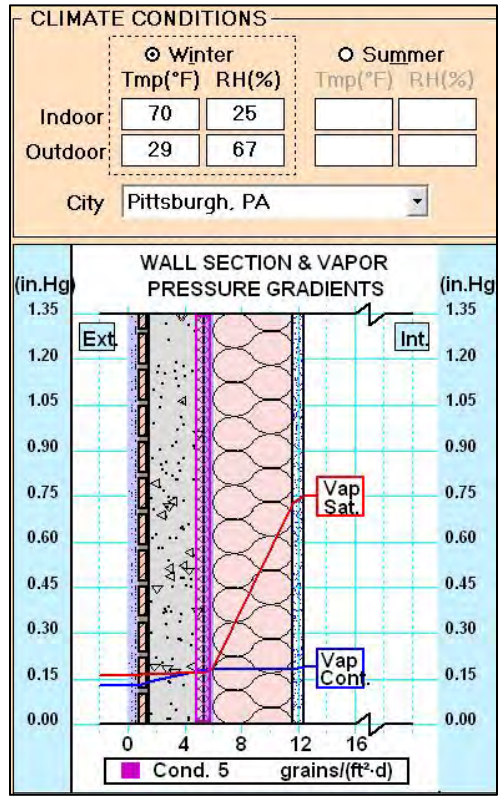


Figure 29: Winter Condensation Analysis

Structural Requirements

Through conversation with the structural design engineer for the new high school, I found that the original design load considered for the brick veneer cavity wall was 50lbs/ft^2 and the majority of the load was designed to bear upon the building's foundation. The literature provided by SlenderWall states that their panels are designed to be 30 lbs/ft^2 and they can either be self-supporting or supported by the building structure. Therefore, it was suggested by the engineer that the main steel structure would not require any additional changes in order to handle SlenderWall panels. As this was not meant to be a structural breadth, no additional calculations were performed.

Panel Layout

When considering precast paneling for any building, it is always important to consider how easily the building's architecture can be replicated using repeating panel modules. Since the New Moon Area High School was not initially designed for precast paneling, I expected the task of designing panel sizes to be laborious. However, I found that with little change to the architecture or fenestration layout, the façade can be skinned using only 7 different panel widths, totaling 26 different panel sizes. If the architect were to seriously consider using precast panels, a closer look at the areas around the swimming pool and gymnasium may allow for further reduction of the required panel sizes. Also, As shown in Figure 30, many of the panels are rather small in order to cover areas around windows. If the window spacing and sizes were standardized, it may enable larger panels to be produced with openings for the windows. This would further eliminate the total number of panels needed and the total installation time. Using a layout based upon the general panel sizes displayed in Figure 30, the building will require 860 panels for completion. A detailed breakdown of the panel requirements for each façade can be found in Appendix H.

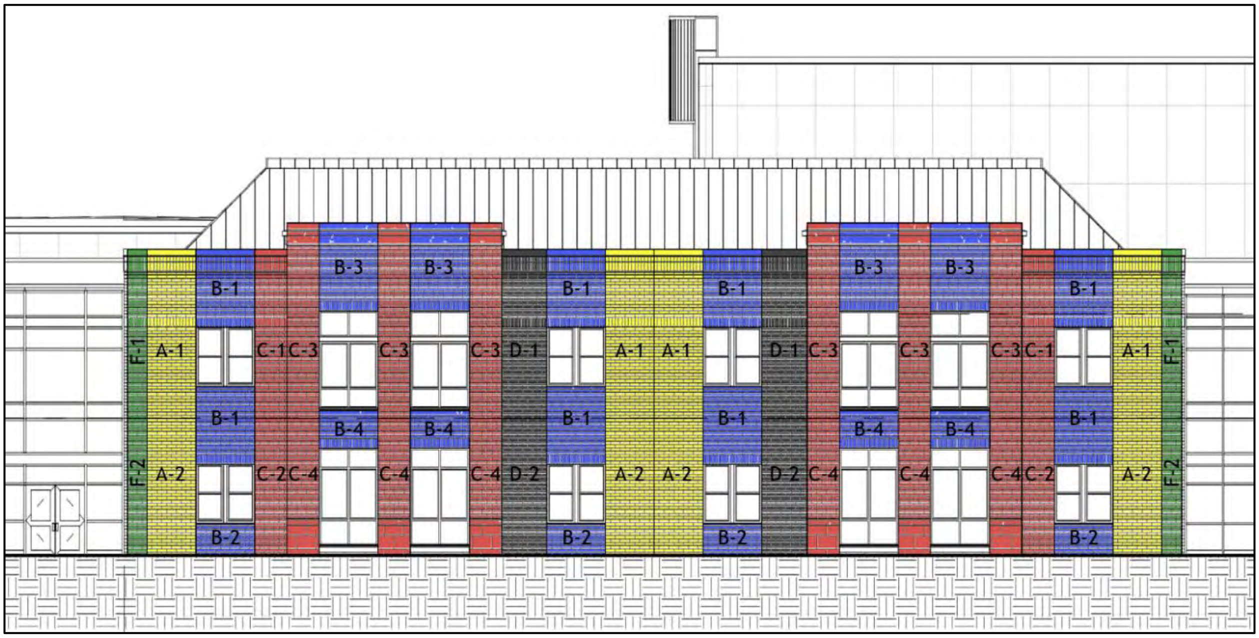


Figure 30: Example of SlenderWall Panel Layout

Construction Sequence

Unlike most masonry applications, the installation of a precast wall system requires the use of a crane. This is particularly important when developing an erection sequence for a precast wall system. Since, in most cases, precast walls can be installed much faster than traditional brick veneer, careful consideration must be made to ensure that the precast erection team does not interfere with other work going in place. Many times, this results in a precast installation sequence that does not begin until the building structure is complete. Fortunately for the new high school, the building is large enough that the two crews can work together temporarily while the structure is being completed. Figure 31 on the next page shows the location of the steel and precast erectors at the beginning of precast installation. The green arrow in the figure also shows how the installation sequence for the SlenderWall will proceed. The panels will be set beginning on the North façade continuing clockwise around the building until the west façade is completed. The overlap of steel erection and precast installation will only occur for a few days once the precast is started.

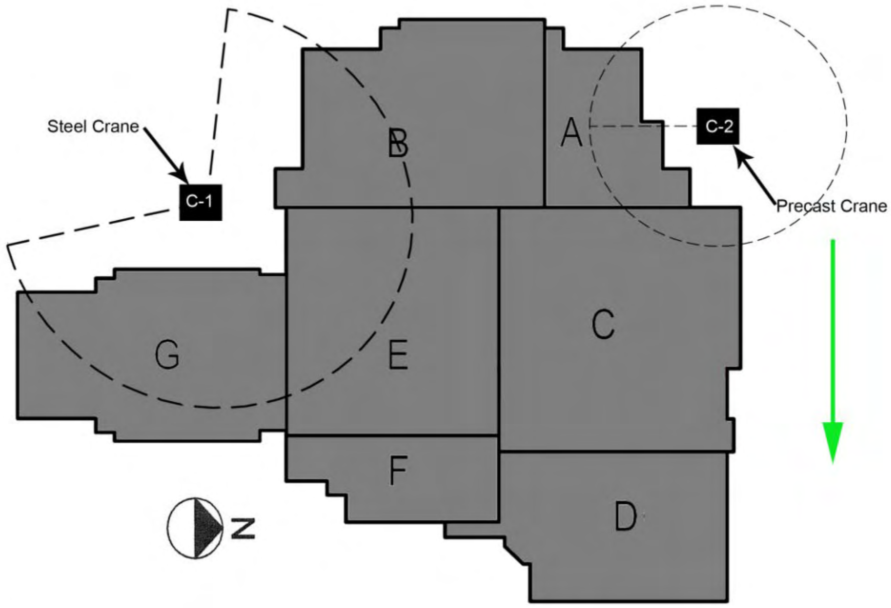


Figure 31: Precast Installation Sequencing

Schedule and Cost Implications

On many projects, the decision to use precast panels weighs heavily upon the overall cost of the system. Most often, the material cost of a precast façade is less expensive than a traditional brick veneer, but the labor costs often favor the precast panels. In some instances, however, the extra cost of the precast can be justified by the potential for significant time savings.

In order to compare the cost of the SlenderWall system with the cost of the cavity wall it was important to obtain cost data from the manufacturer. It was suggested that a typical SlenderWall application will cost $25/ft^2 - $40/ft^2. With the suggested design consisting of many small pieces and a few special panel requirements, the decision was made to use $40/ft^2. This will ensure that the extra erection time and additional panel molds are accounted for in the final pricing. This price was then compared to that of the cavity wall design. All cost data for the cavity wall system was taken directly from the schedule of values provided by the general contractor. Figure 32, provided on the next page, provides a summary comparing the final costs. When the cavity wall components are compared to SlenderWall, the final price of the precast system comes in $277,034.09 below the total cost to install the cavity wall. This is a potential cost savings that would be directed towards the owner. A detailed cost takeoff of the SlenderWall System can be found in Appendix H.

SlenderWall Precast vs. Brick Veneer Cost Comparison		
Added Material		
Material	**Cost**	
SlenderWall	$	1,929,694
Foil Backed Blanket Insulation	$	83,218
Total:	**$**	**2,012,912**
Deleted Material		
Material	**Cost**	
Brick Veneer	$	1,765,620.80
Extruded Polystyrene Insul.	$	123,553.60
Exterior Sheathing	$	82,368.44
Air Barrier	$	73,884.00
Exterior Metal Studs	$	244,519.74
Total:	**$**	**2,289,946.58**
Cost Savings:	**$**	**277,034.09**

Figure 32: Façade Cost Comparison

From a contractor's perspective the most appealing attribute of a precast building façade is the ability to decrease the overall duration of the project schedule. SlenderWall claims that their Lift-and-Release panel-landing system allows a panel to be set every 19 minutes. To allow some extra time, a duration of 20 minutes per panel was used to calculate the overall time required to install the 48,242 ft^2 of panels. All durations required to install the brick veneer were taken directly from the provided project schedule. When reading the results, it is important to remember that the schedule savings is not directly related to overall time to complete each façade type, but rather the difference in the completion dates. The figure below reveals that the installation of the SlenderWall will require 32 less days than that of the brick veneer when considering the original construction schedule. The second half of Figure 33 provides a comparison of the two façade options related to the project schedule developed in Analysis Two.

Slenderwall Precast vs. Brick Veneer Schedule Comparison			
Original Construction Schedule			
Type	**Start Date**	**Finish Date**	**Total Duration**
SlenderWall	3/10/2010	5/3/2010	39
Brick Veneer	10/29/2009	6/15/2010	164
	Total Savings:	**32 Days**	
Schedule with Concrete Wall Bracing			
Type	**Start Date**	**Finish Date**	**Total Duration**
SlenderWall	1/8/2010	4/16/2010	39
Brick Veneer	10/29/2010	4/23/2009	127
	Total Savings:	**6 Days**	

Figure 33: Façade Schedule Comparison

It was surprising that the installation of the SlenderWall only provided a 32 day savings on the original schedule. However, when it is considered that the installation of the brick veneer can begin much earlier in the project than the precast panels, it is more easily understood. Also, the SlenderWall schedule is designed to allow the precast erection crew to complete their installation from start to finish without any delays or interruptions. Otherwise, the schedule would have been developed for the erection crew to complete two elevations and then return two months later to complete the remaining two elevations. In order to provide a smooth workflow, the schedule was developed requiring the crew to mobilize only one time.

Conclusions and Recommendations

Based upon the scheduling and cost information provide in Figures 32 and 33, it can easily b*e seen* that the installation of a SlenderWall system in lieu of brick veneer has the potential to greatly benefit both the owner and project team. Not only will the panels reduce the construction schedule by 32 days, but will also provide the owner with a savings of $277,034 that can be allocated elsewhere on the project or shaved from the overall budget. Both of these benefits are particularly important to any project, but they are especially important for this type of school project. Like most, this project is under pressure to be completed before the beginning of a new semester and any time savings during construction is greatly appreciated by both the owner and contractor alike. Also, it is becoming more difficult for districts to receive money for new projects, and a reduction in the overall cost would only make it easier to secure the loans from the state.

As my final recommendation, I would suggest that the owner and architect take time to seriously consider the application of SlenderWall or any similar precast wall product. Further, from speaking with a SlenderWall representative I believe that the overall cost of the system could be reduced further if slight changes were made to the building's appearance. As mentioned above, the cost estimate only considered slight adjustments in the layout of the building fenestrations. If the architect were willing to make more drastic changes to the building's appearance the project could be completed with a cost closer to $\$36/ft^2$ offering an additional saving potential of $192,969.

Master of Architectural Engineering Requirements

The work completed in Analysis Three was aided by material learned and gathered while taking AE 542: *Building Enclosure Science and Design*. Throughout the course, an emphasis was made on the evaluation of building façade performance and how it relates to other building systems. One of the main discussions, in terms of envelope performance, was the ability for a wall system to resist the flow of heat and moisture. By taking what was learned in the class and applying it to my proposed SlenderWall system and a standard cavity wall system, I was able to determine that the SlenderWall will perform to the same standard as the cavity wall. This is extremely important when considering changes to a building façade once the mechanical systems have already been specified. Any great change in the envelope performance could result in a drastically oversized or undersized mechanical system. Additionally, the class introduced the use of the H.A.M. Toolbox software, a simple program used to evaluate heat, moisture and air flow through wall systems. The program was used to assist in the evaluation of the SlenderWall panels versus the cavity wall system.

Summary and Closing Remarks

Through the construction of the New Moon Area High School and various other additions and renovations throughout the campus, the Moon Area School District hopes to provide their students with a high quality educational environment for decades to come. In the end, the success of this goal depends a great deal on the ability of the project team to design and construct the facilities in a quality manner within the allotted time. Throughout the three previously discussed analyses, attempts were made to develop strategies for assisting the project team in achieving their final goals.

Like any public school project in Pennsylvania, the new high school is employing the use of multiple prime contracts. In trying to incorporate Building Information Modeling into this widely used delivery method, it was determined that there is the potential for great benefits. However, the owners, designers, and contractors working in this area must first be willing to work together and make changes to the way they traditionally interacted. With the help of the newly developed AIA contracts, BIM has a good chance of surviving in the multiple prime world. The changes will need to occur slowly and mostly likely in the beginning mistakes will be made. Learning from the mistakes will be crucial for future success. With many industry members already utilizing 3D modeling tools, the transition to BIM is the next logical step in the progression of the industry. In the end, the eventual success of BIM in multiple prime contracting is going to depend on the willingness of owners to try something new.

The final two analyses were focused around creating alternate methods for the construction of the new high school. School projects are often under strict time constraints to be completed for the beginning of a new school year or semester. This makes it crucial for a project to remain on schedule from beginning to end. However, there are always instances when something unexpected occurs and a strategy must be developed to accelerate work in the event of a delay. Analysis One and Two describe methods for reducing the overall project schedule from a design and construction perspective.

The use of a bracing system to support the foundation wall in Areas C and E was determined to reduce the overall project schedule by 37 days and increase the projects general conditions allotment by $27,356. The selected bracing system, provided by Mabey Bridge & Shore, can easily be acquired by the general contractor from a local distribution center. While the existing design and construction of the wall are perfectly acceptable, the use of the bracing is strongly recommended. The savings to the project schedule has the potential to save more money than it will cost to use the Mabey System 160 braces, by reducing the amount of time the steel erectors are onsite. Overall, given the proper amount of time at the beginning of the project, it would be recommended to the project team that a bracing system be designed and acquired for the concrete foundation wall.

The final analysis was developed on the idea of eliminating dependence on the availability of the masonry contractor, to ensure that the installation of the building envelope remained on schedule. In order to achieve this goal, a proposal was made to implement the use of architectural precast panels. It was determined that SlenderWall, a non-traditional lightweight panel with integral metal studs, was the best for the job. The final SlenderWall design was determined to provide an overall savings of 32 days and $277,034 when compared to the traditional cavity wall system in the building's design. Also, with the analysis of the heat and moisture movement through both wall systems, it was concluded that the

SlenderWall will provide the same standard of envelope performance as was provided by the original design. As a final recommendation, the use of a precast wall system should be strongly considered for a project like the New Moon Area High School. Although, it is always best to consider this type of change while still in the early stages of design in order to maximize the potential savings.

The last two semesters of work have afforded me the opportunity to utilize the diverse knowledge provided by the Penn State Architectural Engineering Department. This has allowed me to gain a better appreciation for the interdisciplinary curriculum provided by Penn State. I am also very thankful for the willingness of industry members to assist me, many of whom were former Penn Staters. I would also, once again, like to thank my friends and family for their continued encouragement and support throughout my life. Finally, I would particularly like to thank my wife Jocelyn for her love and support, as well as her assistance in completing my senior thesis project.

Resources

American Institute of Architects. (2008). *AIA Document E202-2008.* AIA.

Beck, F. (2010, March 25). SlenderWall. (K. Brice, Interviewer)

Behr, D. R. (2010). AE 542: Building Enclosure Science and Design. University Park, Pennsylvania: The Pennsylvania State University.

Computer Integrated Construction Research Program. (2009). *BIM Project Execution Planning Guide Version 1.0.* University Park: The Pennsylvania State University.

Computer Integrated Construction Research Program. (2008). *BIM Uses*. Retrieved January 25, 2010, from Computer Integrated Construction Research Program Web Site: http://www.engr.psu.edu/ae/cic/bimex/bim_uses.aspx

Cooper, S. (2010, February 23). MEP Engineer. (K. Brice, Interviewer)

Das, B. M. (2007). *Principles of Foundation Engineering.* Ontario: Nelson.

Dedrick, J. (2008, September 18). *Organizing the Development of a Building Information Model*. Retrieved March 17, 2010, from AECbytes: http://www.aecbytes.com/feature/2008/MPSforBIM.html

Dubler, C. (2010, January 27). CIC Research Assistant. (K. Brice, Interviewer)

Easi-Set Industries. (2009). *SlenderWall: Feature and Benefits*. Retrieved March 15, 2010, from SlenderWall Architectural Precast Concrete and Steel Stud Building Panels: http://www.slenderwall.com/new_construction.shtml

Falso, J. (2010, February 23). Project Manager. (K. Brice, Interviewer)

Fulkerson, B. (2010, February). Project Administrator. (K. Brice, Interviewer)

Kibert, C. J. (2008). *Sustainable Construction: Green Buildind Design and Delivery.* Hoboken: John Wiley & Sons, Inc.

Mabey Bridge & Shore, Inc. (2008). *Mabey Bridge & Shore, Ins.: Structural Shoring*. Retrieved March 11, 2010, from Mabey Bridge & Shore, Inc.: http://www.mabey.com/ProductsServices/StructuralShoring/tabid/57/Default.aspx

Miller, R. (2010, February 26). W. G. Tomko. (K. Brice, Interviewer)

National Institute of Building Sciences. (2010). *Building Envelope Desing Guide*. Retrieved March 15, 2010, from Whole Building Design Guide: http://www.wbdg.org/design/envelope.php

Porreca, J. (2010, March 11). Mabey Bridge & Shore, Inc. (K. Brice, Interviewer)

Pospisil, J. (2010, February 26). Structural Engineer. (K. Brice, Interviewer)

Quirouette, R. (1999). H.A.M. Building Science Toolbox.

Reed Construction Data. (2010). *RSMeans Costsworks: Construction Cost Data*. Retrieved March 9, 2010, from RSMeans Costworks: http://meanscostworks.com/home/QuickStartGuide.aspx

Reese, M. (2010, February 19). Chief Draftsman. (K. Brice, Interviewer)

Renninger, C. (2010, February 12). Project Architect. (K. Brice, Interviewer)

Sach, L. C. (2009). *Multiple-Prime Top 10 Concerns Especially when . . .* CMAA.

Stein, B., Reynolds, J. S., Grondzik, W. T., & Kwok, A. G. (2006). *Mechanical and Electrical Equipment for Buildings.* Hoboken: John Wiley & Sons, Inc.

The American Institute of Architects. (2010). *Contract Documents*. Retrieved March 17, 2010, from The American Institute of Architects: http://aia.org/contractdocs/index.htm

M.A.E. Resources

Beck, F. (2010, March 25). SlenderWall. (K. Brice, Interviewer)

Behr, D. R. (2010). AE 542: Building Enclosure Science and Design. University Park, Pennsylvania: The Pennsylvania State University.

Easi-Set Industries. (2009). *SlenderWall: Feature and Benefits*. Retrieved March 15, 2010, from SlenderWall Architectural Precast Concrete and Steel Stud Building Panels: http://www.slenderwall.com/new_construction.shtml

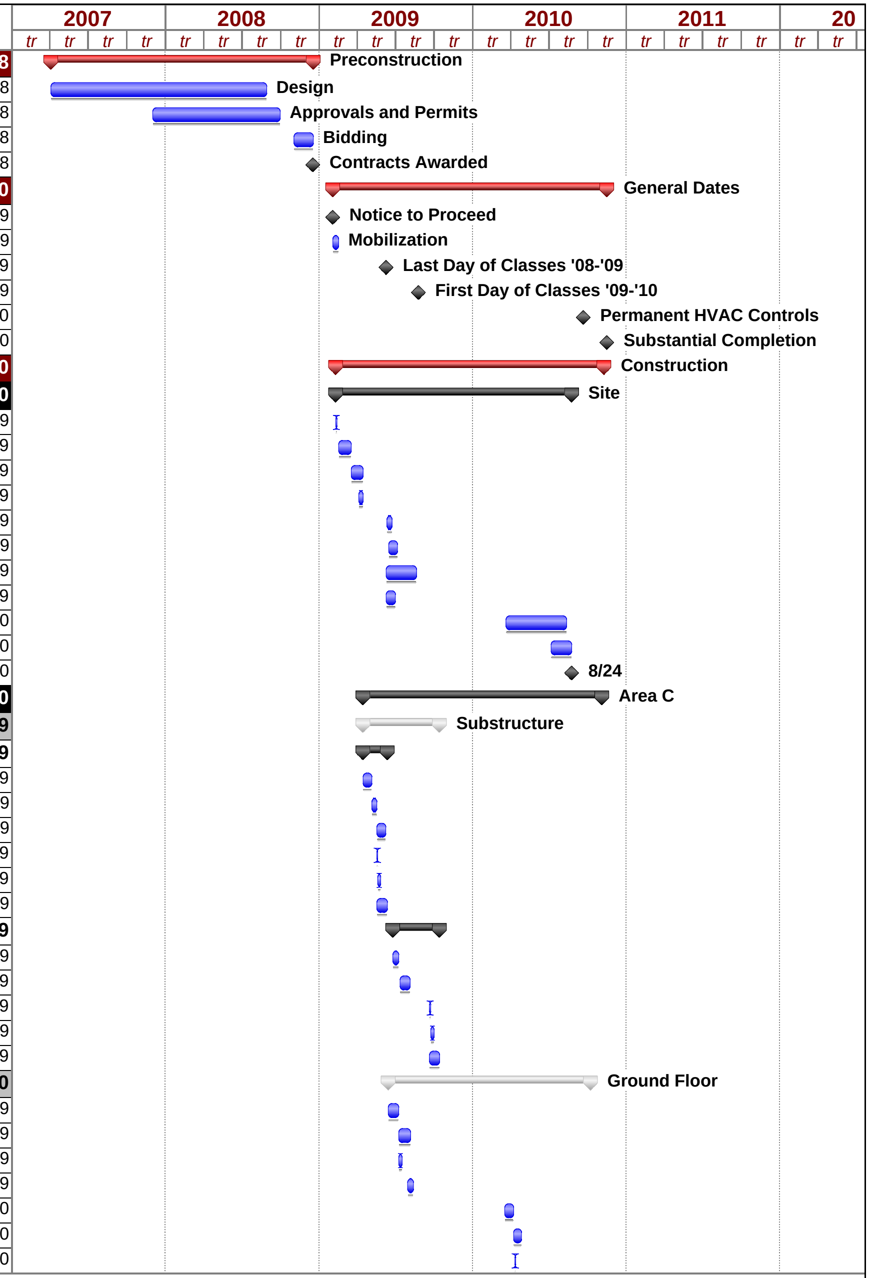
Quirouette, R. (1999). H.A.M. Building Science Toolbox.

Stein, B., Reynolds, J. S., Grondzik, W. T., & Kwok, A. G. (2006). *Mechanical and Electrical Equipment for Buildings.* Hoboken: John Wiley & Sons, Inc.

National Institute of Building Sciences. (2010). *Building Envelope Desing Guide*. Retrieved March 15, 2010, from Whole Building Design Guide: http://www.wbdg.org/design/envelope.php

Appendix A: Overall Construction Schedule

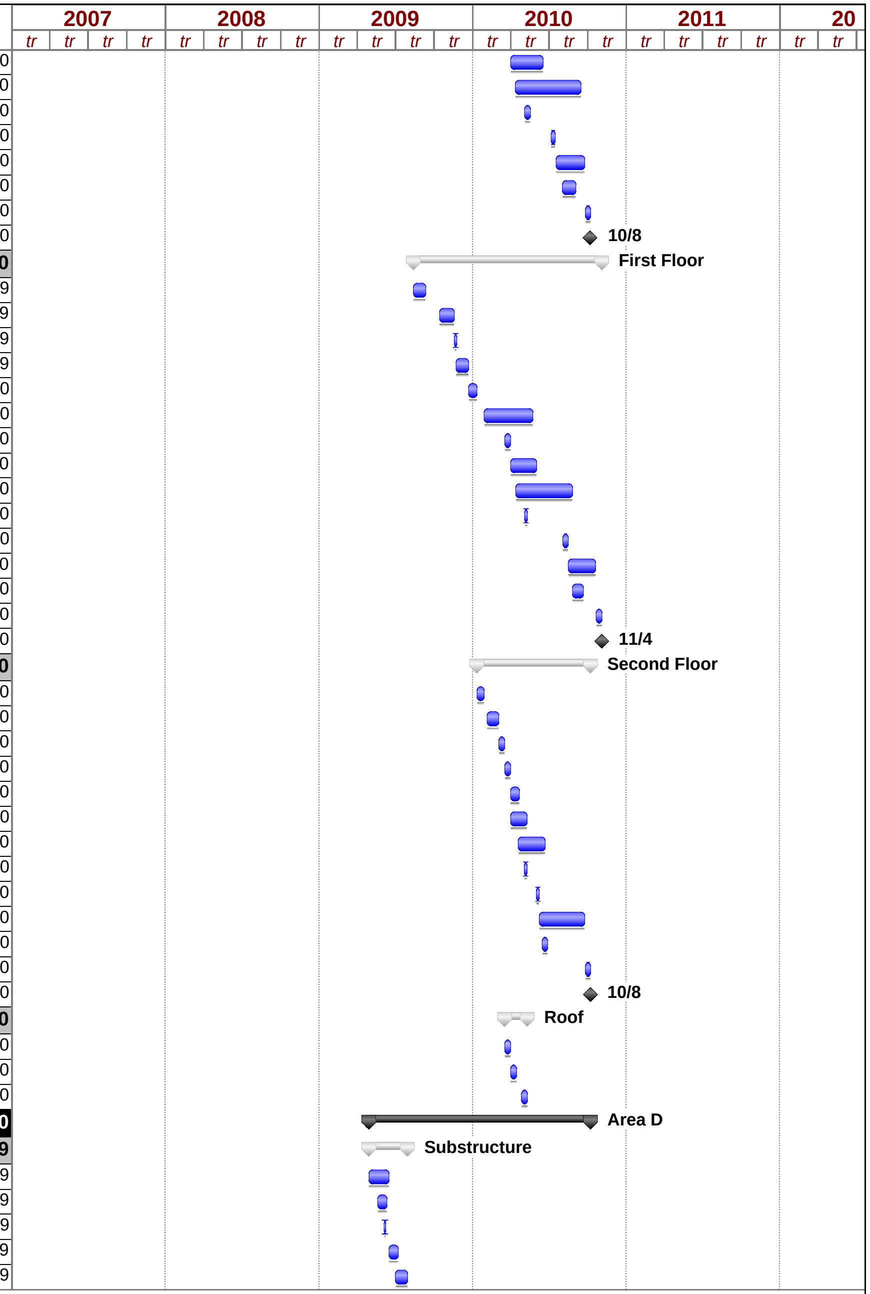
ID	Task Name	Duration	Start	Finish
1	**Preconstruction**	**446 days**	**Thu 4/5/07**	**Thu 12/18/08**
2	Design	367 days	Thu 4/5/07	Fri 8/29/08
3	Approvals and Permits	217 days	Mon 12/3/07	Tue 9/30/08
4	Bidding	34 days	Mon 11/3/08	Thu 12/18/08
5	Contracts Awarded	0 days	Thu 12/18/08	Thu 12/18/08
6	**General Dates**	**466 days**	**Tue 2/3/09**	**Tue 11/16/10**
7	Notice to Proceed	0 days	Tue 2/3/09	Tue 2/3/09
8	Mobilization	10 days	Tue 2/3/09	Mon 2/16/09
9	Last Day of Classes '08-'09	0 days	Wed 6/10/09	Wed 6/10/09
10	First Day of Classes '09-'10	0 days	Tue 8/25/09	Tue 8/25/09
11	Permanent HVAC Controls	0 days	Wed 9/22/10	Wed 9/22/10
12	Substantial Completion	0 days	Tue 11/16/10	Tue 11/16/10
13	**Construction**	**456 days**	**Tue 2/10/09**	**Tue 11/9/10**
14	**Site**	**401 days**	**Tue 2/10/09**	**Tue 8/24/10**
15	Silt Fence / E&S Control	3 days	Tue 2/10/09	Thu 2/12/09
16	Site Demolition	22 days	Tue 2/17/09	Wed 3/18/09
17	Bulk Cut for Basement	20 days	Thu 3/19/09	Wed 4/15/09
18	Detention Tanks	8 days	Mon 4/6/09	Wed 4/15/09
19	Swimming Pool Excavation	8 days	Fri 6/12/09	Tue 6/23/09
20	Excavate to Grade	15 days	Tue 6/16/09	Mon 7/6/09
21	North and Northwest site	52 days	Wed 6/10/09	Thu 8/20/09
22	Site Utilities	16 days	Wed 6/10/09	Wed 7/1/09
23	Baseball Field	104 days	Mon 3/22/10	Thu 8/12/10
24	Landscape	35 days	Wed 7/7/10	Tue 8/24/10
25	Complete Site work	0 days	Tue 8/24/10	Tue 8/24/10
26	**Area C**	**406 days**	**Thu 4/16/09**	**Thu 11/4/10**
27	**Substructure**	**130 days**	**Thu 4/16/09**	**Wed 10/14/09**
28	**Ground Floor**	**42 days**	**Thu 4/16/09**	**Fri 6/12/09**
29	Install Caissons	15 days	Thu 4/16/09	Wed 5/6/09
30	Install Grade Beams	8 days	Thu 5/7/09	Mon 5/18/09
31	Concrete Walls	15 days	Tue 5/19/09	Mon 6/8/09
32	CMU to Grade	2 days	Tue 5/19/09	Wed 5/20/09
33	Perimeter Insulation and Waterproofing	5 days	Thu 5/21/09	Wed 5/27/09
34	MEP Underground RI	19 days	Tue 5/19/09	Fri 6/12/09
35	**First Floor**	**79 days**	**Fri 6/26/09**	**Wed 10/14/09**
36	Install Caissons	10 days	Fri 6/26/09	Thu 7/9/09
37	Install Grade Beams	18 days	Mon 7/13/09	Wed 8/5/09
38	CMU to Grade	3 days	Mon 9/21/09	Wed 9/23/09
39	Perimeter Insulation and Waterproofing	6 days	Thu 9/24/09	Thu 10/1/09
40	MEP Underground RI	18 days	Mon 9/21/09	Wed 10/14/09
41	**Ground Floor**	**345 days**	**Mon 6/15/09**	**Fri 10/8/10**
42	Prep/Pour SOG	19 days	Mon 6/15/09	Thu 7/9/09
43	CMU to First Floor Bearing	20 days	Fri 7/10/09	Thu 8/6/09
44	Set Hollow Metal Frames	6 days	Fri 7/10/09	Fri 7/17/09
45	Erect Steel and Deck for First Floor	10 days	Fri 7/31/09	Thu 8/13/09
46	Exterior Masonry	15 days	Fri 3/19/10	Thu 4/8/10
47	Curtain Wall and Windows	13 days	Fri 4/9/10	Tue 4/27/10
48	Fireproofing	2 days	Mon 4/12/10	Tue 4/13/10



Project: New Moon Area High School & District Admin. Office
Date: 4/7/2010

Task		Milestone		External Tasks	
Split		Summary		External Milestone	
Progress		Project Summary		Deadline	

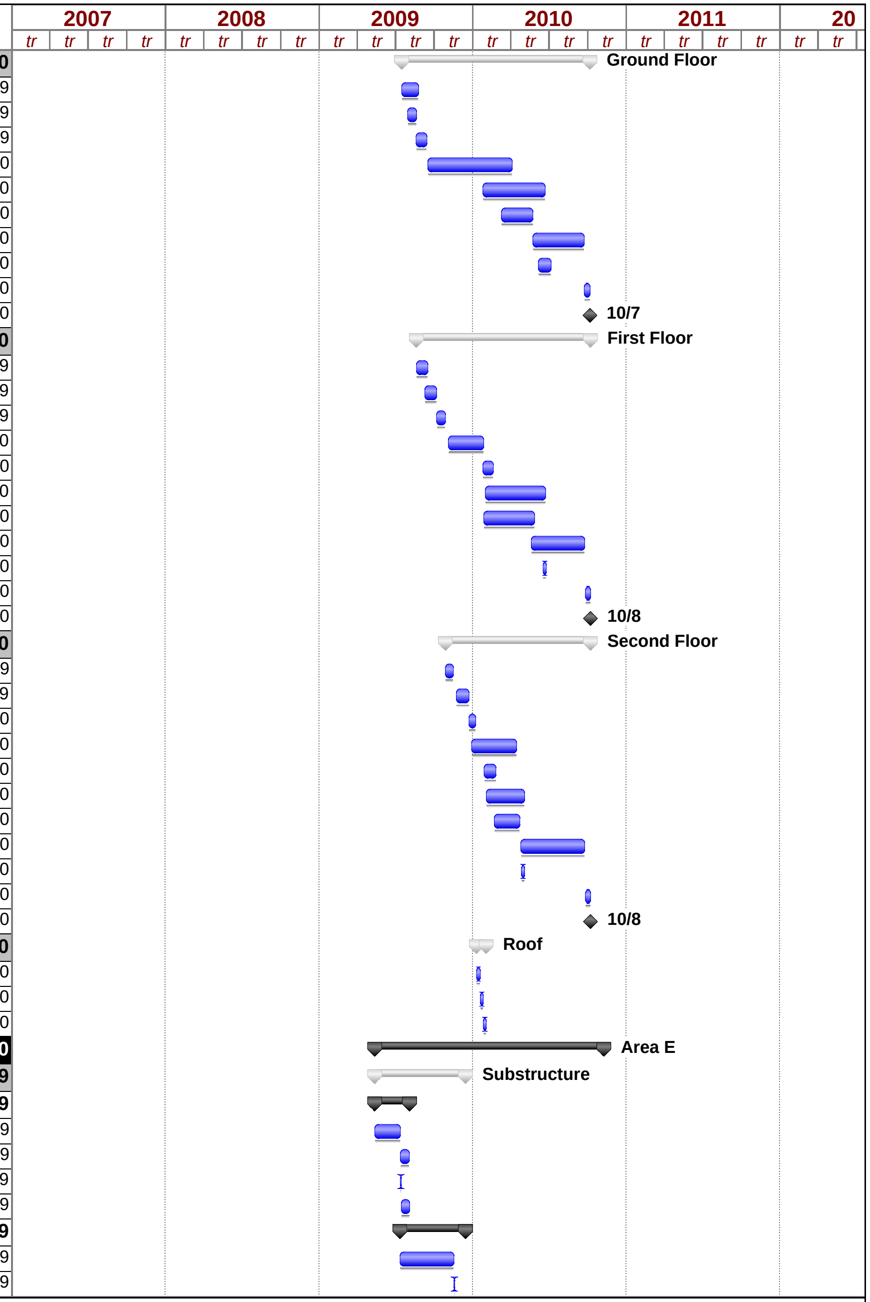
ID	Task Name	Duration	Start	Finish
49	MEP Overhead RI	55 days	Fri 4/2/10	Thu 6/17/10
50	MEP Installation	112 days	Tue 4/13/10	Wed 9/15/10
51	Standard Gauge Framing	10 days	Wed 5/5/10	Tue 5/18/10
52	Drywall	8 days	Wed 7/7/10	Fri 7/16/10
53	Interior Finishes	50 days	Mon 7/19/10	Fri 9/24/10
54	MEP Testing	24 days	Tue 8/3/10	Fri 9/3/10
55	Punch List Area C.1	10 days	Mon 9/27/10	Fri 10/8/10
56	Complete Area C.1	0 days	Fri 10/8/10	Fri 10/8/10
57	**First Floor**	**320 days**	**Fri 8/14/09**	**Thu 11/4/10**
58	Rough-in/Place SOD	21 days	Fri 8/14/09	Fri 9/11/09
59	Prep/Pour SOG	25 days	Thu 10/15/09	Wed 11/18/09
60	Set Hollow Metal Frames	4 days	Thu 11/19/09	Tue 11/24/09
61	CMU to Second Floor Bearing	22 days	Mon 11/23/09	Tue 12/22/09
62	Erect Steel and Deck for 2nd Floor	14 days	Wed 12/23/09	Mon 1/11/10
63	MEP Overhead RI	82 days	Fri 1/29/10	Mon 5/24/10
64	Exterior Masonry - Veneer	10 days	Fri 3/19/10	Thu 4/1/10
65	Curtain Wall and Windows	44 days	Fri 4/2/10	Wed 6/2/10
66	MEP Installation	97 days	Wed 4/14/10	Thu 8/26/10
67	Standard Gauge Framing	5 days	Wed 5/5/10	Tue 5/11/10
68	Drywall	9 days	Wed 8/4/10	Mon 8/16/10
69	Interior Finishes	47 days	Tue 8/17/10	Wed 10/20/10
70	MEP Testing	18 days	Fri 8/27/10	Tue 9/21/10
71	Punch List Area C.2	10 days	Fri 10/22/10	Thu 11/4/10
72	Complete Area C.2	0 days	Thu 11/4/10	Thu 11/4/10
73	**Second Floor**	**194 days**	**Tue 1/12/10**	**Fri 10/8/10**
74	Rough-in/Place SOD	13 days	Tue 1/12/10	Thu 1/28/10
75	CMU to Roof Bearing	20 days	Fri 2/5/10	Thu 3/4/10
76	Erect Steel and Deck for Roof	10 days	Fri 3/5/10	Thu 3/18/10
77	Exterior Masonry - Veneer	10 days	Fri 3/19/10	Thu 4/1/10
78	Curtain Wall and Windows	15 days	Fri 4/2/10	Thu 4/22/10
79	MEP Overhead RI	27 days	Fri 4/2/10	Mon 5/10/10
80	MEP Installation	46 days	Tue 4/20/10	Tue 6/22/10
81	Standard Gauge Framing	5 days	Tue 5/4/10	Mon 5/10/10
82	Drywall	5 days	Wed 6/2/10	Tue 6/8/10
83	Interior Finishes	78 days	Wed 6/9/10	Fri 9/24/10
84	MEP Testing	9 days	Wed 6/16/10	Mon 6/28/10
85	Punch List Area C.3	10 days	Mon 9/27/10	Fri 10/8/10
86	Complete Area C.3	0 days	Fri 10/8/10	Fri 10/8/10
87	**Roof**	**38 days**	**Fri 3/19/10**	**Tue 5/11/10**
88	Install EPDM Roofing	10 days	Fri 3/19/10	Thu 4/1/10
89	Install Roof Screens	10 days	Fri 4/2/10	Thu 4/15/10
90	Final MEP Connections	10 days	Wed 4/28/10	Tue 5/11/10
91	**Area D**	**377 days**	**Thu 4/30/09**	**Fri 10/8/10**
92	**Substructure**	**66 days**	**Thu 4/30/09**	**Thu 7/30/09**
93	Install Caissons and Grade Beams	34 days	Thu 4/30/09	Tue 6/16/09
94	Sheet Piling and Pool	16 days	Thu 5/21/09	Thu 6/11/09
95	CMU to Grade	2 days	Fri 6/5/09	Mon 6/8/09
96	MEP Underground RI	16 days	Wed 6/17/09	Wed 7/8/09
97	CMU to First Floor Bearing	21 days	Thu 7/2/09	Thu 7/30/09



Project: New Moon Area High School & District Admin. Office
Date: 4/7/2010

Task		Milestone		External Tasks	
Split		Summary		External Milestone	
Progress		Project Summary		Deadline	

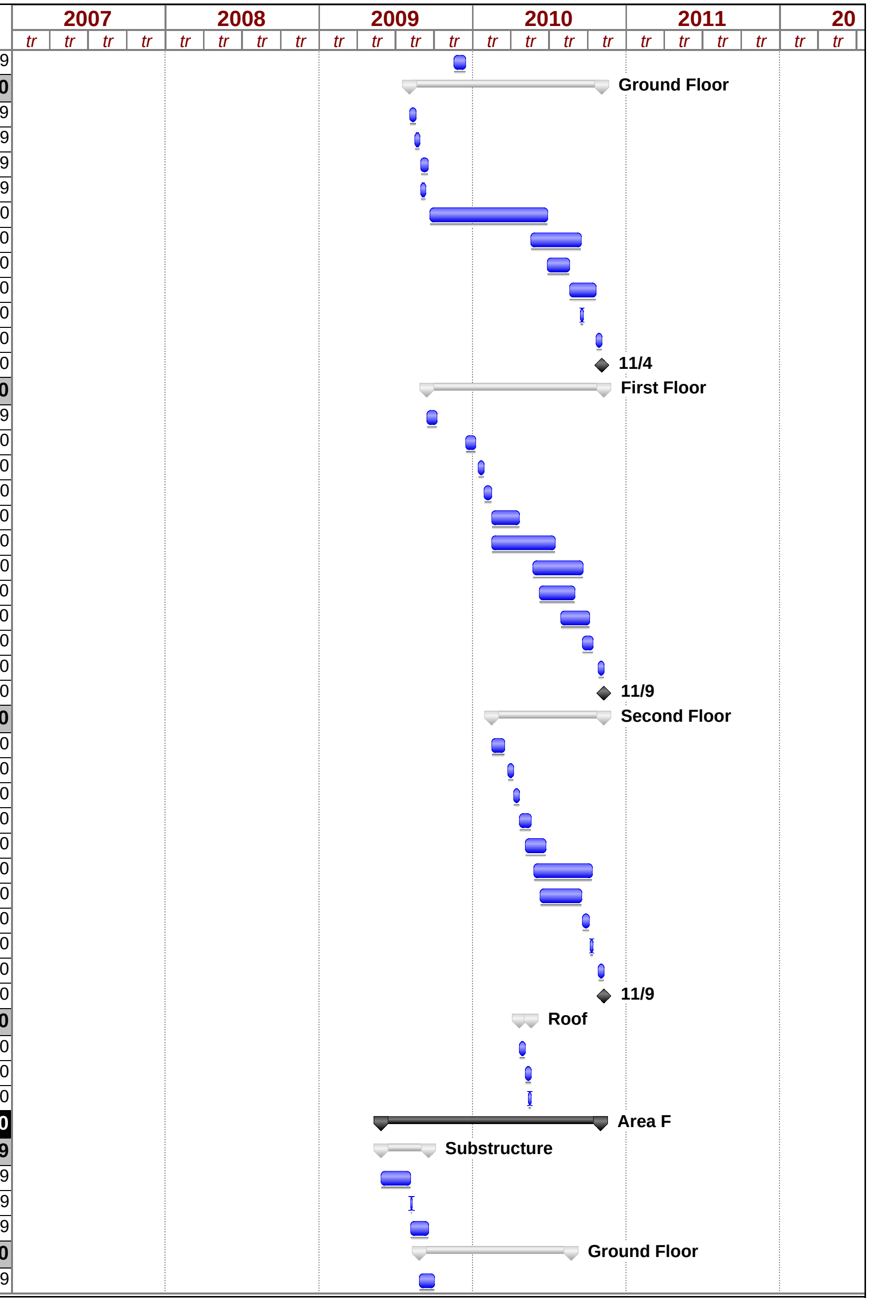
ID	Task Name	Duration	Start	Finish
98	**Ground Floor**	**320 days**	**Fri 7/17/09**	**Thu 10/7/10**
99	Building Envelope	28 days	Fri 7/17/09	Tue 8/25/09
100	Erect Steel and Deck for First Floor	15 days	Fri 7/31/09	Thu 8/20/09
101	Prep/Pour SOG	18 days	Thu 8/20/09	Mon 9/14/09
102	MEP Overhead RI	143 days	Thu 9/17/09	Mon 4/5/10
103	MEP Installation	106 days	Tue 1/26/10	Tue 6/22/10
104	Framing and Drywall	53 days	Thu 3/11/10	Mon 5/24/10
105	Interior Finishes	88 days	Tue 5/25/10	Thu 9/23/10
106	MEP Testing	22 days	Mon 6/7/10	Tue 7/6/10
107	Punch List Area D.1	10 days	Fri 9/24/10	Thu 10/7/10
108	Complete Area D.1	0 days	Thu 10/7/10	Thu 10/7/10
109	**First Floor**	**296 days**	**Fri 8/21/09**	**Fri 10/8/10**
110	Rough-in/Place SOD	19 days	Fri 8/21/09	Wed 9/16/09
111	CMU to Second Floor and Low Roof	20 days	Thu 9/10/09	Wed 10/7/09
112	Erect Steel and Deck for 2nd Floor	15 days	Thu 10/8/09	Wed 10/28/09
113	Building Envelope	60 days	Thu 11/5/09	Wed 1/27/10
114	MEP Overhead RI	19 days	Tue 1/26/10	Fri 2/19/10
115	MEP Installation	103 days	Mon 2/1/10	Wed 6/23/10
116	Framing and Drywall	87 days	Thu 1/28/10	Fri 5/28/10
117	Interior Finishes	91 days	Fri 5/21/10	Fri 9/24/10
118	MEP Testing	6 days	Fri 6/18/10	Fri 6/25/10
119	Punch List Area D.2	10 days	Mon 9/27/10	Fri 10/8/10
120	Complete Area D.2	0 days	Fri 10/8/10	Fri 10/8/10
121	**Second Floor**	**247 days**	**Thu 10/29/09**	**Fri 10/8/10**
122	Rough-in/Place SOD	13 days	Thu 10/29/09	Mon 11/16/09
123	CMU to Roof Bearing	22 days	Tue 11/24/09	Wed 12/23/09
124	Erect Steel and Deck for Roof	12 days	Thu 12/24/09	Fri 1/8/10
125	Building Envelope	77 days	Wed 12/30/09	Thu 4/15/10
126	MEP Overhead RI	20 days	Fri 1/29/10	Thu 2/25/10
127	MEP Installation	65 days	Wed 2/3/10	Tue 5/4/10
128	Framing and Drywall	45 days	Mon 2/22/10	Fri 4/23/10
129	Interior Finishes	110 days	Mon 4/26/10	Fri 9/24/10
130	MEP Testing	5 days	Wed 4/28/10	Tue 5/4/10
131	Punch List Area D.3	10 days	Mon 9/27/10	Fri 10/8/10
132	Complete Area D.3	0 days	Fri 10/8/10	Fri 10/8/10
133	**Roof**	**17 days**	**Mon 1/11/10**	**Tue 2/2/10**
134	Install EPDM Roofing	7 days	Mon 1/11/10	Tue 1/19/10
135	Final MEP Connections	5 days	Wed 1/20/10	Tue 1/26/10
136	Install Roof Screens	5 days	Wed 1/27/10	Tue 2/2/10
137	**Area E**	**389 days**	**Thu 5/14/09**	**Tue 11/9/10**
138	**Substructure**	**154 days**	**Thu 5/14/09**	**Tue 12/15/09**
139	**Ground Floor**	**59 days**	**Thu 5/14/09**	**Tue 8/4/09**
140	Install Caissons and Grade Beams	43 days	Thu 5/14/09	Mon 7/13/09
141	Concrete Walls	15 days	Tue 7/14/09	Mon 8/3/09
142	CMU to Grade	2 days	Tue 7/14/09	Wed 7/15/09
143	MEP Underground RI	14 days	Thu 7/16/09	Tue 8/4/09
144	**First Floor**	**112 days**	**Mon 7/13/09**	**Tue 12/15/09**
145	Install Caissons and Grade Beams	92 days	Mon 7/13/09	Tue 11/17/09
146	CMU to Grade	2 days	Wed 11/18/09	Thu 11/19/09



Project: New Moon Area High School & District Admin. Office
Date: 4/7/2010

Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline

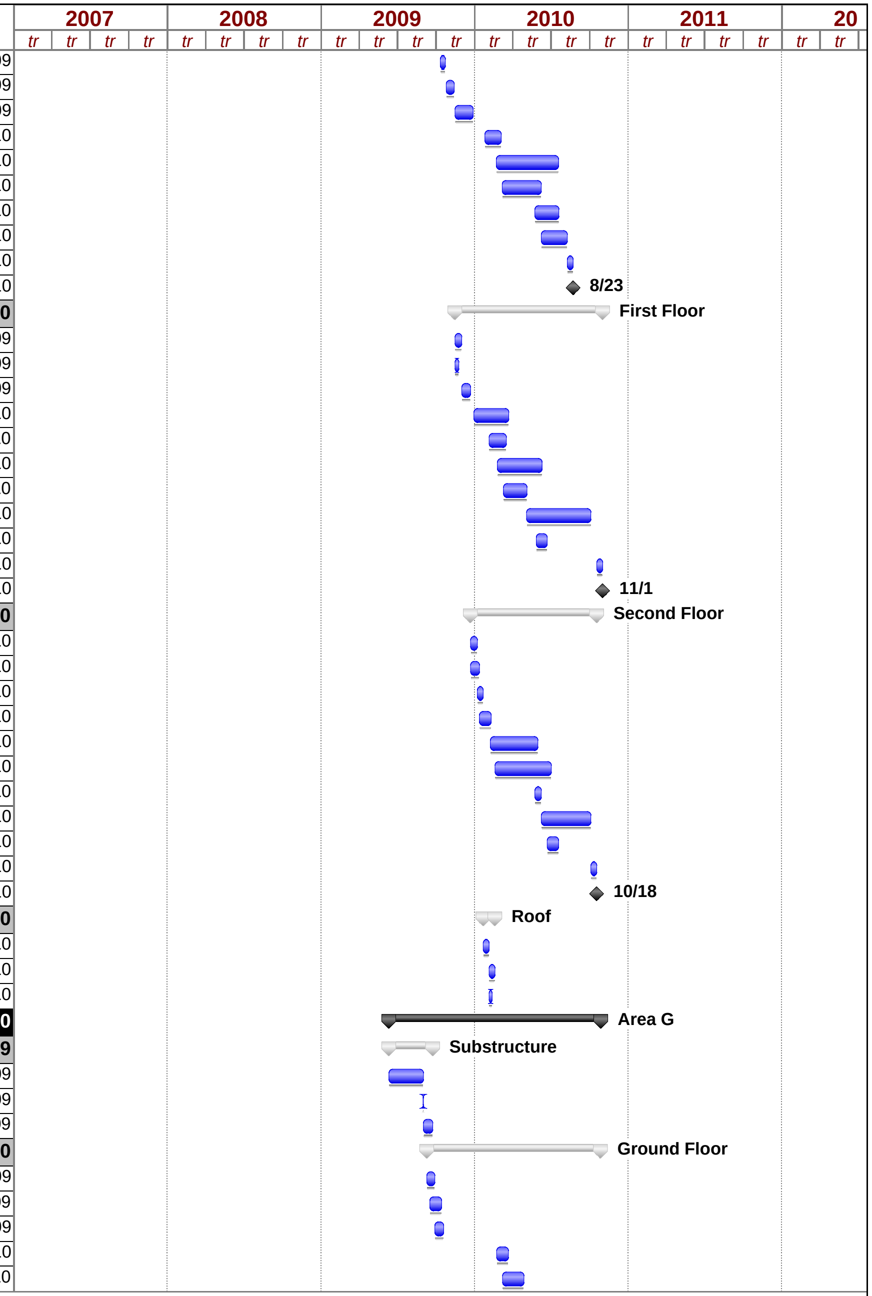
ID	Task Name	Duration	Start	Finish
147	MEP Underground RI	20 days	Wed 11/18/09	Tue 12/15/09
148	**Ground Floor**	**327 days**	**Wed 8/5/09**	**Thu 11/4/10**
149	Prep/Pour SOG	11 days	Wed 8/5/09	Wed 8/19/09
150	CMU to First Floor Bearing	10 days	Mon 8/17/09	Fri 8/28/09
151	Building Envelope	14 days	Mon 8/31/09	Thu 9/17/09
152	Erect Steel and Deck for First Floor	10 days	Mon 8/31/09	Fri 9/11/09
153	MEP Overhead RI	200 days	Tue 9/22/09	Mon 6/28/10
154	MEP Installation	86 days	Thu 5/20/10	Thu 9/16/10
155	Framing and Drywall	39 days	Mon 6/28/10	Thu 8/19/10
156	Interior Finishes	45 days	Fri 8/20/10	Thu 10/21/10
157	MEP Testing	5 days	Wed 9/15/10	Tue 9/21/10
158	Punch List Area E.1	10 days	Fri 10/22/10	Thu 11/4/10
159	Complete Area E.1	0 days	Thu 11/4/10	Thu 11/4/10
160	**First Floor**	**301 days**	**Tue 9/15/09**	**Tue 11/9/10**
161	Rough-in/Place SOD	18 days	Tue 9/15/09	Thu 10/8/09
162	Prep/Pour SOG	18 days	Wed 12/16/09	Fri 1/8/10
163	CMU to Second Floor and Low Roof	10 days	Fri 1/15/10	Thu 1/28/10
164	Erect Steel and Deck for 2nd Floor	12 days	Fri 1/29/10	Mon 2/15/10
165	Building Envelope	48 days	Tue 2/16/10	Thu 4/22/10
166	MEP Overhead RI	109 days	Tue 2/16/10	Fri 7/16/10
167	MEP Installation	85 days	Tue 5/25/10	Mon 9/20/10
168	Framing and Drywall	61 days	Wed 6/9/10	Wed 9/1/10
169	Interior Finishes	49 days	Fri 7/30/10	Wed 10/6/10
170	MEP Testing	19 days	Mon 9/20/10	Thu 10/14/10
171	Punch List Area E.2	10 days	Wed 10/27/10	Tue 11/9/10
172	Complete Area E.2	0 days	Tue 11/9/10	Tue 11/9/10
173	**Second Floor**	**191 days**	**Tue 2/16/10**	**Tue 11/9/10**
174	Rough-in/Place SOD	23 days	Tue 2/16/10	Thu 3/18/10
175	CMU to Roof Bearing	10 days	Fri 3/26/10	Thu 4/8/10
176	Erect Steel and Deck for Roof	10 days	Fri 4/9/10	Thu 4/22/10
177	Building Envelope	20 days	Fri 4/23/10	Thu 5/20/10
178	MEP Overhead RI	35 days	Fri 5/7/10	Thu 6/24/10
179	MEP Installation	99 days	Thu 5/27/10	Tue 10/12/10
180	Framing and Drywall	71 days	Fri 6/11/10	Fri 9/17/10
181	Interior Finishes	12 days	Mon 9/20/10	Tue 10/5/10
182	MEP Testing	5 days	Fri 10/8/10	Thu 10/14/10
183	Punch List Area E.3	10 days	Wed 10/27/10	Tue 11/9/10
184	Complete Area E.3	0 days	Tue 11/9/10	Tue 11/9/10
185	**Roof**	**20 days**	**Fri 4/23/10**	**Thu 5/20/10**
186	Install EPDM Roofing	10 days	Fri 4/23/10	Thu 5/6/10
187	Install Roof Screens	10 days	Fri 5/7/10	Thu 5/20/10
188	Final MEP Connections	5 days	Fri 5/14/10	Thu 5/20/10
189	**Area F**	**372 days**	**Fri 5/29/09**	**Mon 11/1/10**
190	**Substructure**	**81 days**	**Fri 5/29/09**	**Fri 9/18/09**
191	Install Caissons and Grade Beams	50 days	Fri 5/29/09	Thu 8/6/09
192	CMU to Grade	2 days	Fri 8/7/09	Mon 8/10/09
193	MEP Underground RI	31 days	Fri 8/7/09	Fri 9/18/09
194	**Ground Floor**	**257 days**	**Fri 8/28/09**	**Mon 8/23/10**
195	Prep/Pour SOG	26 days	Fri 8/28/09	Fri 10/2/09



Project: New Moon Area High School & District Admin. Office
Date: 4/7/2010

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

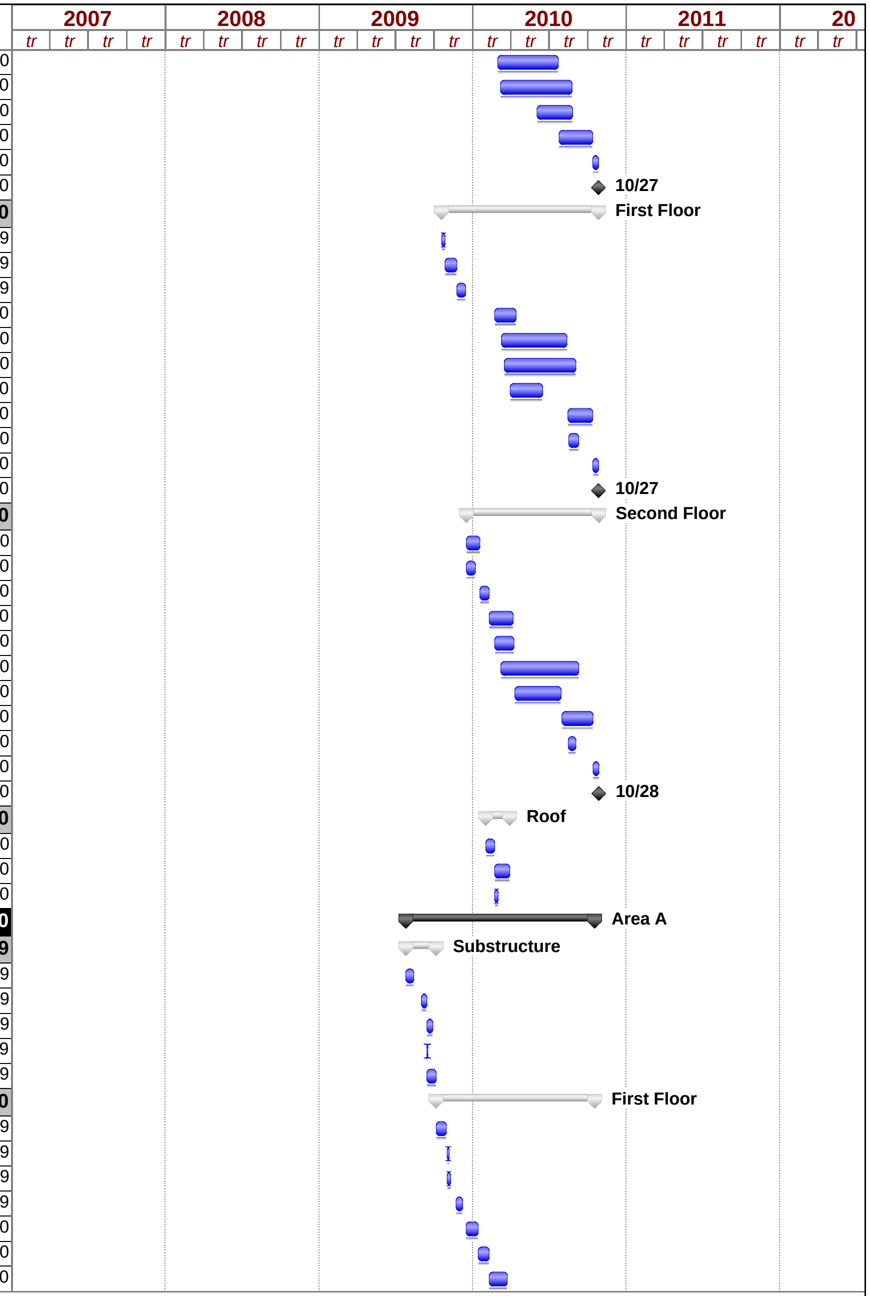
ID	Task Name	Duration	Start	Finish
196	CMU to First Floor Bearing	10 days	Mon 10/12/09	Fri 10/23/09
197	Erect Steel and Deck for First Floor	15 days	Mon 10/26/09	Fri 11/13/09
198	Building Envelope	31 days	Mon 11/16/09	Mon 12/28/09
199	MEP Overhead RI	29 days	Tue 1/26/10	Fri 3/5/10
200	MEP Installation	106 days	Mon 2/22/10	Mon 7/19/10
201	Framing and Drywall	67 days	Mon 3/8/10	Tue 6/8/10
202	MEP Testing	41 days	Tue 5/25/10	Tue 7/20/10
203	Interior Finishes	44 days	Wed 6/9/10	Mon 8/9/10
204	Punch List Area F.1	10 days	Tue 8/10/10	Mon 8/23/10
205	Complete Area F.1	0 days	Mon 8/23/10	Mon 8/23/10
206	**First Floor**	**251 days**	**Mon 11/16/09**	**Mon 11/1/10**
207	CMU to Second Floor and Low Roof	12 days	Mon 11/16/09	Tue 12/1/09
208	Rough-in/Place SOD	7 days	Mon 11/16/09	Tue 11/24/09
209	Erect Steel and Deck for 2nd Floor	15 days	Wed 12/2/09	Tue 12/22/09
210	Building Envelope	59 days	Thu 12/31/09	Tue 3/23/10
211	MEP Overhead RI	29 days	Fri 2/5/10	Wed 3/17/10
212	MEP Installation	76 days	Thu 2/25/10	Thu 6/10/10
213	Framing and Drywall	40 days	Thu 3/11/10	Wed 5/5/10
214	Interior Finishes	109 days	Wed 5/5/10	Mon 10/4/10
215	MEP Testing	18 days	Fri 5/28/10	Tue 6/22/10
216	Punch List Area F.2	10 days	Tue 10/19/10	Mon 11/1/10
217	Complete Area F.2	0 days	Mon 11/1/10	Mon 11/1/10
218	**Second Floor**	**214 days**	**Wed 12/23/09**	**Mon 10/18/10**
219	CMU to Roof Bearing	12 days	Wed 12/23/09	Thu 1/7/10
220	Rough-in/Place SOD	15 days	Wed 12/23/09	Tue 1/12/10
221	Erect Steel and Deck for Roof	10 days	Fri 1/8/10	Thu 1/21/10
222	Building Envelope	20 days	Wed 1/13/10	Tue 2/9/10
223	MEP Overhead RI	81 days	Mon 2/8/10	Mon 5/31/10
224	MEP Installation	96 days	Fri 2/19/10	Fri 7/2/10
225	Framing and Drywall	11 days	Tue 5/25/10	Tue 6/8/10
226	Interior Finishes	84 days	Wed 6/9/10	Mon 10/4/10
227	MEP Testing	19 days	Wed 6/23/10	Mon 7/19/10
228	Punch List Area F.3	10 days	Tue 10/5/10	Mon 10/18/10
229	Complete Area F.3	0 days	Mon 10/18/10	Mon 10/18/10
230	**Roof**	**20 days**	**Fri 1/22/10**	**Thu 2/18/10**
231	Install EPDM Roofing	10 days	Fri 1/22/10	Thu 2/4/10
232	Install Roof Screens	10 days	Fri 2/5/10	Thu 2/18/10
233	Final MEP Connections	5 days	Fri 2/5/10	Thu 2/11/10
234	**Area G**	**360 days**	**Fri 6/12/09**	**Thu 10/28/10**
235	**Substructure**	**74 days**	**Fri 6/12/09**	**Wed 9/23/09**
236	Install Caissons and Grade Beams	58 days	Fri 6/12/09	Tue 9/1/09
237	CMU to Grade	1 day	Tue 9/1/09	Tue 9/1/09
238	MEP Underground RI	16 days	Wed 9/2/09	Wed 9/23/09
239	**Ground Floor**	**295 days**	**Thu 9/10/09**	**Wed 10/27/10**
240	CMU to First Floor Bearing	13 days	Thu 9/10/09	Mon 9/28/09
241	Prep/Pour SOG	20 days	Thu 9/17/09	Wed 10/14/09
242	Erect Steel and Deck for First Floor	15 days	Tue 9/29/09	Mon 10/19/09
243	MEP Overhead RI	20 days	Tue 2/23/10	Mon 3/22/10
244	Building Envelope	37 days	Tue 3/9/10	Wed 4/28/10



Project: New Moon Area High School & District Admin. Office
Date: 4/7/2010

Task	Milestone	External Tasks
Split	Summary	External Milestone
Progress	Project Summary	Deadline

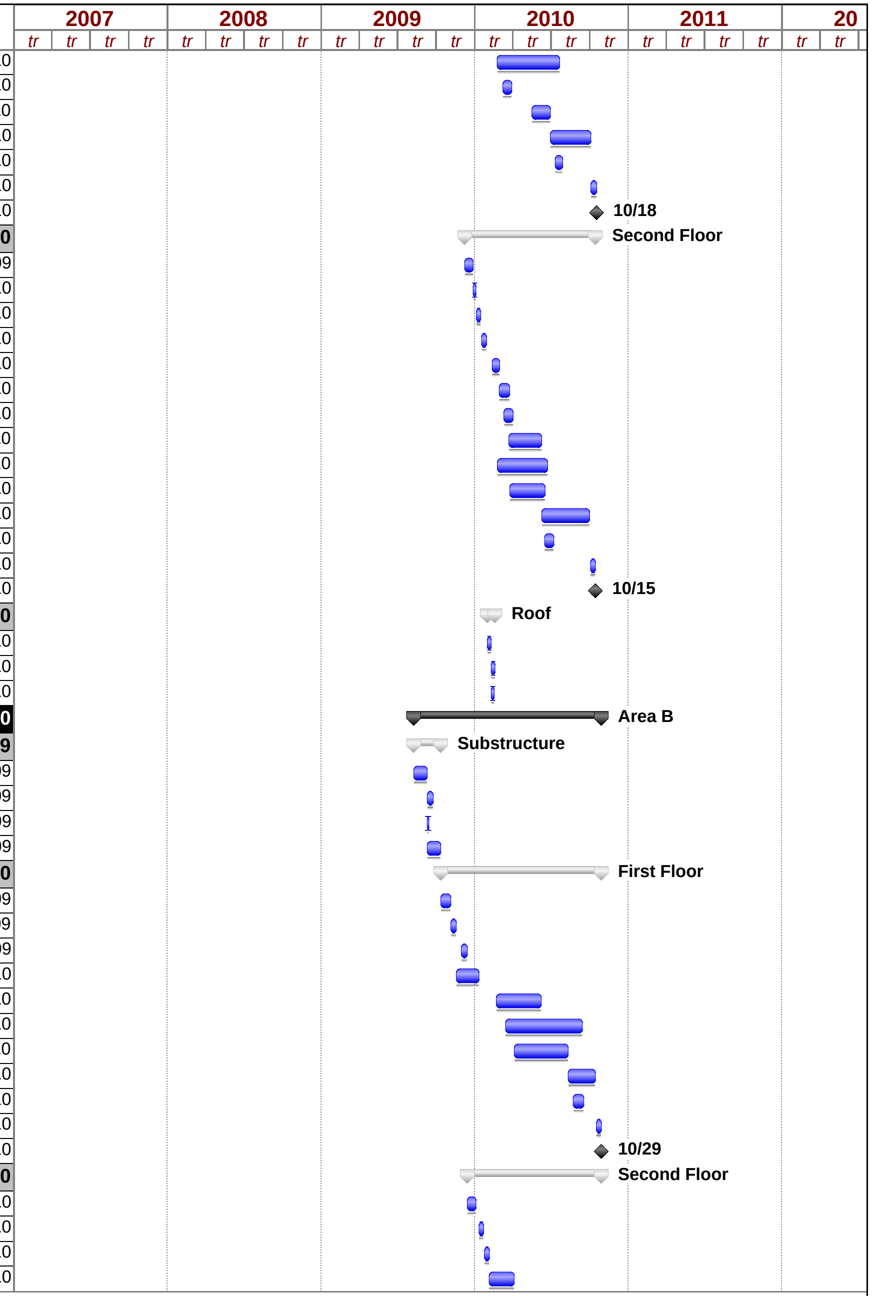
ID	Task Name	Duration	Start	Finish
245	Framing and Drywall	104 days	Tue 3/2/10	Fri 7/23/10
246	MEP Installation	122 days	Tue 3/9/10	Wed 8/25/10
247	MEP Testing	60 days	Fri 6/4/10	Thu 8/26/10
248	Interior Finishes	58 days	Mon 7/26/10	Wed 10/13/10
249	Punch List Area G.1	10 days	Thu 10/14/10	Wed 10/27/10
250	Complete Area G.1	0 days	Wed 10/27/10	Wed 10/27/10
251	**First Floor**	**267 days**	**Tue 10/20/09**	**Wed 10/27/10**
252	Rough-in/Place SOD	6 days	Tue 10/20/09	Tue 10/27/09
253	CMU to Second Floor and Low Roof	20 days	Wed 10/28/09	Tue 11/24/09
254	Erect Steel and Deck for 2nd Floor	15 days	Wed 11/25/09	Tue 12/15/09
255	MEP Overhead RI	37 days	Tue 2/23/10	Wed 4/14/10
256	Framing and Drywall	112 days	Thu 3/11/10	Fri 8/13/10
257	MEP Installation	122 days	Thu 3/18/10	Fri 9/3/10
258	Building Envelope	55 days	Thu 4/1/10	Wed 6/16/10
259	Interior Finishes	43 days	Mon 8/16/10	Wed 10/13/10
260	MEP Testing	18 days	Wed 8/18/10	Fri 9/10/10
261	Punch List Area G.2	10 days	Thu 10/14/10	Wed 10/27/10
262	Complete Area G.2	0 days	Wed 10/27/10	Wed 10/27/10
263	**Second Floor**	**225 days**	**Fri 12/18/09**	**Thu 10/28/10**
264	CMU to Roof Bearing	22 days	Fri 12/18/09	Mon 1/18/10
265	Rough-in/Place SOD	15 days	Fri 12/18/09	Thu 1/7/10
266	Erect Steel and Deck for Roof	16 days	Tue 1/19/10	Tue 2/9/10
267	Building Envelope	41 days	Wed 2/10/10	Wed 4/7/10
268	MEP Overhead RI	34 days	Tue 2/23/10	Fri 4/9/10
269	MEP Installation	133 days	Wed 3/10/10	Fri 9/10/10
270	Framing and Drywall	80 days	Mon 4/12/10	Fri 7/30/10
271	Interior Finishes	54 days	Mon 8/2/10	Thu 10/14/10
272	MEP Testing	14 days	Tue 8/17/10	Fri 9/3/10
273	Punch List Area G.3	10 days	Fri 10/15/10	Thu 10/28/10
274	Complete Area G.3	0 days	Thu 10/28/10	Thu 10/28/10
275	**Roof**	**41 days**	**Tue 2/2/10**	**Tue 3/30/10**
276	Install EPDM Roofing	15 days	Tue 2/2/10	Mon 2/22/10
277	Install Roof Screens	26 days	Tue 2/23/10	Tue 3/30/10
278	Final MEP Connections	6 days	Tue 2/23/10	Tue 3/2/10
279	**Area A**	**321 days**	**Mon 7/27/09**	**Mon 10/18/10**
280	**Substructure**	**52 days**	**Mon 7/27/09**	**Tue 10/6/09**
281	Install Caissons	15 days	Mon 7/27/09	Fri 8/14/09
282	Install Grade Beams	9 days	Wed 9/2/09	Mon 9/14/09
283	Concrete Walls	10 days	Tue 9/15/09	Mon 9/28/09
284	CMU to Grade	2 days	Tue 9/15/09	Wed 9/16/09
285	MEP Underground RI	16 days	Tue 9/15/09	Tue 10/6/09
286	**First Floor**	**269 days**	**Wed 10/7/09**	**Mon 10/18/10**
287	Prep/Pour SOG	18 days	Wed 10/7/09	Fri 10/30/09
288	CMU to First Floor Bearing	5 days	Mon 11/2/09	Fri 11/6/09
289	Set Hollow Metal Frames	6 days	Mon 11/2/09	Mon 11/9/09
290	Erect Steel and Deck for 2nd Floor	12 days	Mon 11/23/09	Tue 12/8/09
291	Exterior Masonry	21 days	Thu 12/17/09	Thu 1/14/10
292	Curtain Wall and Windows	18 days	Fri 1/15/10	Tue 2/9/10
293	MEP Overhead RI	31 days	Wed 2/10/10	Wed 3/24/10



Project: New Moon Area High School & District Admin. Office
Date: 4/7/2010

Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline

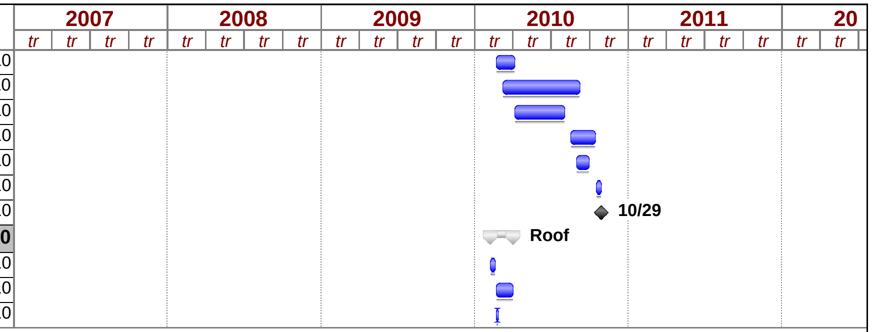
ID	Task Name	Duration	Start	Finish
294	MEP Installation	107 days	Wed 2/24/10	Thu 7/22/10
295	Standard Gauge Framing	15 days	Wed 3/10/10	Tue 3/30/10
296	Drywall	32 days	Tue 5/18/10	Wed 6/30/10
297	Interior Finishes	68 days	Thu 7/1/10	Mon 10/4/10
298	MEP Testing	14 days	Mon 7/12/10	Thu 7/29/10
299	Punch List Area A.2	10 days	Tue 10/5/10	Mon 10/18/10
300	Complete Area A.2	0 days	Mon 10/18/10	Mon 10/18/10
301	**Second Floor**	**223 days**	**Wed 12/9/09**	**Fri 10/15/10**
302	Rough-in/Place SOD	14 days	Wed 12/9/09	Mon 12/28/09
303	Set Hollow Metal Frames	5 days	Tue 12/29/09	Mon 1/4/10
304	CMU to Roof Bearing	8 days	Wed 1/6/10	Fri 1/15/10
305	Erect Steel and Deck for Roof	10 days	Mon 1/18/10	Fri 1/29/10
306	MEP Overhead RI	12 days	Fri 2/12/10	Mon 3/1/10
307	Exterior Masonry	19 days	Mon 3/1/10	Thu 3/25/10
308	Framing and Drywall	16 days	Fri 3/12/10	Fri 4/2/10
309	Drywall	56 days	Wed 3/24/10	Wed 6/9/10
310	MEP Installation	85 days	Thu 2/25/10	Wed 6/23/10
311	Curtain Wall and Windows	60 days	Fri 3/26/10	Thu 6/17/10
312	Interior Finishes	82 days	Thu 6/10/10	Fri 10/1/10
313	MEP Testing	16 days	Thu 6/17/10	Thu 7/8/10
314	Punch List Area A.3	10 days	Mon 10/4/10	Fri 10/15/10
315	Complete Area A.3	0 days	Fri 10/15/10	Fri 10/15/10
316	**Roof**	**14 days**	**Mon 2/1/10**	**Thu 2/18/10**
317	Install EPDM Roofing	7 days	Mon 2/1/10	Tue 2/9/10
318	Install Roof Screens	7 days	Wed 2/10/10	Thu 2/18/10
319	Final MEP Connections	5 days	Wed 2/10/10	Tue 2/16/10
320	**Area B**	**320 days**	**Mon 8/10/09**	**Fri 10/29/10**
321	**Substructure**	**46 days**	**Mon 8/10/09**	**Mon 10/12/09**
322	Install Caissons and Grade Beams	24 days	Mon 8/10/09	Thu 9/10/09
323	Concrete Walls	10 days	Fri 9/11/09	Thu 9/24/09
324	CMU to Grade	2 days	Fri 9/11/09	Mon 9/14/09
325	MEP Underground RI	22 days	Fri 9/11/09	Mon 10/12/09
326	**First Floor**	**274 days**	**Tue 10/13/09**	**Fri 10/29/10**
327	Prep/Pour SOG	18 days	Tue 10/13/09	Thu 11/5/09
328	CMU to First Floor Bearing	9 days	Fri 11/6/09	Wed 11/18/09
329	Erect Steel and Deck for 2nd Floor	10 days	Tue 12/1/09	Mon 12/14/09
330	Building Envelope	38 days	Thu 11/19/09	Mon 1/11/10
331	MEP Overhead RI	77 days	Mon 2/22/10	Tue 6/8/10
332	MEP Installation	131 days	Tue 3/16/10	Tue 9/14/10
333	Framing and Drywall	92 days	Tue 4/6/10	Wed 8/11/10
334	Interior Finishes	47 days	Thu 8/12/10	Fri 10/15/10
335	MEP Testing	19 days	Tue 8/24/10	Fri 9/17/10
336	Punch List Area B.2	10 days	Mon 10/18/10	Fri 10/29/10
337	Complete Area B.2	0 days	Fri 10/29/10	Fri 10/29/10
338	**Second Floor**	**229 days**	**Tue 12/15/09**	**Fri 10/29/10**
339	Rough-in/Place SOD	15 days	Tue 12/15/09	Mon 1/4/10
340	CMU to Roof Bearing	9 days	Tue 1/12/10	Fri 1/22/10
341	Erect Steel and Deck for Roof	10 days	Mon 1/25/10	Fri 2/5/10
342	Building Envelope	42 days	Fri 2/5/10	Mon 4/5/10



Project: New Moon Area High School & District Admin. Office
Date: 4/7/2010

Task	Milestone	External Tasks
Split	Summary	External Milestone
Progress	Project Summary	Deadline

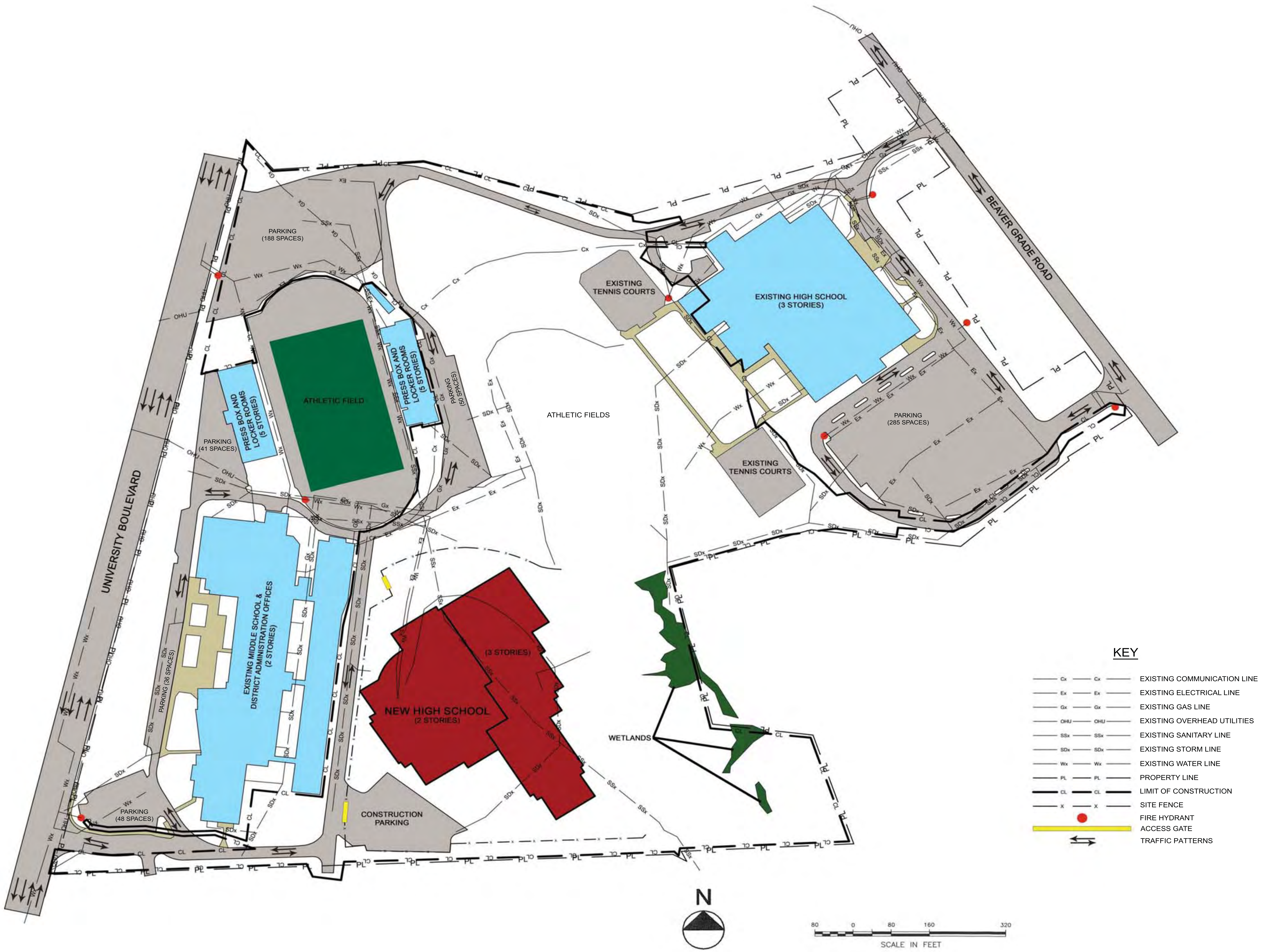
ID	Task Name	Duration	Start	Finish
343	MEP Overhead RI	32 days	Mon 2/22/10	Tue 4/6/10
344	MEP Installation	131 days	Wed 3/10/10	Wed 9/8/10
345	Framing and Drywall	85 days	Wed 4/7/10	Tue 8/3/10
346	Interior Finishes	43 days	Wed 8/18/10	Fri 10/15/10
347	MEP Testing	22 days	Wed 9/1/10	Thu 9/30/10
348	Punch List Area B.3	10 days	Mon 10/18/10	Fri 10/29/10
349	Complete Area B.3	0 days	Fri 10/29/10	Fri 10/29/10
350	**Roof**	**40 days**	**Mon 2/8/10**	**Fri 4/2/10**
351	Install EPDM Roofing	10 days	Mon 2/8/10	Fri 2/19/10
352	Install Roof Screens	30 days	Mon 2/22/10	Fri 4/2/10
353	Final MEP Connections	5 days	Mon 2/22/10	Fri 2/26/10



Project: New Moon Area High School & District Admin. Office
Date: 4/7/2010

Task		Milestone		External Tasks	
Split		Summary		External Milestone	
Progress		Project Summary		Deadline	

Appendix B: Site Plans



architecture ECKLES engineering

NEW MOON AREA HIGH SCHOOL / DISTRICT ADMIN OFFICE

P.D.E. No. 3442

MOON AREA SCHOOL DISTRICT — MOON TOWNSHIP, PA

EXISTING SITE CONDITIONS

Project Number 06750.00

Date 10/5/2009

Scale AS NOTED

DRAWN BY: KRISTOPHER BRICE
OPTION: CM
ASSIGNMENT: TECH 1

Drawing Number

C0-001

NEW MOON AREA HIGH SCHOOL / DISTRICT ADMIN OFFICE

P.D.E. No. 3442

MOON AREA SCHOOL DISTRICT — MOON TOWNSHIP, PA

OVERALL SITE RENDERING

architecture
ECKLES
engineering

301 North Mercer Street
New Castle, Pa. 16101
p 724.652.6607
f 724.652.0751

132 South Broad Street
Canfield, Oh. 44406
p 330.286.0438
f 330.286.0439

Project Number 06750.00
Date 10/5/2009
Scale N.T.S.

EDITED BY: KRISTOPHER BRICE
OPTION: CM
ASSIGNMENT: TECH 1

Drawing Number
C0-002

Appendix C: Sample Copy of AIA E202-2008

AIA® Document E202™ – 2008

Building Information Modeling Protocol Exhibit

This Exhibit is incorporated into the accompanying agreement (the "Agreement") dated the day of in the year
(In words, indicate day, month and year.)

This document has important legal consequences. Consultation with an attorney is encouraged with respect to its completion or modification.

BETWEEN:
(Name, address and contact information, including electronic addresses)

AND:
(Name, address and contact information, including electronic addresses)

for the following Project:
(Name and location or address)

TABLE OF ARTICLES

ARTICLE 1 GENERAL PROVISIONS

§ 1.1 This Exhibit establishes the protocols, expected levels of development, and authorized uses of Building Information Models on this Project and assigns specific responsibility for the development of each Model Element to a defined Level of Development at each Project phase. Where a provision in this Exhibit conflicts with a provision in the Agreement into which this Exhibit is incorporated, the provision in this Exhibit will prevail.

§ 1.1.1 The parties agree to incorporate this Exhibit by reference into any other agreement for services or construction for the Project.

§ 1.2 Definitions

§ 1.2.1 **Building Information Model.** A Building Information Model(s) is a digital representation of the physical and functional characteristics of the Project and is referred to in this Exhibit as the "Model(s)," which term may be used herein to describe a Model Element, a single Model or multiple Models used in the aggregate. "Building Information Modeling" means the process and technology used to create the Model.

§ 1.2.2 **Level of Development.** The Level(s) of Development (LOD) describes the level of completeness to which a Model Element is developed.

§ 1.2.3 **Model Element.** A Model Element is a portion of the Building Information Model representing a component, system or assembly within a building or building site. For the purposes of this Exhibit, Model Elements are represented by the Construction Specifications Institute (CSI) UniFormat™ classification system in the Model Element Table at Section 4.3.

§ 1.2.4 **Model Element Author.** The Model Element Author is the party responsible for developing the content of a specific Model Element to the LOD required for a particular phase of the Project. Model Element Authors are identified in the Model Element Table at Section 4.3.

§ 1.2.5 **Model User.** The Model User refers to any individual or entity authorized to use the Model on the Project, such as for analysis, estimating or scheduling.

ARTICLE 2 PROTOCOL

§ 2.1 Coordination and Conflicts

Where conflicts are found in the Model, regardless of the phase of the Project or LOD, the discovering party shall promptly notify the Model Element Author(s). Upon such notification, the Model Element Author(s) shall act promptly to mitigate the conflict.

§ 2.2 Model Ownership

In contributing content to the Model, the Model Element Author does not convey any ownership right in the content provided or in the software used to generate the content. Unless otherwise granted in a separate license, any subsequent Model Element Author's and Model User's right to use, modify, or further transmit the Model is specifically limited to the design and construction of the Project, and nothing contained in this Exhibit conveys any other right to use the Model for another purpose.

§ 2.3 Model Requirements

§ 2.3.1 **Model Standard.** The Model shall be developed in accordance with the following standard, if any:
(Set forth below object naming conventions, graphic standards, common symbology, etc., or state an applicable standard, such as the National Building Information Model Standards (NBIMS).)

§ 2.3.2 **File Format(s).** Models shall be delivered in the following format(s) as appropriate to the use of the Model:

Use of Model	Required File Format(s)

§ 2.4 Model Management

§ 2.4.1 The requirements for managing the Model include, but are not limited to, the duties set forth below in this Section 2.4. The Architect will manage the Model from the inception of the Project. If the responsibility for Model management will be assigned to another party at a particular phase of the Project, indicate below the identity of the party that will assume that responsibility, and the phase at which that party will assume those responsibilities.

Responsible Party	Project Phase

§ 2.4.2 **Initial Responsibilities.** The party responsible for managing the Model shall facilitate the establishment of protocols for the following:

.1 Model origin, coordinate system, and units
.2 File storage location(s)
.3 Processes for transferring and accessing Model files
.4 Clash detection
.5 Access rights
.6 Other protocols:
(Insert additional protocols below.)

§ 2.4.3 **Ongoing Responsibilities.** The party responsible for managing the Model shall have the following ongoing responsibilities:

.1 Collect incoming Models:
  .1 Coordinate submission and exchange of Models
  .2 Log incoming Models
  .3 Validate that files are complete and usable and in compliance with applicable protocols
  .4 Maintain record copy of each file received
.2 Aggregate Model files and make available for viewing
.3 Perform clash detection in accordance with established protocols and issue periodic clash detection reports
.4 Maintain Model archives and backups
.5 Manage access rights
.6 Follow protocols established in Section 2.4.2

§ 2.4.4 **Model Archives.** The party responsible for Model management as set forth in this Section 2.4 shall produce a Model Archive at the end of each Project phase and shall preserve the Model Archive as a record that may not be altered for any reason.

§ 2.4.4.1 The Model Archive shall consist of two sets of files. The first set shall be a collection of individual Models as received from the Model Element Author(s). The second set of files shall consist of the aggregate of those individual Models in a format suitable for archiving and viewing. The second set shall be saved in the following file format:

§ 2.4.4.2 Additional Model Archive requirements, if any, are as follows:

§ 2.4.4.3 The procedures for storing and preserving the Model upon final completion of the Project are as follows:

§ 2.4.5 Other requirements for Model management, if any, are as follows:
(Describe in detail any other Model management requirements.)

ARTICLE 3 LEVEL OF DEVELOPMENT

§ 3.1 The following LOD descriptions identify the specific content requirements and associated authorized uses for each Model Element at five progressively detailed levels of completeness. Each subsequent LOD builds on the previous level and includes all the characteristics of previous levels. The parties shall utilize the five LOD described below in completing the Model Element Table at Section 4.3, which establishes the required LOD for each Model Element at each phase of the Project.

§ 3.2 LOD 100
§ 3.2.1 **Model Content Requirements.** Overall building massing indicative of area, height, volume, location, and orientation may be modeled in three dimensions or represented by other data.

§ 3.2.2 Authorized Uses
§ 3.2.2.1 **Analysis.** The Model may be analyzed based on volume, area and orientation by application of generalized performance criteria assigned to the representative Model Elements.

§ 3.2.2.2 **Cost Estimating.** The Model may be used to develop a cost estimate based on current area, volume or similar conceptual estimating techniques (e.g., square feet of floor area, condominium unit, hospital bed, etc.).

§ 3.2.2.3 **Schedule.** The Model may be used for project phasing and overall duration.

§ 3.2.2.4 **Other Authorized Uses.** Additional authorized uses of the Model developed to a Level 100, if any, are as follows:

§ 3.3 LOD 200
§ 3.3.1 **Model Content Requirements.** Model Elements are modeled as generalized systems or assemblies with approximate quantities, size, shape, location, and orientation. Non-geometric information may also be attached to Model Elements.

§ 3.3.2 Authorized Uses
§ 3.3.2.1 **Analysis.** The Model may be analyzed for performance of selected systems by application of generalized performance criteria assigned to the representative Model Elements.

§ 3.3.2.2 **Cost Estimating.** The Model may be used to develop cost estimates based on the approximate data provided and conceptual estimating techniques (e.g., volume and quantity of elements or type of system selected).

§ 3.3.2.3 **Schedule.** The Model may be used to show ordered, time-scaled appearance of major elements and systems.

§ 3.3.2.4 **Other Authorized Uses.** Additional authorized uses of the Model developed to a Level 200, if any, are as follows:

§ 3.4 LOD 300

§ 3.4.1 **Model Content Requirements.** Model Elements are modeled as specific assemblies accurate in terms of quantity, size, shape, location, and orientation. Non-geometric information may also be attached to Model Elements.

§ 3.4.2 Authorized Uses

§ 3.4.2.1 **Construction.** Suitable for the generation of traditional construction documents and shop drawings.

§ 3.4.2.2 **Analysis.** The Model may be analyzed for performance of selected systems by application of specific performance criteria assigned to the representative Model Elements.

§ 3.4.2.3 **Cost Estimating.** The Model may be used to develop cost estimates based on the specific data provided and conceptual estimating techniques.

§ 3.4.2.4 **Schedule.** The Model may be used to show ordered, time-scaled appearance of detailed elements and systems.

§ 3.4.2.5 **Other Authorized Uses.** Additional authorized uses of the Model developed to a Level 300, if any, are as follows:

§ 3.5 LOD 400

§ 3.5.1 **Model Content Requirements.** Model Elements are modeled as specific assemblies that are accurate in terms of size, shape, location, quantity, and orientation with complete fabrication, assembly, and detailing information. Non-geometric information may also be attached to Model Elements.

§ 3.5.2 Authorized Uses

§ 3.5.2.1 **Construction.** Model Elements are virtual representations of the proposed element and are suitable for construction.

§ 3.5.2.2 **Analysis.** The Model may be analyzed for performance of approved selected systems based on specific Model Elements.

§ 3.5.2.3 **Cost Estimating.** Costs are based on the actual cost of specific elements at buyout.

§ 3.5.2.4 **Schedule.** The Model may be used to show ordered, time-scaled appearance of detailed specific elements and systems including construction means and methods.

§ 3.5.2.5 **Other Authorized Uses.** Additional authorized uses of the Model developed to a Level 400, if any, are as follows:

§ 3.6 LOD 500

§ 3.6.1 **Model Content Requirements.** Model Elements are modeled as constructed assemblies actual and accurate in terms of size, shape, location, quantity, and orientation. Non-geometric information may also be attached to modeled elements.

§ 3.6.2 Authorized Uses

§ 3.6.2.1 **General Usage.** The Model may be utilized for maintaining, altering, and adding to the Project, but only to the extent consistent with any licenses granted in the Agreement or in a separate licensing agreement.

§ 3.6.2.2 **Other Authorized Uses.** Additional authorized uses of the Model developed to a Level 500, if any, are as follows:

ARTICLE 4 MODEL ELEMENTS

§ 4.1 Reliance on Model Elements

§ 4.1.1 The Model Element Table at Section 4.3 identifies (1) the LOD required for each Model Element at the end of each Project phase, and (2) the Model Element Author responsible for developing the Model Element to the LOD identified. Each Model Element Author's content is intended to be shared with subsequent Model Element Authors and Model Users throughout the course of the Project.

§ 4.1.2 It is understood that while the content of a specific Model Element may include data that exceeds the required LOD identified in Section 4.3 for a particular phase, Model Users and subsequent Model Element Authors may rely on the accuracy and completeness of a Model Element consistent only with the content required for the LOD identified in Section 4.3.

§ 4.1.3 Any use of, or reliance on, a Model Element inconsistent with the LOD indicated in Section 4.3 by subsequent Model Element Authors or Model Users shall be at their sole risk and without liability to the Model Element Author. To the fullest extent permitted by law, subsequent Model Element Authors and Model Users shall indemnify and defend the Model Element Author from and against all claims arising from or related to the subsequent Model Element Author's or Model User's modification to, or unauthorized use of, the Model Element Author's content.

§ 4.2 Table Instructions

§ 4.2.1 The table in Section 4.3 indicates the LOD to which each Model Element Author (MEA) is required to develop the content of the Model Element at the conclusion of each phase of the Project.

§ 4.2.2 Abbreviations for each MEA to be used in the Model Element Table are as follows:
(Provide abbreviations such as "A – Architect," or "C – Contractor.")

§ 4.3 Model Element Table

Identify (1) the LOD required for each Model Element at the end of each phase, and (2) the Model Element Author (MEA) responsible for developing the Model Element to the LOD identified.

Insert abbreviations for each MEA identified in the table below, such as "A – Architect," or "C – Contractor."

NOTE: LODs must be adapted for the unique characteristics of each Project.

Model Elements Utilizing CSI UniFormat™					LOD	MEA	LOD	MEA	LOD	MEA	LOD	MEA	LOD	MEA	LOD	MEA	**Note Number (See 4.4)**
A SUBSTRUCTURE	A10	Foundations	A1010	Standard Foundations													
			A1020	Special Foundations													
			A1030	Slab on Grade													
	A20	Basement Construction	A2010	Basement Excavation													
			A2020	Basement Walls													
B SHELL	B10	Superstructure	B1010	Floor Construction													
			B1020	Roof Construction													
	B20	Exterior Enclosure	B2010	Exterior Walls													
			B2020	Exterior Windows													
			B2030	Exterior Doors													
	B30	Roofing	B3010	Roof Coverings													
			B3020	Roof Openings													
C INTERIORS	C10	Interior Construction	C1010	Partitions													
			C1020	Interior Doors													
			C1030	Fittings													
	C20	Stairs	C2010	Stair Construction													
			C2020	Stair Finishes													
	C30	Interior Finishes	C3010	Wall Finishes													
			C3020	Floor Finishes													
			C3030	Ceiling Finishes													
D SERVICES	D10	Conveying	D1010	Elevators & Lifts													
			D1020	Escalators & Moving Walks													
			D1030	Other Conveying Systems													
	D20	Plumbing	D2010	Plumbing Fixtures													
			D2020	Domestic Water Distribution													
			D2030	Sanitary Waste													
			D2040	Rain Water Drainage													
			D2090	Other Plumbing Systems													
	D30	HVAC	D3010	Energy Supply													
			D3020	Heat Generating Systems													
			D3030	Cooling Generating Systems													
			D3040	Distribution Systems													
			D3050	Terminal & Package Units													
			D3060	Controls & Instrumentation													
			D3070	Systems Testing & Balancing													
			D3090	Other HVAC Systems & Equipment													
	D40	Fire Protection	D4010	Sprinklers													
			D4020	Standpipes													
			D4030	Fire Protection Specialties													
			D4090	Other Fire Protection Systems													

§ 4.3 Model Element Table

Identify (1) the LOD required for each Model Element at the end of each phase, and (2) the Model Element Author (MEA) responsible for developing the Model Element to the LOD identified.

Insert abbreviations for each MEA identified in the table below, such as "A – Architect," or "C – Contractor."

NOTE: LODs must be adapted for the unique characteristics of each Project.

Model Elements Utilizing CSI UniFormat™					LOD	MEA	LOD	MEA	LOD	MEA	LOD	MEA	LOD	MEA	LOD	MEA	**Note Number (See 4.4)**
	D50	Electrical	D5010	Electrical Service & Distribution													
			D5020	Lighting and Branch Wiring													
			D5030	Communications & Security													
			D5090	Other Electrical Systems													
E EQUIPMENT & FURNISHINGS	E10	Equipment	E1010	Commercial Equipment													
			E1020	Institutional Equipment													
			E1030	Vehicular Equipment													
			E1090	Other Equipment													
	E20	Furnishings	E2010	Fixed Furnishings													
			E2020	Movable Furnishings													
F SPECIAL CONSTR. & DEMO	F10	Special Construction	F1010	Special Structures													
			F1020	Integrated Construction													
			F1030	Special Construction Systems													
			F1040	Special Facilities													
			F1050	Special Controls & Instrumentation													
	F20	Selective Bldg Demo	F2010	Building Elements Demolition													
			F2020	Hazardous Components Abatement													
G BUILDING SITEWORK	G10	Site Preparation	G1010	Site Clearing													
			G1020	Site Demolition & Relocations													
			G1030	Site Earthwork													
			G1040	Hazardous Waste Remediation													
	G20	Site Improvements	G2010	Roadways													
			G2020	Parking Lots													
			G2030	Pedestrian Paving													
			G2040	Site Development													
			G2050	Landscaping													
	G30	Site Civil/ Mech. Utilities	G3010	Water Supply & Distribution Systems													
			G3020	Sanitary Sewer Systems													
			G3030	Storm Sewer Systems													
			G3040	Heating Distribution													
			G3050	Cooling Distribution													
			G3060	Fuel Distribution													
			G3090	Other Civil/ Mechanical Utilities													
	G40	Site Electrical Utilities	G4010	Electrical Distribution													
			G4020	Site Lighting													
			G4030	Site Communications & Security													
			G4090	Other Electrical Utilities													
	G50	Other Site Construction	G5010	Service Tunnels													
			G5090	Other Site Systems & Equipment													

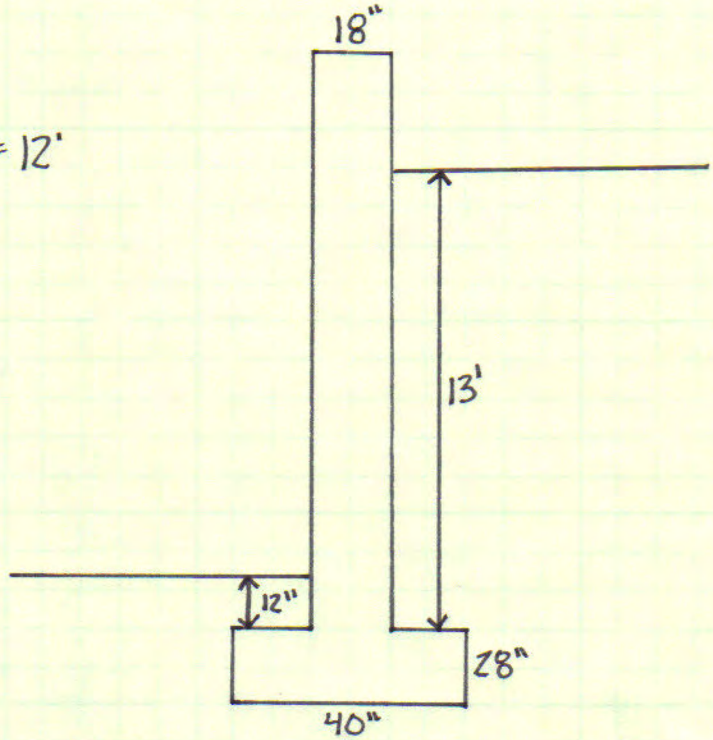
§ 4.3 Model Element Table *Identify (1) the LOD required for each Model Element at the end of each phase, and (2) the Model Element Author (MEA) responsible for developing the Model Element to the LOD identified.* *Insert abbreviations for each MEA identified in the table below, such as "A – Architect," or "C – Contractor."* *NOTE: LODs must be adapted for the unique characteristics of each Project.*													**Note Number (See 4.4)**
Model Elements Not Utilizing CSI UniFormat™	LOD	MEA	LOD	MEA	LOD	MEA	LOD	MEA	LOD	MEA	LOD	MEA	

§ 4.4 Model Element Table Notes
Notes:
(List by number shown on table.)

Appendix D: Concrete Wall Bracing Design Calculations

Assumptions

- $\phi = 35^\circ$
- $\gamma = 120$ pcf
- Unbalanced fill = 12'



Overturning @ Toe

Active Pressure

$K_a = \tan^2(45 - \frac{\phi}{2}) = \tan^2(45 - \frac{35}{2}) = 0.271$

$P_a = \frac{1}{2}(0.271)(120)(15.33)^2 = 3{,}821$ plf

Soil Weight

$W_s = (13')(2.58')(120) = 4{,}025$ plf

Wall Weight

$W_w = (1.5')(15')(150) = 3{,}375$ plf

Footing Weight

$W_f = (2.33')(3.33')(150\text{ pcf}) = 1{,}164$ plf

Passive Pressure

$K_p = \tan^2(45 + \frac{\phi}{2}) = \tan^2(45 + \frac{35}{2}) = 3.69$

$P_p = \frac{1}{2}(120)(3.69)(3.33)^2 = 2{,}455$ plf

Overturning moments

$\Sigma M_o = (3,821)\left(\frac{15.33}{3}\right) = 19,525$ 'lb

Resisting moments

$\Sigma M_R = 4,025(6.67') + 3,375(1.67') + (1,164)(1.67') = 34,427$ 'lb

Factor of Safety

* Required F.S. for Overturning is ≥ 3.0 *

$F.S. = \frac{34,427}{19,525} = 1.76 \leq 3 \therefore$ Not OK

* Bracing most resist 24,148' lbs *

Sliding

$\delta = 0.5\phi = 0.5(35) = 17.5°$

$R = (\Sigma V \tan\delta + B_{ca}) + P_p$

$= [(4,025 + 3,375 + 1,164)\tan 17.5°] + 2,455$

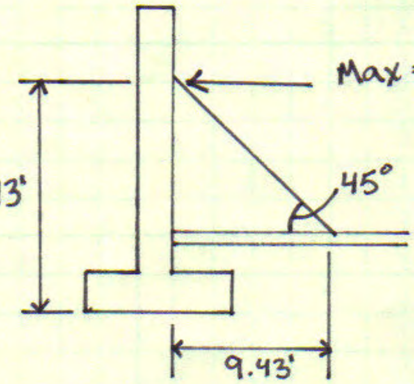
$= 5,155_{pcf}$

* Required F.S. for sliding is ≥ 1.5 *

$F.S. = \frac{5,155}{3,821} = 1.35 < 1.5 \therefore$ Not OK

* Bracing should be designed to resist sliding or slab on grade should be placed prior to backfilling of wall.

Bracing Design



Max = 27,000 cos(45°) = 19,092 lbs

↳ Maximum axial load for selected Mabey System 160 with Safety Factor = 2.0

Moment Resistance @ Toe

$M_r = 19092(13) = 248{,}196$ 'lbs

Spacing for Braces

$\text{Space (ft.)} = \frac{M_r}{24{,}148} = \frac{248{,}196}{24{,}148} = 10.3' \Rightarrow \text{Use } \underline{\underline{10'}}$

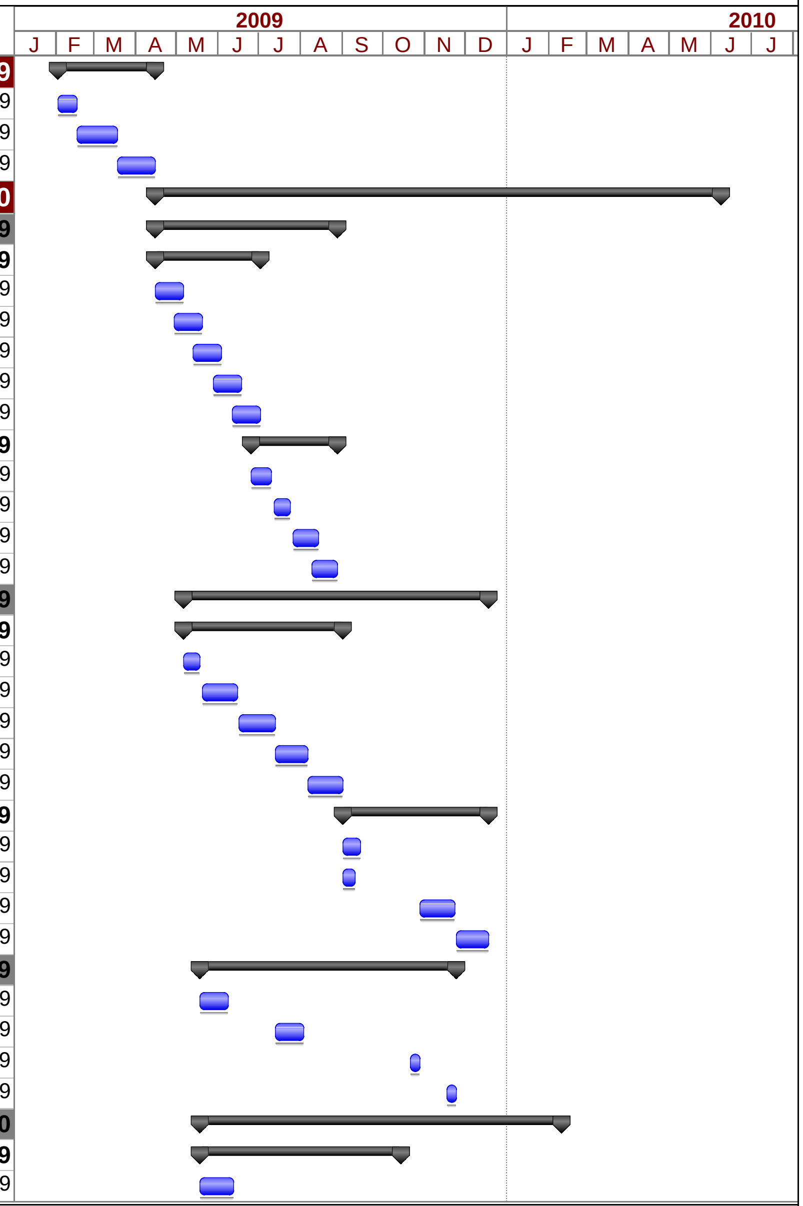
↳ Overturning moment

* Braces will be spaced @ 10' O.C. *

Appendix E: Detailed Structure Schedules

Original Structure Without Wall Bracing

ID	Task Name	Duration	Start	Finish
1	**General Dates**	**52 days**	**Tue 2/3/09**	**Wed 4/15/09**
2	Mobilization	10 days	Tue 2/3/09	Mon 2/16/09
3	Site Demolition	22 days	Tue 2/17/09	Wed 3/18/09
4	Bulk Cut for Building Basement	20 days	Thu 3/19/09	Wed 4/15/09
5	**Structure Schedule**	**299 days**	**Thu 4/16/09**	**Tue 6/8/10**
6	**Caissons**	**97 days**	**Thu 4/16/09**	**Fri 8/28/09**
7	**Ground Floor**	**56 days**	**Thu 4/16/09**	**Thu 7/2/09**
8	Area C	15 days	Thu 4/16/09	Wed 5/6/09
9	Area D	15 days	Thu 4/30/09	Wed 5/20/09
10	Area E	15 days	Thu 5/14/09	Wed 6/3/09
11	Area F	15 days	Fri 5/29/09	Thu 6/18/09
12	Area G	15 days	Fri 6/12/09	Thu 7/2/09
13	**First Floor**	**46 days**	**Fri 6/26/09**	**Fri 8/28/09**
14	Area C	11 days	Fri 6/26/09	Fri 7/10/09
15	Area E	10 days	Mon 7/13/09	Fri 7/24/09
16	Area A	15 days	Mon 7/27/09	Fri 8/14/09
17	Area B	15 days	Mon 8/10/09	Fri 8/28/09
18	**Grade Beams**	**162 days**	**Thu 5/7/09**	**Fri 12/18/09**
19	**Ground Floor**	**84 days**	**Thu 5/7/09**	**Tue 9/1/09**
20	Area C	8 days	Thu 5/7/09	Mon 5/18/09
21	Area D	18 days	Thu 5/21/09	Mon 6/15/09
22	Area E	19 days	Wed 6/17/09	Mon 7/13/09
23	Area F	18 days	Tue 7/14/09	Thu 8/6/09
24	Area G	18 days	Fri 8/7/09	Tue 9/1/09
25	**First Floor**	**78 days**	**Wed 9/2/09**	**Fri 12/18/09**
28	Area A	9 days	Wed 9/2/09	Mon 9/14/09
29	Area B	7 days	Wed 9/2/09	Thu 9/10/09
26	Area C	18 days	Thu 10/29/09	Mon 11/23/09
27	Area E	18 days	Wed 11/25/09	Fri 12/18/09
30	**Concrete Wall**	**136 days**	**Tue 5/19/09**	**Tue 11/24/09**
31	Area C	15 days	Tue 5/19/09	Mon 6/8/09
32	Area E	15 days	Tue 7/14/09	Mon 8/3/09
33	Area C Backfill	5 days	Thu 10/22/09	Wed 10/28/09
34	Area E Backfill	5 days	Wed 11/18/09	Tue 11/24/09
81	**SOG's**	**192 days**	**Tue 5/19/09**	**Wed 2/10/10**
82	**Ground Floor**	**107 days**	**Tue 5/19/09**	**Wed 10/14/09**
83	Area C R/I	19 days	Tue 5/19/09	Fri 6/12/09

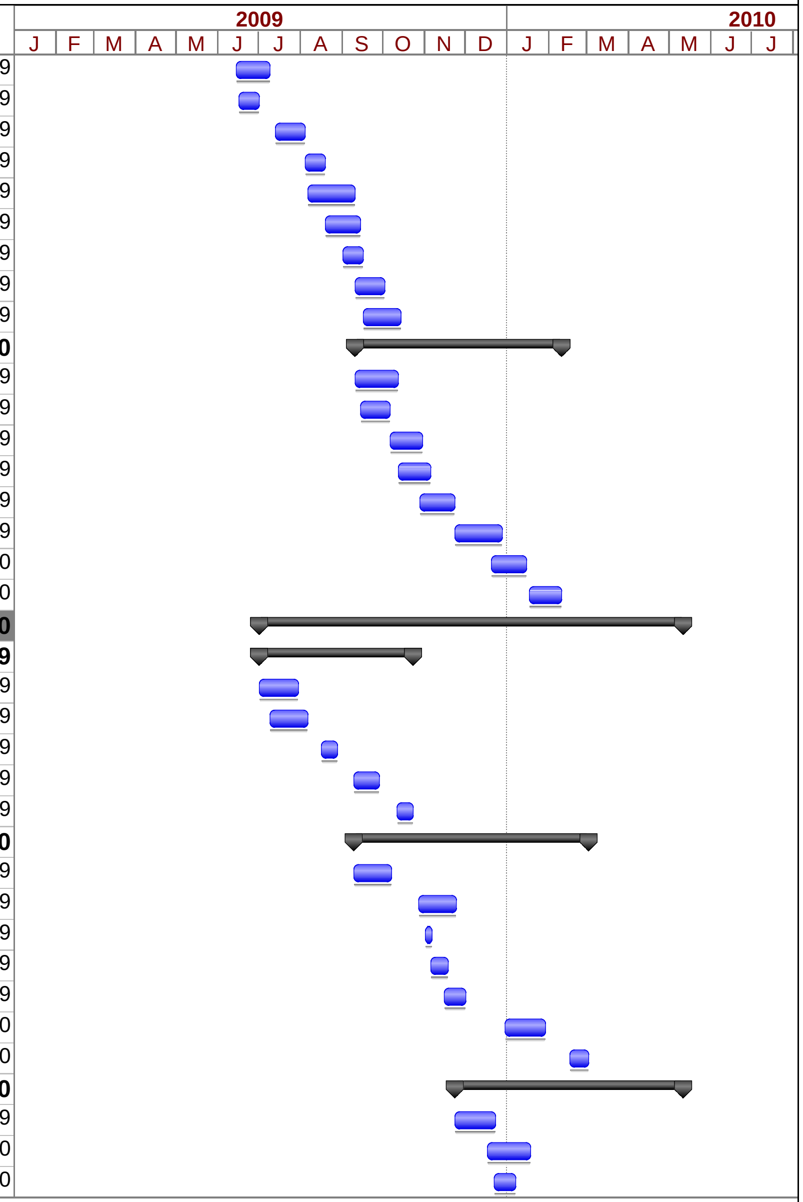


Project: Moon Area HS
Description: Structure Without Wall Bracing
Date: 4/7/2010

Task		Milestone		External Tasks	
Split		Summary		External Milestone	
Progress		Project Summary		Deadline	

Original Structure Without Wall Bracing

ID	Task Name	Duration	Start	Finish
84	Area C P/P	19 days	Mon 6/15/09	Thu 7/9/09
85	Area D R/I	11 days	Wed 6/17/09	Wed 7/1/09
87	Area E R/I	16 days	Tue 7/14/09	Tue 8/4/09
88	Area E P/P	11 days	Wed 8/5/09	Wed 8/19/09
89	Area F R/I	25 days	Fri 8/7/09	Thu 9/10/09
86	Area D P/P	18 days	Thu 8/20/09	Mon 9/14/09
91	Area G R/I	11 days	Wed 9/2/09	Wed 9/16/09
90	Area F P/P	16 days	Fri 9/11/09	Fri 10/2/09
92	Area G P/P	20 days	Thu 9/17/09	Wed 10/14/09
93	**First Floor**	**109 days**	**Fri 9/11/09**	**Wed 2/10/10**
100	Area B R/I	22 days	Fri 9/11/09	Mon 10/12/09
98	Area A R/I	16 days	Tue 9/15/09	Tue 10/6/09
99	Area A P/P	18 days	Wed 10/7/09	Fri 10/30/09
101	Area B P/P	18 days	Tue 10/13/09	Thu 11/5/09
94	Area C R/I	18 days	Thu 10/29/09	Mon 11/23/09
95	Area C P/P	25 days	Tue 11/24/09	Mon 12/28/09
96	Area E R/I	20 days	Mon 12/21/09	Fri 1/15/10
97	Area E P/P	18 days	Mon 1/18/10	Wed 2/10/10
58	**Structural Masonry**	**224 days**	**Thu 7/2/09**	**Tue 5/11/10**
59	**Ground Floor**	**82 days**	**Thu 7/2/09**	**Fri 10/23/09**
61	Area D	21 days	Thu 7/2/09	Thu 7/30/09
60	Area C	20 days	Fri 7/10/09	Thu 8/6/09
62	Area E	10 days	Mon 8/17/09	Fri 8/28/09
64	Area G	13 days	Thu 9/10/09	Mon 9/28/09
63	Area F	10 days	Mon 10/12/09	Fri 10/23/09
65	**First Floor**	**124 days**	**Thu 9/10/09**	**Tue 3/2/10**
67	Area D	20 days	Thu 9/10/09	Wed 10/7/09
70	Area G	20 days	Wed 10/28/09	Tue 11/24/09
71	Area A	5 days	Mon 11/2/09	Fri 11/6/09
72	Area B	9 days	Fri 11/6/09	Wed 11/18/09
69	Area F	12 days	Mon 11/16/09	Tue 12/1/09
66	Area C	22 days	Thu 12/31/09	Fri 1/29/10
68	Area E	10 days	Wed 2/17/10	Tue 3/2/10
73	**Second Floor**	**121 days**	**Tue 11/24/09**	**Tue 5/11/10**
75	Area D	22 days	Tue 11/24/09	Wed 12/23/09
78	Area G	22 days	Fri 12/18/09	Mon 1/18/10
77	Area F	12 days	Wed 12/23/09	Thu 1/7/10

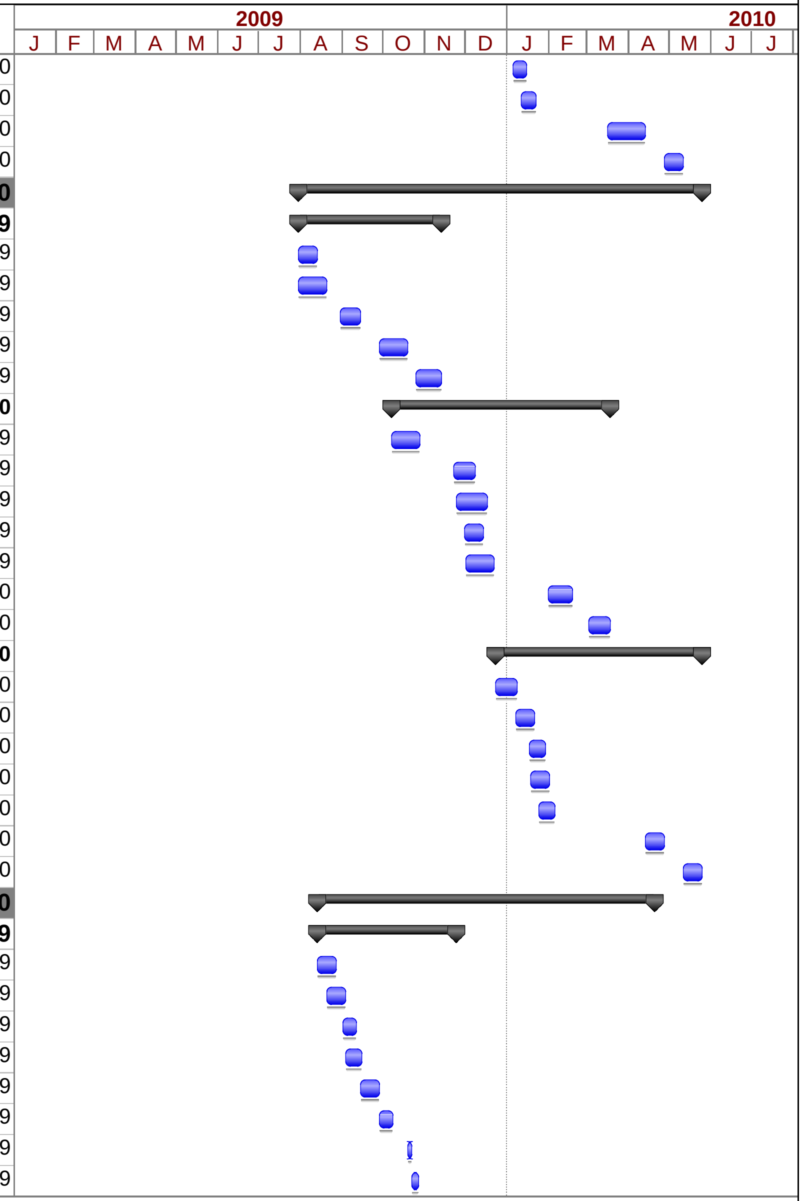


Project: Moon Area HS
Description: Structure Without Wall Bracing
Date: 4/7/2010

Task		Milestone		External Tasks	
Split		Summary		External Milestone	
Progress		Project Summary		Deadline	

Original Structure Without Wall Bracing

ID	Task Name	Duration	Start	Finish
79	**Area A**	8 days	Wed 1/6/10	Fri 1/15/10
80	Area B	9 days	Tue 1/12/10	Fri 1/22/10
74	Area C	20 days	Wed 3/17/10	Tue 4/13/10
76	Area E	10 days	Wed 4/28/10	Tue 5/11/10
35	**Steel Columns and Beams**	**213 days**	**Fri 7/31/09**	**Tue 5/25/10**
36	**Ground Floor**	**76 days**	**Fri 7/31/09**	**Fri 11/13/09**
37	Area C	10 days	Fri 7/31/09	Thu 8/13/09
38	Area D	15 days	Fri 7/31/09	Thu 8/20/09
39	Area E	11 days	Mon 8/31/09	Mon 9/14/09
41	Area G	15 days	Tue 9/29/09	Mon 10/19/09
40	Area F	15 days	Mon 10/26/09	Fri 11/13/09
42	**First Floor**	**116 days**	**Thu 10/8/09**	**Thu 3/18/10**
44	Area D	15 days	Thu 10/8/09	Wed 10/28/09
48	Area A	12 days	Mon 11/23/09	Tue 12/8/09
47	Area G	17 days	Wed 11/25/09	Thu 12/17/09
49	Area B	10 days	Tue 12/1/09	Mon 12/14/09
46	Area F	15 days	Wed 12/2/09	Tue 12/22/09
43	Area C	14 days	Mon 2/1/10	Thu 2/18/10
45	Area E	12 days	Wed 3/3/10	Thu 3/18/10
50	**Second Floor**	**109 days**	**Thu 12/24/09**	**Tue 5/25/10**
52	Area D	12 days	Thu 12/24/09	Fri 1/8/10
54	Area F	10 days	Fri 1/8/10	Thu 1/21/10
56	Area A	10 days	Mon 1/18/10	Fri 1/29/10
55	Area G	10 days	Tue 1/19/10	Mon 2/1/10
57	Area B	10 days	Mon 1/25/10	Fri 2/5/10
51	Area C	10 days	Wed 4/14/10	Tue 4/27/10
53	Area E	10 days	Wed 5/12/10	Tue 5/25/10
102	**Slabs on Deck**	**178 days**	**Fri 8/14/09**	**Tue 4/20/10**
103	**First Floor**	**73 days**	**Fri 8/14/09**	**Tue 11/24/09**
104	Area C R/I	10 days	Fri 8/14/09	Thu 8/27/09
106	Area D R/I	10 days	Fri 8/21/09	Thu 9/3/09
105	Area C P/P	8 days	Wed 9/2/09	Fri 9/11/09
107	Area D P/P	8 days	Fri 9/4/09	Tue 9/15/09
108	Area E R/I	10 days	Tue 9/15/09	Mon 9/28/09
109	Area E P/P	8 days	Tue 9/29/09	Thu 10/8/09
112	Area G R/I	3 days	Tue 10/20/09	Thu 10/22/09
113	Area G P/P	3 days	Fri 10/23/09	Tue 10/27/09

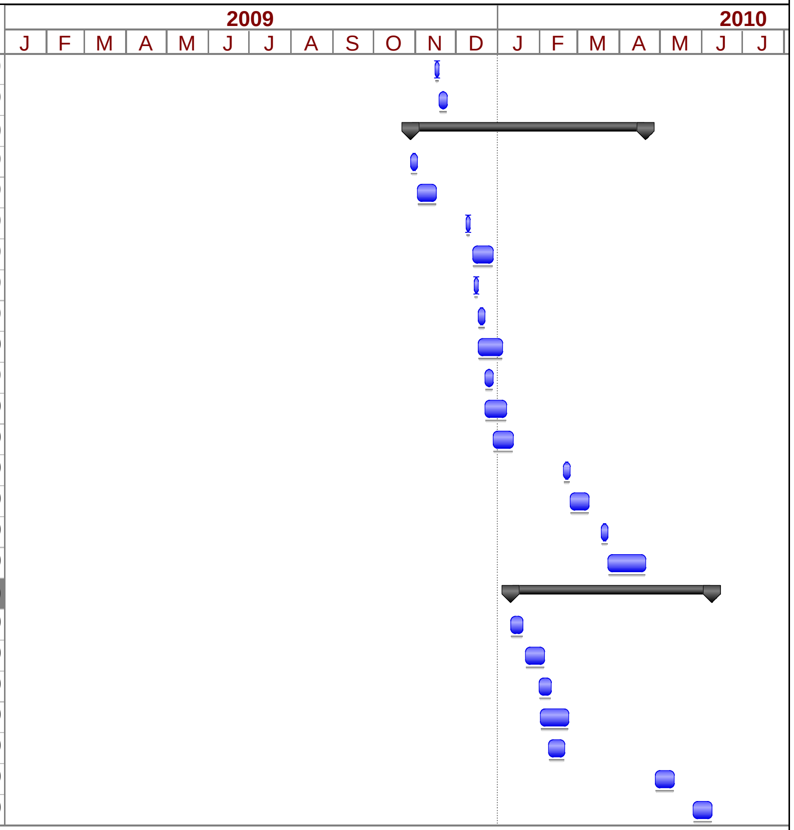


Project: Moon Area HS
Description: Structure Without Wall Bracing
Date: 4/7/2010

Task		Milestone		External Tasks	
Split		Summary		External Milestone	
Progress		Project Summary		Deadline	

Original Structure Without Wall Bracing

ID	Task Name	Duration	Start	Finish
110	Area F R/I	3 days	Mon 11/16/09	Wed 11/18/09
111	Area F P/P	4 days	Thu 11/19/09	Tue 11/24/09
114	**Second Floor**	**124 days**	**Thu 10/29/09**	**Tue 4/20/10**
117	Area D R/I	3 days	Thu 10/29/09	Mon 11/2/09
118	Area D P/P	10 days	Tue 11/3/09	Mon 11/16/09
125	Area A R/I	3 days	Wed 12/9/09	Fri 12/11/09
126	Area A P/P	11 days	Mon 12/14/09	Mon 12/28/09
127	Area B R/I	3 days	Tue 12/15/09	Thu 12/17/09
123	Area G R/I	3 days	Fri 12/18/09	Tue 12/22/09
128	Area B P/P	12 days	Fri 12/18/09	Mon 1/4/10
121	Area F R/I	4 days	Wed 12/23/09	Mon 12/28/09
124	Area G P/P	12 days	Wed 12/23/09	Thu 1/7/10
122	Area F P/P	11 days	Tue 12/29/09	Tue 1/12/10
115	Area C R/I	3 days	Fri 2/19/10	Tue 2/23/10
116	Area C P/P	10 days	Wed 2/24/10	Tue 3/9/10
119	Area E R/I	3 days	Fri 3/19/10	Tue 3/23/10
120	Area E P/P	20 days	Wed 3/24/10	Tue 4/20/10
129	**Roof**	**107 days**	**Mon 1/11/10**	**Tue 6/8/10**
131	Area D	7 days	Mon 1/11/10	Tue 1/19/10
133	Area F	10 days	Fri 1/22/10	Thu 2/4/10
135	Area A	7 days	Mon 2/1/10	Tue 2/9/10
134	Area G	15 days	Tue 2/2/10	Mon 2/22/10
136	Area B	10 days	Mon 2/8/10	Fri 2/19/10
130	Area C	10 days	Wed 4/28/10	Tue 5/11/10
132	Area E	10 days	Wed 5/26/10	Tue 6/8/10

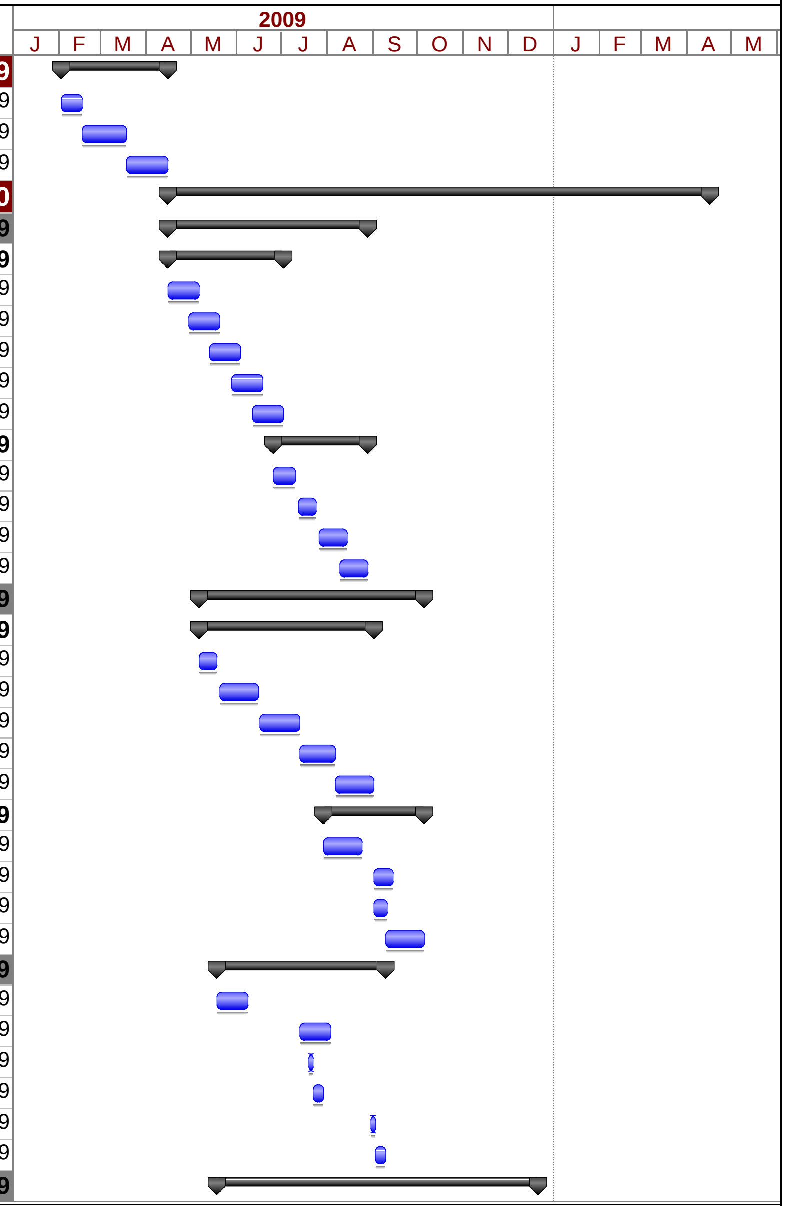


Project: Moon Area HS
Description: Structure Without Wall Bracing
Date: 4/7/2010

Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline

Original Structure WITH Wall Bracing

ID	Task Name	Duration	Start	Finish
1	**General Dates**	**52 days**	**Tue 2/3/09**	**Wed 4/15/09**
2	Mobilization	10 days	Tue 2/3/09	Mon 2/16/09
3	Site Demolition	22 days	Tue 2/17/09	Wed 3/18/09
4	Bulk Cut for Building Basement	20 days	Thu 3/19/09	Wed 4/15/09
5	**Structure Schedule**	**262 days**	**Thu 4/16/09**	**Fri 4/16/10**
6	**Caissons**	**97 days**	**Thu 4/16/09**	**Fri 8/28/09**
7	**Ground Floor**	**56 days**	**Thu 4/16/09**	**Thu 7/2/09**
8	Area C	15 days	Thu 4/16/09	Wed 5/6/09
9	Area D	15 days	Thu 4/30/09	Wed 5/20/09
10	Area E	15 days	Thu 5/14/09	Wed 6/3/09
11	Area F	15 days	Fri 5/29/09	Thu 6/18/09
12	Area G	15 days	Fri 6/12/09	Thu 7/2/09
13	**First Floor**	**46 days**	**Fri 6/26/09**	**Fri 8/28/09**
14	Area C	11 days	Fri 6/26/09	Fri 7/10/09
15	Area E	10 days	Mon 7/13/09	Fri 7/24/09
16	Area A	15 days	Mon 7/27/09	Fri 8/14/09
17	Area B	15 days	Mon 8/10/09	Fri 8/28/09
18	**Grade Beams**	**108 days**	**Thu 5/7/09**	**Mon 10/5/09**
19	**Ground Floor**	**84 days**	**Thu 5/7/09**	**Tue 9/1/09**
20	Area C	8 days	Thu 5/7/09	Mon 5/18/09
21	Area D	18 days	Thu 5/21/09	Mon 6/15/09
22	Area E	19 days	Wed 6/17/09	Mon 7/13/09
23	Area F	18 days	Tue 7/14/09	Thu 8/6/09
24	Area G	18 days	Fri 8/7/09	Tue 9/1/09
25	**First Floor**	**48 days**	**Thu 7/30/09**	**Mon 10/5/09**
26	Area C	18 days	Thu 7/30/09	Mon 8/24/09
28	Area A	9 days	Wed 9/2/09	Mon 9/14/09
29	Area B	7 days	Wed 9/2/09	Thu 9/10/09
27	Area E	18 days	Thu 9/10/09	Mon 10/5/09
30	**Concrete Wall**	**82 days**	**Tue 5/19/09**	**Wed 9/9/09**
31	Area C	15 days	Tue 5/19/09	Mon 6/8/09
33	Area E	15 days	Tue 7/14/09	Mon 8/3/09
32	Area C Wall Brace	3 days	Mon 7/20/09	Wed 7/22/09
35	Area C Backfill	5 days	Thu 7/23/09	Wed 7/29/09
34	Area E Wall Brace	3 days	Mon 8/31/09	Wed 9/2/09
36	Area E Backfill	5 days	Thu 9/3/09	Wed 9/9/09
83	**SOG's**	**155 days**	**Tue 5/19/09**	**Mon 12/21/09**

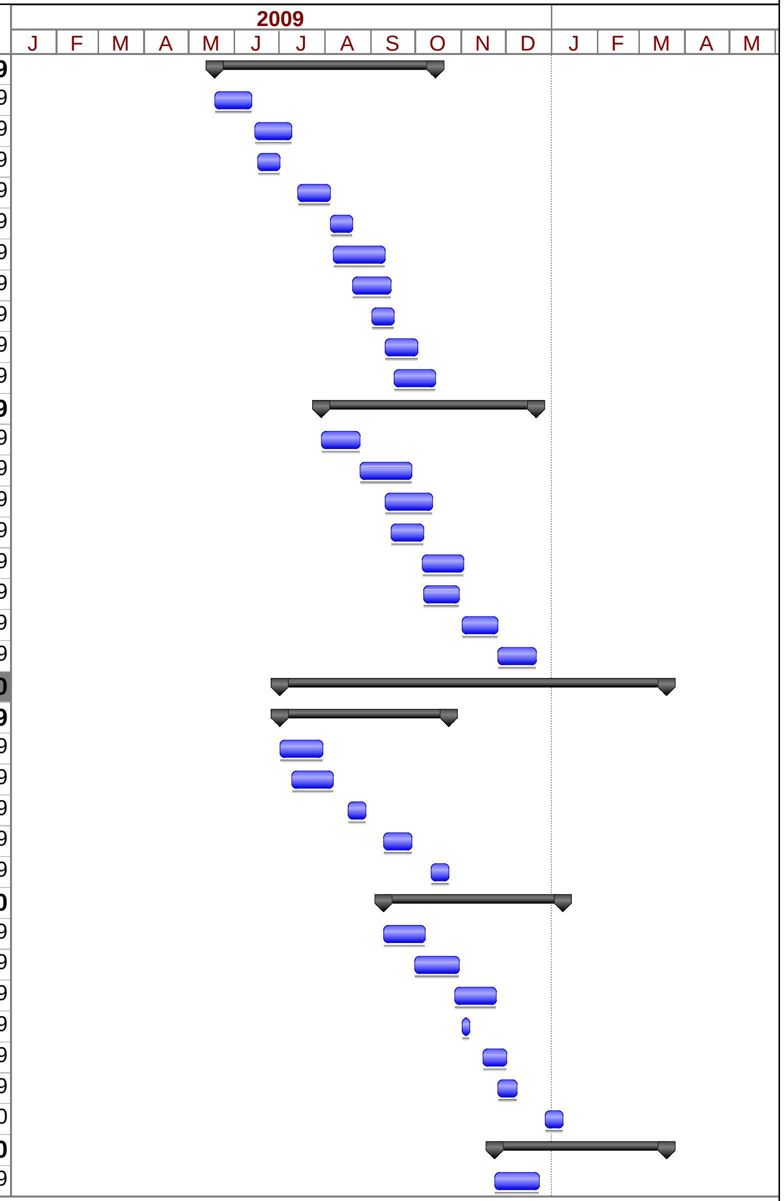


Project: Moon Area HS
Description: Structure With Wall Bracing
Date: 4/7/2010

Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline

Original Structure WITH Wall Bracing

ID	Task Name	Duration	Start	Finish
84	**Ground Floor**	**107 days**	**Tue 5/19/09**	**Wed 10/14/09**
85	Area C R/I	19 days	Tue 5/19/09	Fri 6/12/09
86	Area C P/P	19 days	Mon 6/15/09	Thu 7/9/09
87	Area D R/I	11 days	Wed 6/17/09	Wed 7/1/09
89	Area E R/I	16 days	Tue 7/14/09	Tue 8/4/09
90	Area E P/P	11 days	Wed 8/5/09	Wed 8/19/09
91	Area F R/I	25 days	Fri 8/7/09	Thu 9/10/09
88	Area D P/P	18 days	Thu 8/20/09	Mon 9/14/09
93	Area G R/I	11 days	Wed 9/2/09	Wed 9/16/09
92	Area F P/P	16 days	Fri 9/11/09	Fri 10/2/09
94	Area G P/P	20 days	Thu 9/17/09	Wed 10/14/09
95	**First Floor**	**103 days**	**Thu 7/30/09**	**Mon 12/21/09**
96	Area C R/I	18 days	Thu 7/30/09	Mon 8/24/09
97	Area C P/P	25 days	Tue 8/25/09	Mon 9/28/09
102	Area B R/I	22 days	Fri 9/11/09	Mon 10/12/09
100	Area A R/I	16 days	Tue 9/15/09	Tue 10/6/09
98	Area E R/I	20 days	Tue 10/6/09	Mon 11/2/09
101	Area A P/P	18 days	Wed 10/7/09	Fri 10/30/09
103	Area B P/P	18 days	Mon 11/2/09	Wed 11/25/09
99	Area E P/P	18 days	Thu 11/26/09	Mon 12/21/09
60	**Structural Masonry**	**187 days**	**Thu 7/2/09**	**Fri 3/19/10**
61	**Ground Floor**	**82 days**	**Thu 7/2/09**	**Fri 10/23/09**
63	Area D	21 days	Thu 7/2/09	Thu 7/30/09
62	Area C	20 days	Fri 7/10/09	Thu 8/6/09
64	Area E	10 days	Mon 8/17/09	Fri 8/28/09
66	Area G	13 days	Thu 9/10/09	Mon 9/28/09
65	Area F	10 days	Mon 10/12/09	Fri 10/23/09
67	**First Floor**	**87 days**	**Thu 9/10/09**	**Fri 1/8/10**
69	Area D	20 days	Thu 9/10/09	Wed 10/7/09
68	Area C	22 days	Thu 10/1/09	Fri 10/30/09
72	Area G	20 days	Wed 10/28/09	Tue 11/24/09
73	Area A	5 days	Mon 11/2/09	Fri 11/6/09
71	Area F	12 days	Mon 11/16/09	Tue 12/1/09
74	Area B	9 days	Thu 11/26/09	Tue 12/8/09
70	Area E	10 days	Mon 12/28/09	Fri 1/8/10
75	**Second Floor**	**84 days**	**Tue 11/24/09**	**Fri 3/19/10**
77	Area D	22 days	Tue 11/24/09	Wed 12/23/09

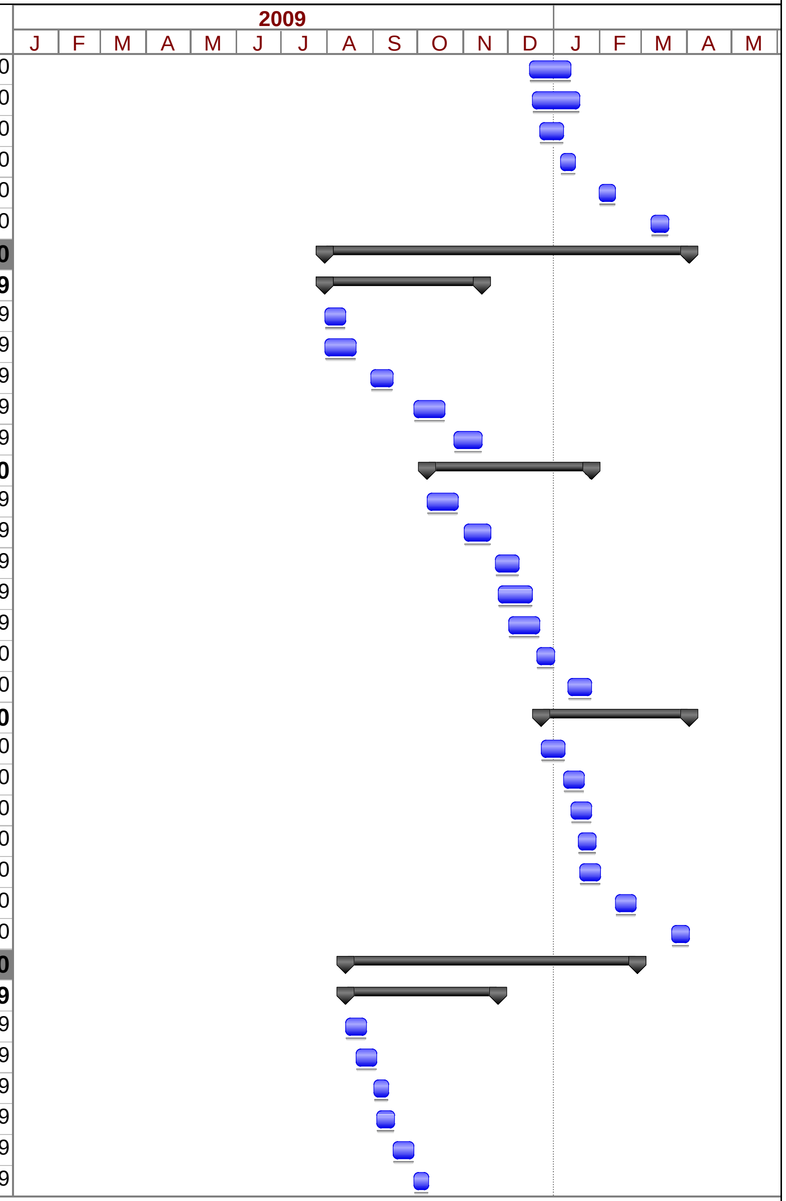


Project: Moon Area HS
Description: Structure With Wall Bracing
Date: 4/7/2010

Task		Milestone		External Tasks	
Split		Summary		External Milestone	
Progress		Project Summary		Deadline	

Original Structure WITH Wall Bracing

ID	Task Name	Duration	Start	Finish
76	Area C	20 days	Wed 12/16/09	Tue 1/12/10
80	Area G	22 days	Fri 12/18/09	Mon 1/18/10
79	Area F	12 days	Wed 12/23/09	Thu 1/7/10
81	Area A	8 days	Wed 1/6/10	Fri 1/15/10
82	Area B	9 days	Mon 2/1/10	Thu 2/11/10
78	Area E	10 days	Mon 3/8/10	Fri 3/19/10
37	**Steel Columns and Beams**	**176 days**	**Fri 7/31/09**	**Fri 4/2/10**
38	**Ground Floor**	**76 days**	**Fri 7/31/09**	**Fri 11/13/09**
39	Area C	10 days	Fri 7/31/09	Thu 8/13/09
40	Area D	15 days	Fri 7/31/09	Thu 8/20/09
41	Area E	11 days	Mon 8/31/09	Mon 9/14/09
43	Area G	15 days	Tue 9/29/09	Mon 10/19/09
42	Area F	15 days	Mon 10/26/09	Fri 11/13/09
44	**First Floor**	**79 days**	**Thu 10/8/09**	**Tue 1/26/10**
46	Area D	15 days	Thu 10/8/09	Wed 10/28/09
45	Area C	14 days	Mon 11/2/09	Thu 11/19/09
50	Area A	12 days	Mon 11/23/09	Tue 12/8/09
49	Area G	17 days	Wed 11/25/09	Thu 12/17/09
48	Area F	15 days	Wed 12/2/09	Tue 12/22/09
51	Area B	10 days	Mon 12/21/09	Fri 1/1/10
47	Area E	12 days	Mon 1/11/10	Tue 1/26/10
52	**Second Floor**	**72 days**	**Thu 12/24/09**	**Fri 4/2/10**
54	Area D	12 days	Thu 12/24/09	Fri 1/8/10
56	Area F	10 days	Fri 1/8/10	Thu 1/21/10
53	Area C	10 days	Wed 1/13/10	Tue 1/26/10
58	Area A	10 days	Mon 1/18/10	Fri 1/29/10
57	Area G	10 days	Tue 1/19/10	Mon 2/1/10
59	Area B	10 days	Fri 2/12/10	Thu 2/25/10
55	Area E	10 days	Mon 3/22/10	Fri 4/2/10
104	**Slabs on Deck**	**141 days**	**Fri 8/14/09**	**Fri 2/26/10**
105	**First Floor**	**73 days**	**Fri 8/14/09**	**Tue 11/24/09**
106	Area C R/I	10 days	Fri 8/14/09	Thu 8/27/09
108	Area D R/I	10 days	Fri 8/21/09	Thu 9/3/09
107	Area C P/P	8 days	Wed 9/2/09	Fri 9/11/09
109	Area D P/P	8 days	Fri 9/4/09	Tue 9/15/09
110	Area E R/I	10 days	Tue 9/15/09	Mon 9/28/09
111	Area E P/P	8 days	Tue 9/29/09	Thu 10/8/09

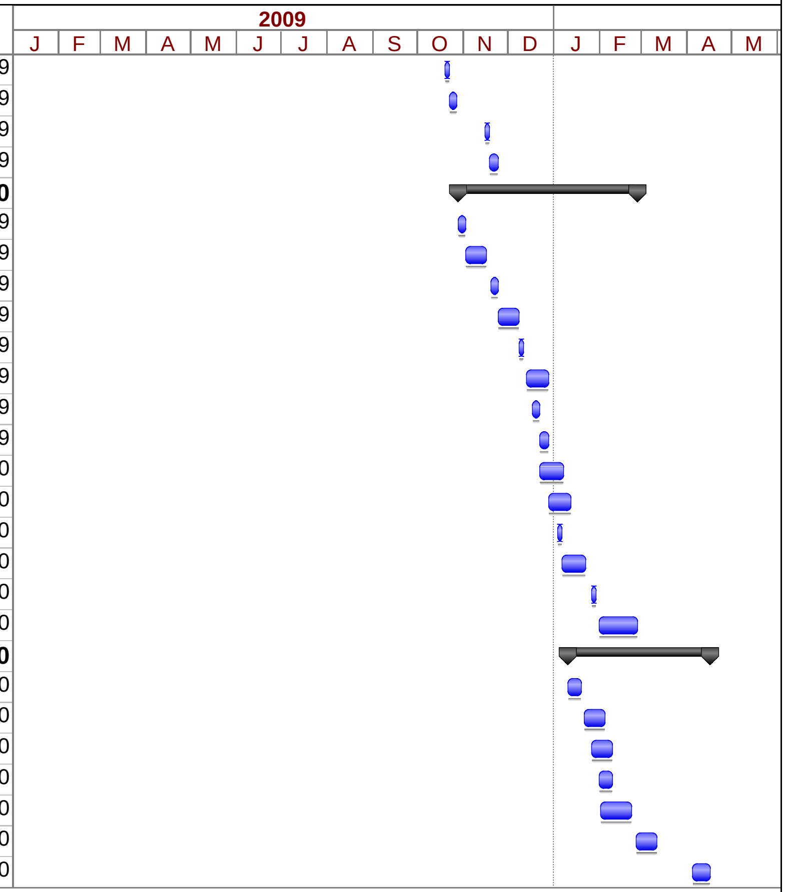


Project: Moon Area HS
Description: Structure With Wall Bracing
Date: 4/7/2010

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

Original Structure WITH Wall Bracing

ID	Task Name	Duration	Start	Finish
114	Area G R/I	3 days	Tue 10/20/09	Thu 10/22/09
115	Area G P/P	3 days	Fri 10/23/09	Tue 10/27/09
112	Area F R/I	3 days	Mon 11/16/09	Wed 11/18/09
113	Area F P/P	4 days	Thu 11/19/09	Tue 11/24/09
116	**Second Floor**	**87 days**	**Thu 10/29/09**	**Fri 2/26/10**
119	Area D R/I	3 days	Thu 10/29/09	Mon 11/2/09
120	Area D P/P	10 days	Tue 11/3/09	Mon 11/16/09
117	Area C R/I	3 days	Fri 11/20/09	Tue 11/24/09
118	Area C P/P	10 days	Wed 11/25/09	Tue 12/8/09
127	Area A R/I	3 days	Wed 12/9/09	Fri 12/11/09
128	Area A P/P	11 days	Mon 12/14/09	Mon 12/28/09
125	Area G R/I	3 days	Fri 12/18/09	Tue 12/22/09
123	Area F R/I	4 days	Wed 12/23/09	Mon 12/28/09
126	Area G P/P	12 days	Wed 12/23/09	Thu 1/7/10
124	Area F P/P	11 days	Tue 12/29/09	Tue 1/12/10
129	Area B R/I	3 days	Mon 1/4/10	Wed 1/6/10
130	Area B P/P	12 days	Thu 1/7/10	Fri 1/22/10
121	Area E R/I	3 days	Wed 1/27/10	Fri 1/29/10
122	Area E P/P	20 days	Mon 2/1/10	Fri 2/26/10
131	**Roof**	**70 days**	**Mon 1/11/10**	**Fri 4/16/10**
133	Area D	7 days	Mon 1/11/10	Tue 1/19/10
135	Area F	10 days	Fri 1/22/10	Thu 2/4/10
132	Area C	10 days	Wed 1/27/10	Tue 2/9/10
137	Area A	7 days	Mon 2/1/10	Tue 2/9/10
136	Area G	15 days	Tue 2/2/10	Mon 2/22/10
138	Area B	10 days	Fri 2/26/10	Thu 3/11/10
134	Area E	10 days	Mon 4/5/10	Fri 4/16/10

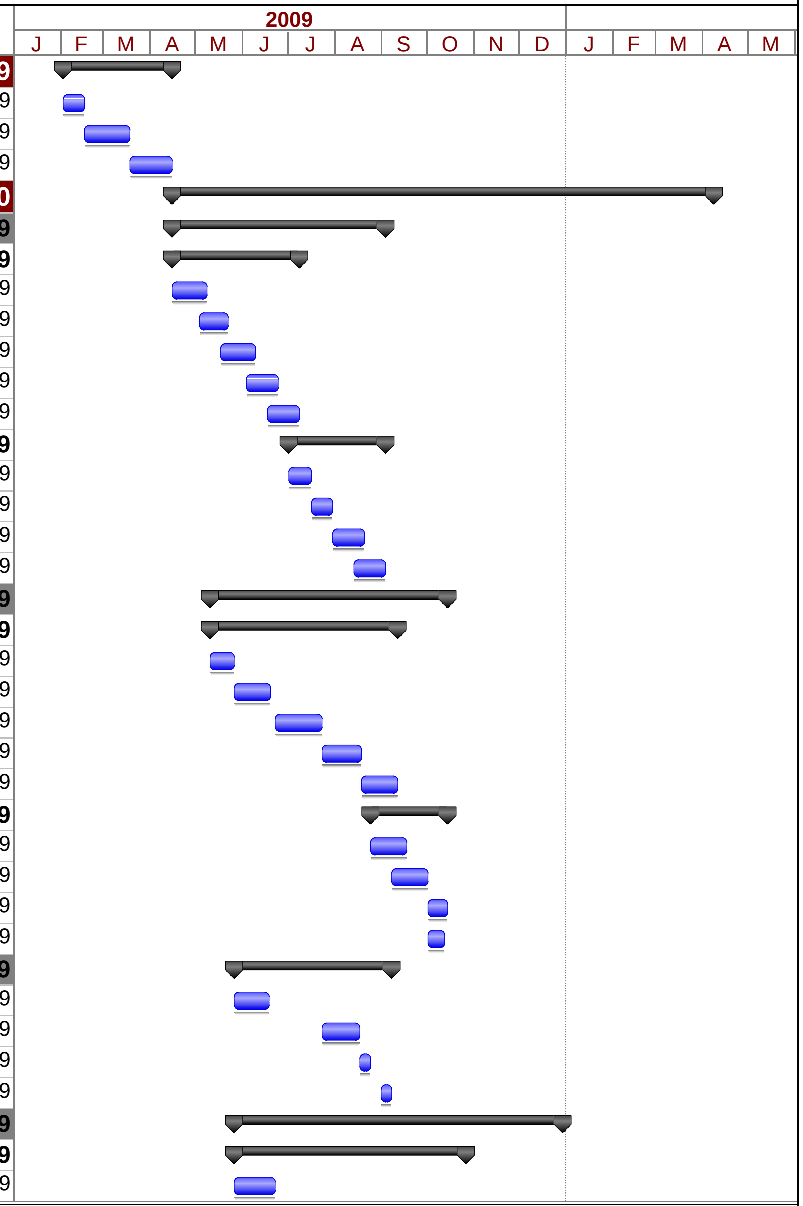


Project: Moon Area HS
Description: Structure With Wall Bracing
Date: 4/7/2010

Task	Milestone	External Tasks
Split	Summary	External Milestone
Progress	Project Summary	Deadline

Original Structure With Retaining Wall Design

ID	Task Name	Duration	Start	Finish
1	**General Dates**	**52 days**	**Tue 2/3/09**	**Wed 4/15/09**
2	Mobilization	10 days	Tue 2/3/09	Mon 2/16/09
3	Site Demolition	22 days	Tue 2/17/09	Wed 3/18/09
4	Bulk Cut for Building Basement	20 days	Thu 3/19/09	Wed 4/15/09
5	**Structure Schedule**	**256 days**	**Thu 4/16/09**	**Thu 4/8/10**
6	**Caissons**	**101 days**	**Thu 4/16/09**	**Thu 9/3/09**
7	**Ground Floor**	**60 days**	**Thu 4/16/09**	**Wed 7/8/09**
8	Area C	17 days	Thu 4/16/09	Fri 5/8/09
9	Area D	15 days	Mon 5/4/09	Fri 5/22/09
10	Area E	17 days	Mon 5/18/09	Tue 6/9/09
11	Area F	15 days	Thu 6/4/09	Wed 6/24/09
12	Area G	15 days	Thu 6/18/09	Wed 7/8/09
13	**First Floor**	**46 days**	**Thu 7/2/09**	**Thu 9/3/09**
14	Area C	11 days	Thu 7/2/09	Thu 7/16/09
15	Area E	10 days	Fri 7/17/09	Thu 7/30/09
16	Area A	15 days	Fri 7/31/09	Thu 8/20/09
17	Area B	15 days	Fri 8/14/09	Thu 9/3/09
18	**Grade Beams**	**113 days**	**Mon 5/11/09**	**Wed 10/14/09**
19	**Ground Floor**	**90 days**	**Mon 5/11/09**	**Fri 9/11/09**
20	Area C	12 days	Mon 5/11/09	Tue 5/26/09
21	Area D	18 days	Wed 5/27/09	Fri 6/19/09
22	Area E	23 days	Tue 6/23/09	Thu 7/23/09
23	Area F	18 days	Fri 7/24/09	Tue 8/18/09
24	Area G	18 days	Wed 8/19/09	Fri 9/11/09
25	**First Floor**	**37 days**	**Tue 8/25/09**	**Wed 10/14/09**
26	Area C	18 days	Tue 8/25/09	Thu 9/17/09
27	Area E	18 days	Tue 9/8/09	Thu 10/1/09
28	Area A	9 days	Fri 10/2/09	Wed 10/14/09
29	Area B	7 days	Fri 10/2/09	Mon 10/12/09
30	**Concrete Wall**	**74 days**	**Wed 5/27/09**	**Mon 9/7/09**
31	Area C	17 days	Wed 5/27/09	Thu 6/18/09
32	Area E	17 days	Fri 7/24/09	Mon 8/17/09
33	Area C Backfill	5 days	Tue 8/18/09	Mon 8/24/09
34	Area E Backfill	5 days	Tue 9/1/09	Mon 9/7/09
81	**SOG's**	**155 days**	**Wed 5/27/09**	**Tue 12/29/09**
82	**Ground Floor**	**109 days**	**Wed 5/27/09**	**Mon 10/26/09**
83	Area C R/I	19 days	Wed 5/27/09	Mon 6/22/09

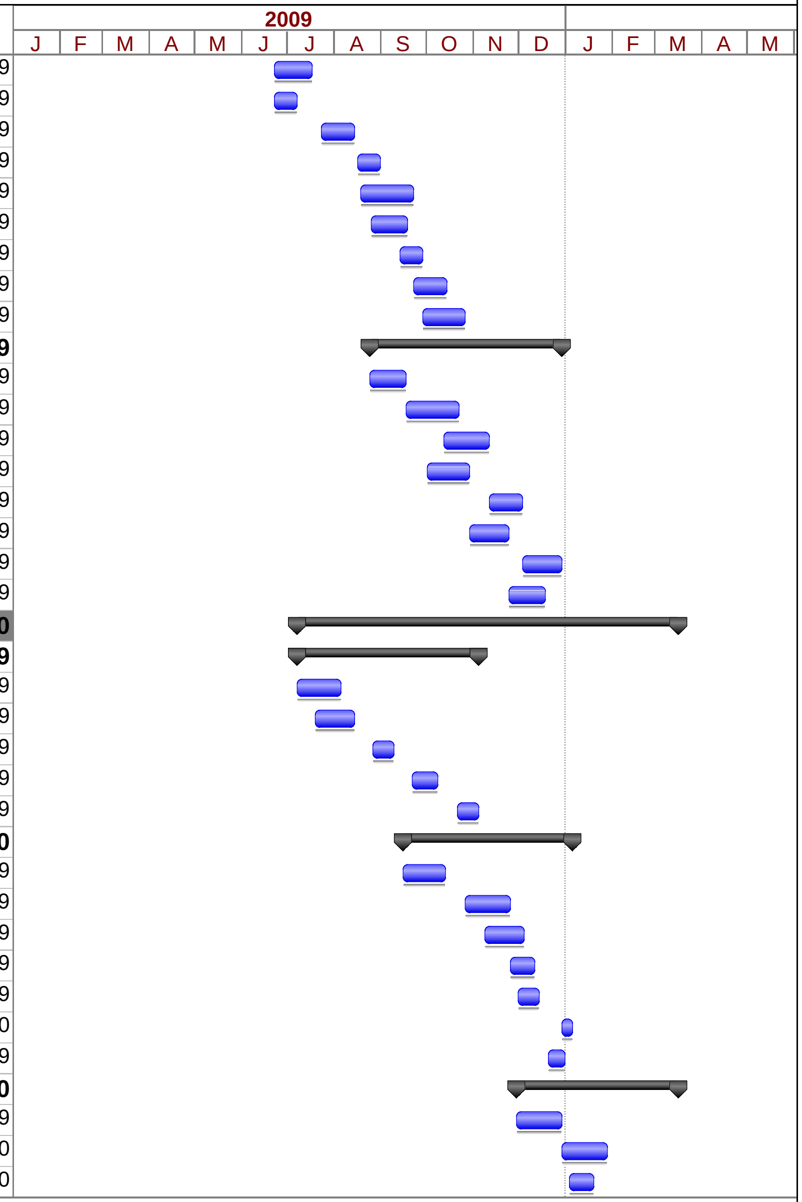


Project: Moon Area HS
Description: Structure With Retaining Wall Design
Date: 4/7/2010

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

Original Structure With Retaining Wall Design

ID	Task Name	Duration	Start	Finish
84	Area C P/P	19 days	Tue 6/23/09	Fri 7/17/09
85	Area D R/I	11 days	Tue 6/23/09	Tue 7/7/09
87	Area E R/I	16 days	Fri 7/24/09	Fri 8/14/09
88	Area E P/P	11 days	Mon 8/17/09	Mon 8/31/09
89	Area F R/I	25 days	Wed 8/19/09	Tue 9/22/09
86	Area D P/P	18 days	Wed 8/26/09	Fri 9/18/09
91	Area G R/I	11 days	Mon 9/14/09	Mon 9/28/09
90	Area F P/P	16 days	Wed 9/23/09	Wed 10/14/09
92	Area G P/P	20 days	Tue 9/29/09	Mon 10/26/09
93	**First Floor**	**91 days**	**Tue 8/25/09**	**Tue 12/29/09**
94	Area C R/I	18 days	Tue 8/25/09	Thu 9/17/09
95	Area C P/P	25 days	Fri 9/18/09	Thu 10/22/09
100	Area B R/I	22 days	Tue 10/13/09	Wed 11/11/09
96	Area E R/I	20 days	Fri 10/2/09	Thu 10/29/09
98	Area A R/I	16 days	Thu 11/12/09	Thu 12/3/09
97	Area E P/P	18 days	Fri 10/30/09	Tue 11/24/09
99	Area A P/P	18 days	Fri 12/4/09	Tue 12/29/09
101	Area B P/P	18 days	Wed 11/25/09	Fri 12/18/09
58	**Structural Masonry**	**180 days**	**Wed 7/8/09**	**Tue 3/16/10**
59	**Ground Floor**	**86 days**	**Wed 7/8/09**	**Wed 11/4/09**
61	Area D	21 days	Wed 7/8/09	Wed 8/5/09
60	Area C	20 days	Mon 7/20/09	Fri 8/14/09
62	Area E	10 days	Thu 8/27/09	Wed 9/9/09
64	Area G	13 days	Tue 9/22/09	Thu 10/8/09
63	Area F	10 days	Thu 10/22/09	Wed 11/4/09
65	**First Floor**	**80 days**	**Wed 9/16/09**	**Tue 1/5/10**
67	Area D	20 days	Wed 9/16/09	Tue 10/13/09
66	Area C	22 days	Tue 10/27/09	Wed 11/25/09
70	Area G	20 days	Mon 11/9/09	Fri 12/4/09
69	Area F	12 days	Thu 11/26/09	Fri 12/11/09
68	Area E	10 days	Tue 12/1/09	Mon 12/14/09
71	Area A	5 days	Wed 12/30/09	Tue 1/5/10
72	Area B	9 days	Mon 12/21/09	Thu 12/31/09
73	**Second Floor**	**77 days**	**Mon 11/30/09**	**Tue 3/16/10**
75	Area D	22 days	Mon 11/30/09	Tue 12/29/09
78	Area G	22 days	Wed 12/30/09	Thu 1/28/10
77	Area F	12 days	Mon 1/4/10	Tue 1/19/10

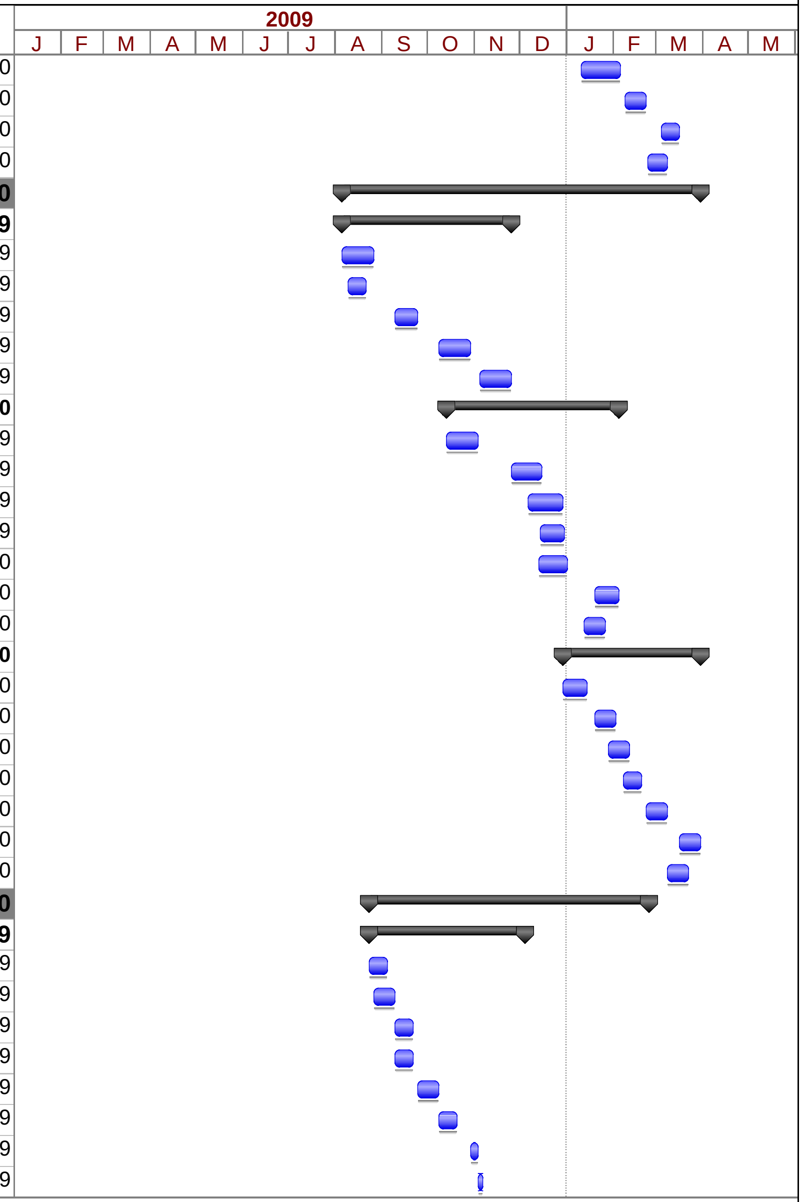


Project: Moon Area HS
Description: Structure With Retaining Wall Design
Date: 4/7/2010

Task · Split · Progress · Milestone · Summary · Project Summary · External Tasks · External Milestone · Deadline

Original Structure With Retaining Wall Design

ID	Task Name	Duration	Start	Finish
74	Area C	20 days	Mon 1/11/10	Fri 2/5/10
76	Area E	10 days	Tue 2/9/10	Mon 2/22/10
79	**Area A**	8 days	Fri 3/5/10	Tue 3/16/10
80	Area B	9 days	Wed 2/24/10	Mon 3/8/10
35	**Steel Columns and Beams**	**169 days**	**Thu 8/6/09**	**Tue 3/30/10**
36	**Ground Floor**	**80 days**	**Thu 8/6/09**	**Wed 11/25/09**
38	Area D	15 days	Thu 8/6/09	Wed 8/26/09
37	Area C	10 days	Mon 8/10/09	Fri 8/21/09
39	Area E	11 days	Thu 9/10/09	Thu 9/24/09
41	Area G	15 days	Fri 10/9/09	Thu 10/29/09
40	Area F	15 days	Thu 11/5/09	Wed 11/25/09
42	**First Floor**	**82 days**	**Wed 10/14/09**	**Thu 2/4/10**
44	Area D	15 days	Wed 10/14/09	Tue 11/3/09
43	Area C	14 days	Thu 11/26/09	Tue 12/15/09
47	Area G	17 days	Mon 12/7/09	Tue 12/29/09
45	Area E	12 days	Tue 12/15/09	Wed 12/30/09
46	Area F	15 days	Mon 12/14/09	Fri 1/1/10
48	Area A	12 days	Wed 1/20/10	Thu 2/4/10
49	Area B	10 days	Wed 1/13/10	Tue 1/26/10
50	**Second Floor**	**65 days**	**Wed 12/30/09**	**Tue 3/30/10**
52	Area D	12 days	Wed 12/30/09	Thu 1/14/10
54	Area F	10 days	Wed 1/20/10	Tue 2/2/10
55	Area G	10 days	Fri 1/29/10	Thu 2/11/10
51	Area C	10 days	Mon 2/8/10	Fri 2/19/10
53	Area E	10 days	Tue 2/23/10	Mon 3/8/10
56	Area A	10 days	Wed 3/17/10	Tue 3/30/10
57	Area B	10 days	Tue 3/9/10	Mon 3/22/10
102	**Slabs on Deck**	**133 days**	**Mon 8/24/09**	**Wed 2/24/10**
103	**First Floor**	**75 days**	**Mon 8/24/09**	**Fri 12/4/09**
104	Area C R/I	10 days	Mon 8/24/09	Fri 9/4/09
106	Area D R/I	10 days	Thu 8/27/09	Wed 9/9/09
105	Area C P/P	8 days	Thu 9/10/09	Mon 9/21/09
107	Area D P/P	8 days	Thu 9/10/09	Mon 9/21/09
108	Area E R/I	10 days	Fri 9/25/09	Thu 10/8/09
109	Area E P/P	8 days	Fri 10/9/09	Tue 10/20/09
112	Area G R/I	3 days	Fri 10/30/09	Tue 11/3/09
113	Area G P/P	3 days	Wed 11/4/09	Fri 11/6/09

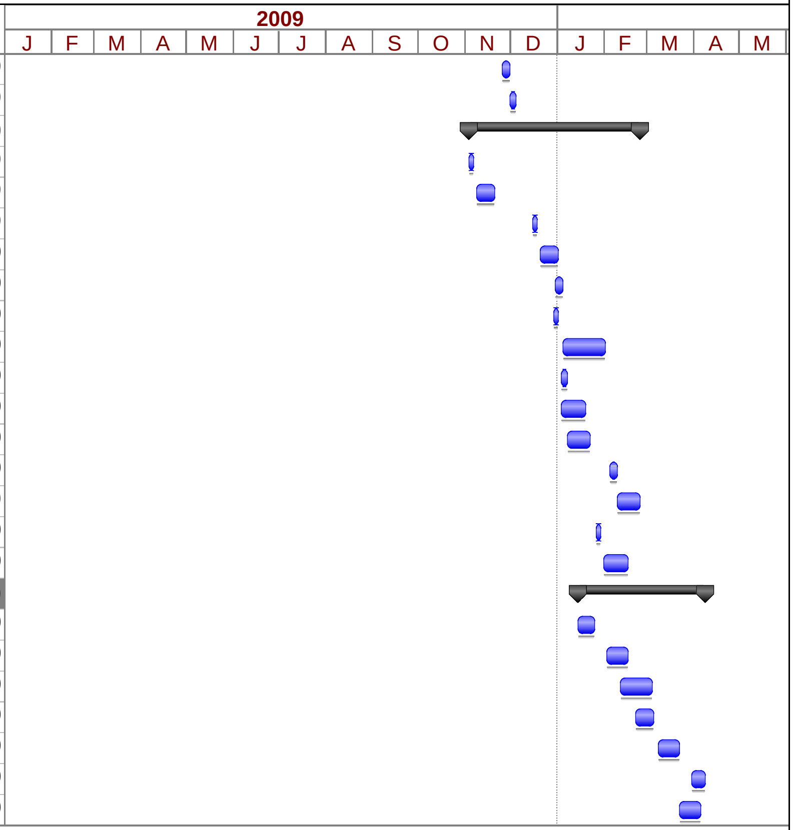


Project: Moon Area HS
Description: Structure With Retaining Wall Design
Date: 4/7/2010

Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline

Original Structure With Retaining Wall Design

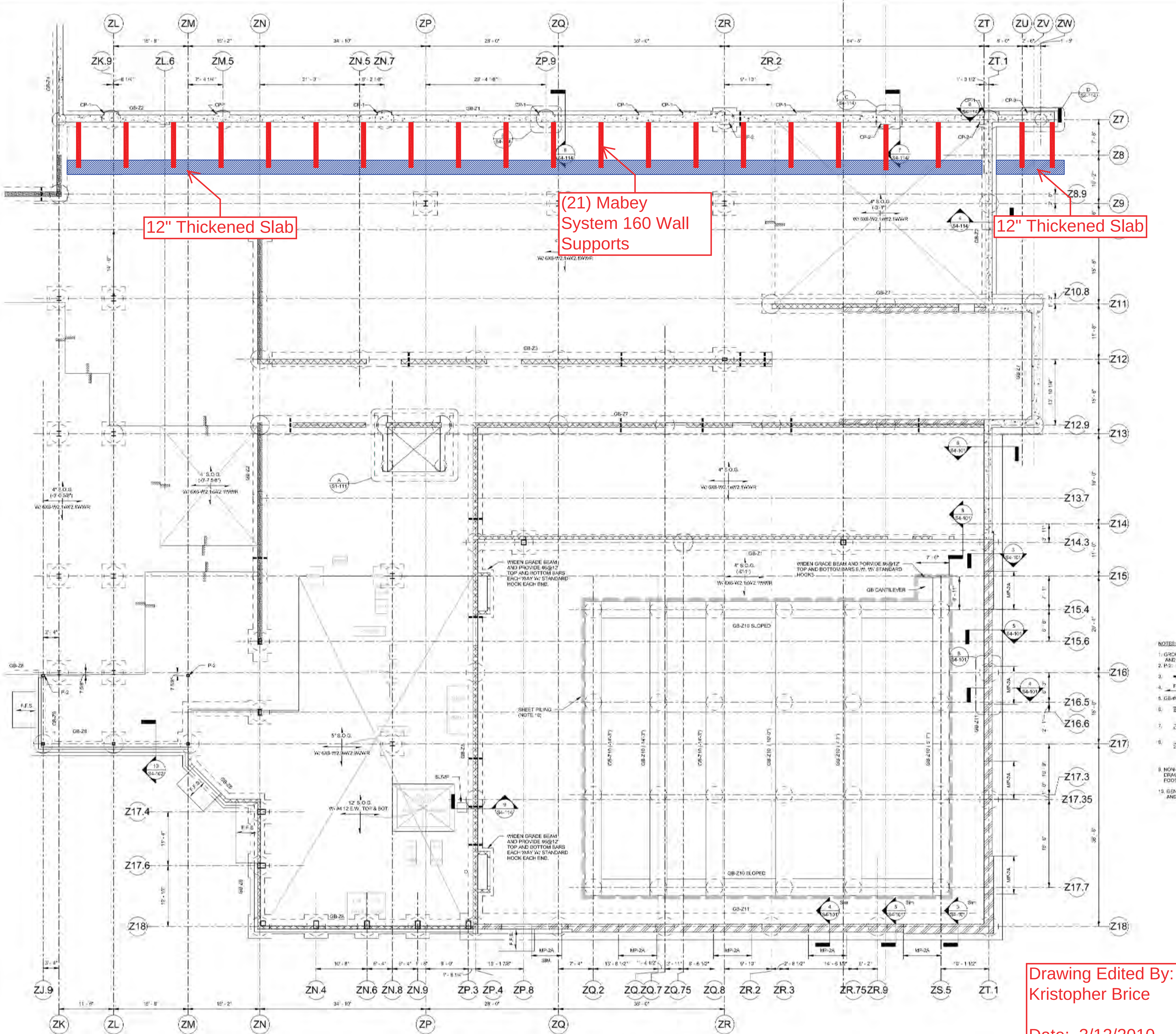
ID	Task Name	Duration	Start	Finish
110	Area F R/I	3 days	Thu 11/26/09	Mon 11/30/09
111	Area F P/P	4 days	Tue 12/1/09	Fri 12/4/09
114	**Second Floor**	**81 days**	**Wed 11/4/09**	**Wed 2/24/10**
117	Area D R/I	3 days	Wed 11/4/09	Fri 11/6/09
118	Area D P/P	10 days	Mon 11/9/09	Fri 11/20/09
115	Area C R/I	3 days	Wed 12/16/09	Fri 12/18/09
116	Area C P/P	10 days	Mon 12/21/09	Fri 1/1/10
119	Area E R/I	3 days	Thu 12/31/09	Mon 1/4/10
123	Area G R/I	3 days	Wed 12/30/09	Fri 1/1/10
120	Area E P/P	20 days	Tue 1/5/10	Mon 2/1/10
121	Area F R/I	4 days	Mon 1/4/10	Thu 1/7/10
124	Area G P/P	12 days	Mon 1/4/10	Tue 1/19/10
122	Area F P/P	11 days	Fri 1/8/10	Fri 1/22/10
125	Area A R/I	3 days	Fri 2/5/10	Tue 2/9/10
126	Area A P/P	11 days	Wed 2/10/10	Wed 2/24/10
127	Area B R/I	3 days	Wed 1/27/10	Fri 1/29/10
128	Area B P/P	12 days	Mon 2/1/10	Tue 2/16/10
129	**Roof**	**60 days**	**Fri 1/15/10**	**Thu 4/8/10**
131	Area D	7 days	Fri 1/15/10	Mon 1/25/10
133	Area F	10 days	Wed 2/3/10	Tue 2/16/10
134	Area G	15 days	Fri 2/12/10	Thu 3/4/10
130	Area C	10 days	Mon 2/22/10	Fri 3/5/10
132	Area E	10 days	Tue 3/9/10	Mon 3/22/10
135	Area A	7 days	Wed 3/31/10	Thu 4/8/10
136	Area B	10 days	Tue 3/23/10	Mon 4/5/10



Project: Moon Area HS
Description: Structure With Retaining Wall Design
Date: 4/7/2010

Task	Milestone	External Tasks
Split	Summary	External Milestone
Progress	Project Summary	Deadline

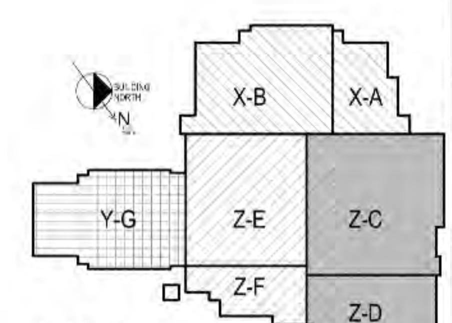
Appendix F: System 160 Wall Brace Layout



Ground Floor Plan - Area C & D
1/8" = 1'-0"

NOTES:

1. GROUND FLOOR ELEVATION IS 966'-0". PLAN REFERENCE ELEVATION (0'-0"). TOP OF GRADE BEAMS AND CAISSON CAPS ARE (-1'-4") UNLESS OTHERWISE NOTED.
2. P-2: INDICATES HSS 6x5x3/8 POST W/ 3/4"x11"x1'-3 BASE PLATE AND (4) 3/4" DIAMETER ANCHOR BOLTS.
3. INDICATES GRADE BEAM PENETRATIONS. SEE MECHANICAL AND PLUMBING DRAWINGS.
4. F.F.S. INDICATES FROST FREE SLAB, SEE TYPICAL DETAILS.
5. GB-##: INDICATES CONCRETE GRADE BEAM, SEE SCHEDULE /S3-102
6. INDICATES REINFORCED MASONRY WALL WITH #6@32" VERTICAL REINFORCING IN GROUTED CELLS PROVIDE DOWELS IN FOOTINGS TO MATCH VERTICAL REINFORCEMENT. GROUT ALL CELLS BELOW GRADE SOLID.
7. INDICATES REINFORCED MASONRY WALL WITH #6@48" CONTINUOUS VERTICAL REINFORCING IN GROUTED CELLS. PROVIDE DOWELS IN FOOTINGS TO MATCH VERTICAL REINFORCEMENT. GROUT ALL CELLS BELOW GRADE SOLID.
8. INDICATES REINFORCED MASONRY IVANY WALL WITH #6@16" CONTINUOUS VERTICAL REINFORMENT EACH FACE AND #3@8" CONTINUOUS HORIZONTAL REINFORCEMENT EACH FACE. PROVIDE DOWELS IN FOOTING TO MATCH VERTICAL REINFORCEMENT. GROUT ENTIRE WALL SOLID.
9. NON-LOADBEARING MASONRY WALLS ARE NOT SHOWN ON THE STRUCTURAL DRAWINGS. SEE ARCH DRAWINGS FOR LOCATIONS, SEE TYPICAL DETAIL FOR NON-LOADBEARING MASONRY PARTITIONS, FOOTINGS, WALL REINFORCING AND TOP BRACING REQUIREMENTS.
10. GENERAL CONTRACTOR TO COORDINATE GRADE BEAM, CAISSON, AND SHEET PILING PLAN LAYOUT AND ELEVATIONS WITH POOL CONTRACTOR.



KEY PLAN
N.T.S.

architecture
ECKLES
engineering

301 North Mercer Street
New Castle, Pa. 16101
p 724.652.5507
f 724.652.0751

132 South Broad Street
Canfield, Oh. 44406
p 330.286.0438
f 330.286.0439

NEW MOON AREA HIGH SCHOOL / DISTRICT ADMIN OFFICE
MOON AREA SCHOOL DISTRICT
MOON TOWNSHIP, PA
P.D.E. No.

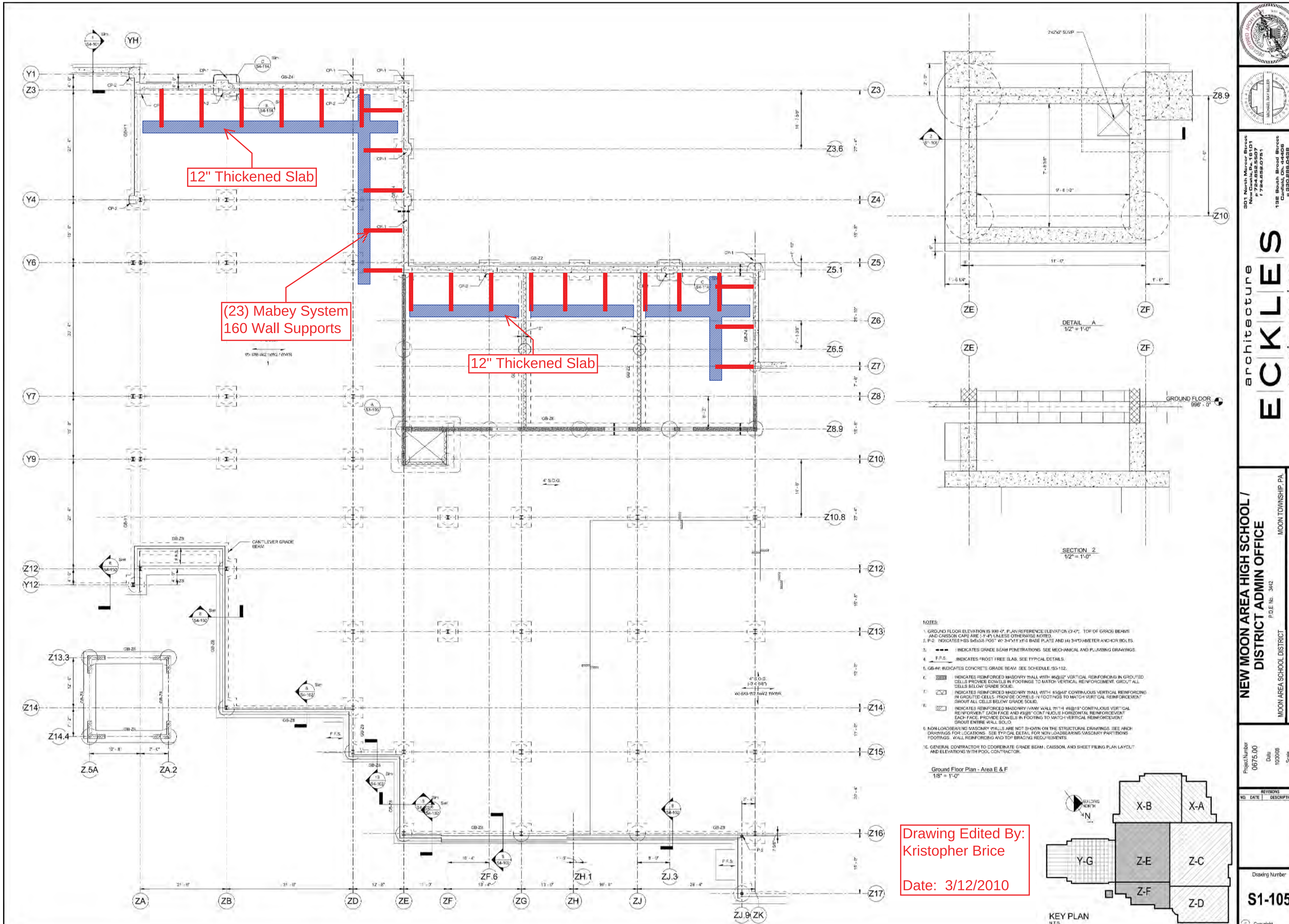
FOUNDATION PLAN - AREAS C & D

Project Number 0675.00
Date 10/30/08
Scale As indicated

REVISIONS

NO.	DATE	DESCRIPTION

Drawing Number
S1-103

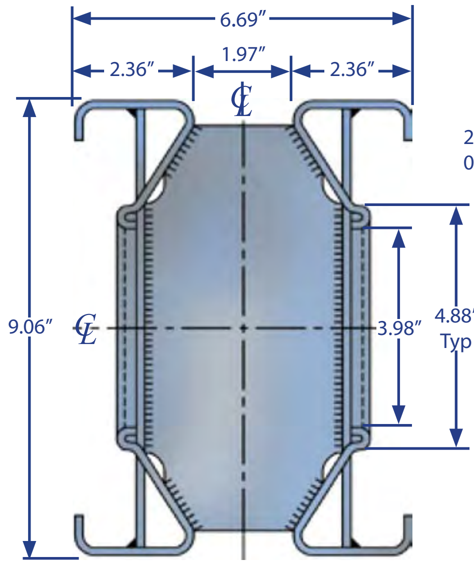


12" Thickened Slab
(23) Mabey System
160 Wall Supports
12" Thickened Slab
DETAIL A
1/2" = 1'-0"
SECTION 2
1/2" = 1'-0"
GROUND FLOOR
CANTILEVER GRADE BEAM
NOTES:
Ground Floor Plan - Area E & F
1/8" = 1'-0"
Drawing Edited By:
Kristopher Brice
Date: 3/12/2010
KEY PLAN
X-B
X-A
Y-G
Z-E
Z-C
Z-F
Z-D
architecture
ECKLES
engineering
NEW MOON AREA HIGH SCHOOL /
DISTRICT ADMIN OFFICE
MOON AREA SCHOOL DISTRICT
MOON TOWNSHIP, PA
FOUNDATION PLAN - AREAS E & F
Project Number
0675.00
Drawing Number
S1-105

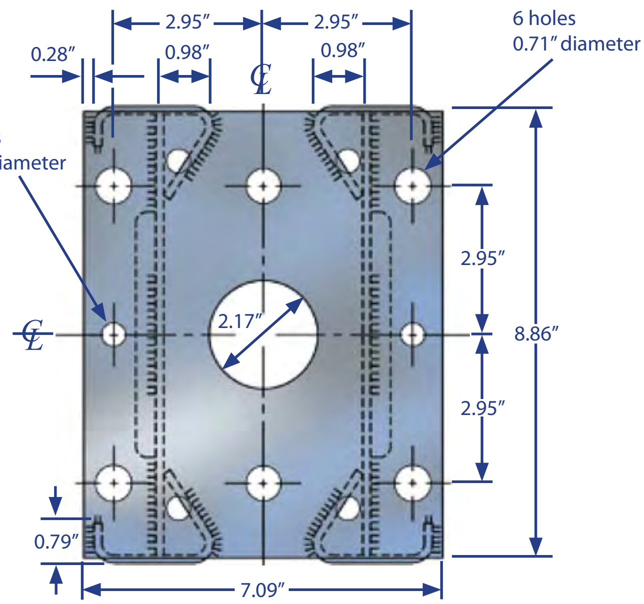
Appendix G: Mabey System 160 Product Details

Mk3 Soldier - Dimensions & Weights

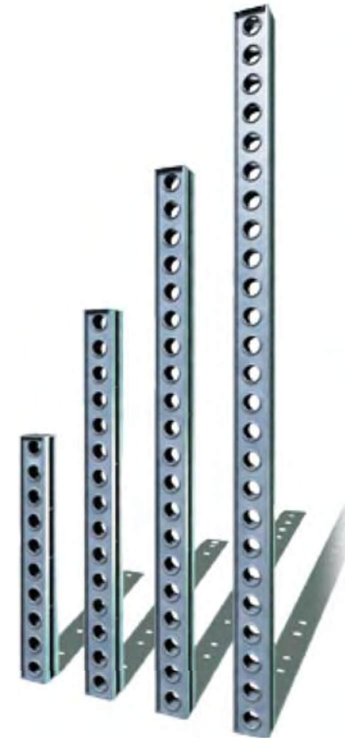
The Mk3 soldier was designed to be the strongest on the market for wall formwork, and its superior section properties provide similar advantages when it is used in propping and shoring applications.



TYPICAL CROSS-SECTION



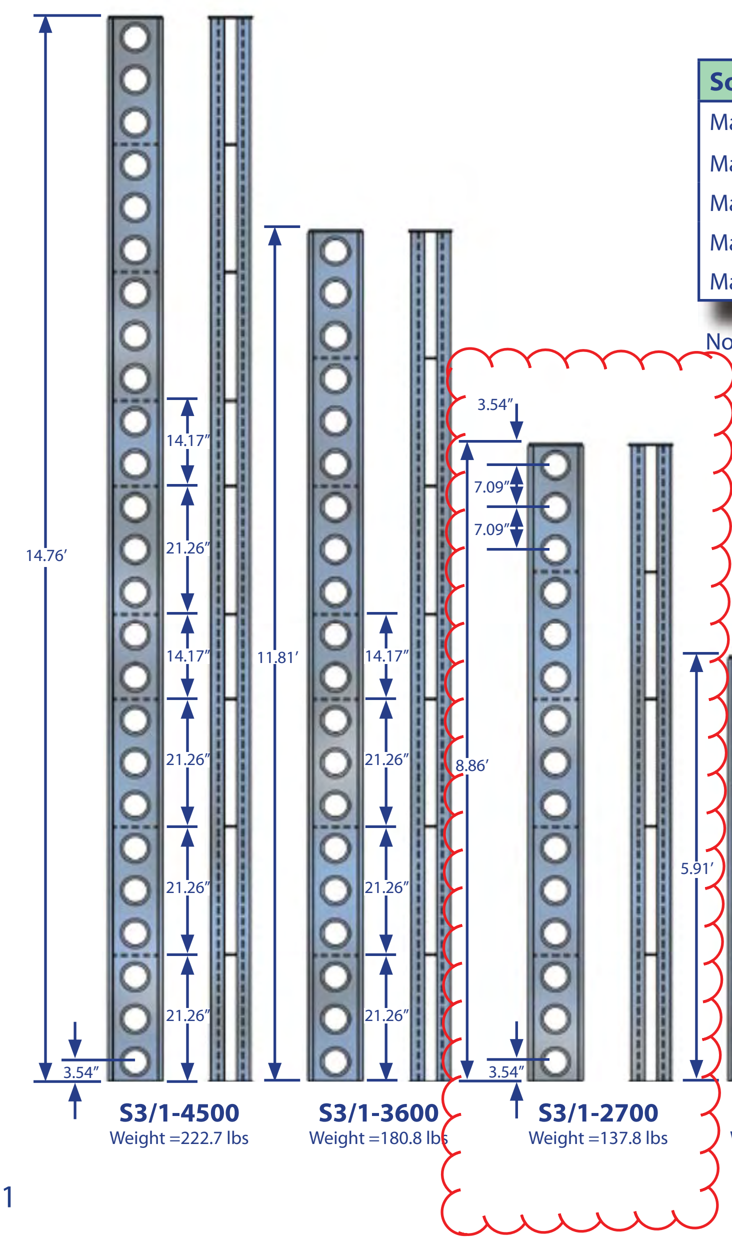
END PLATE DETAILS

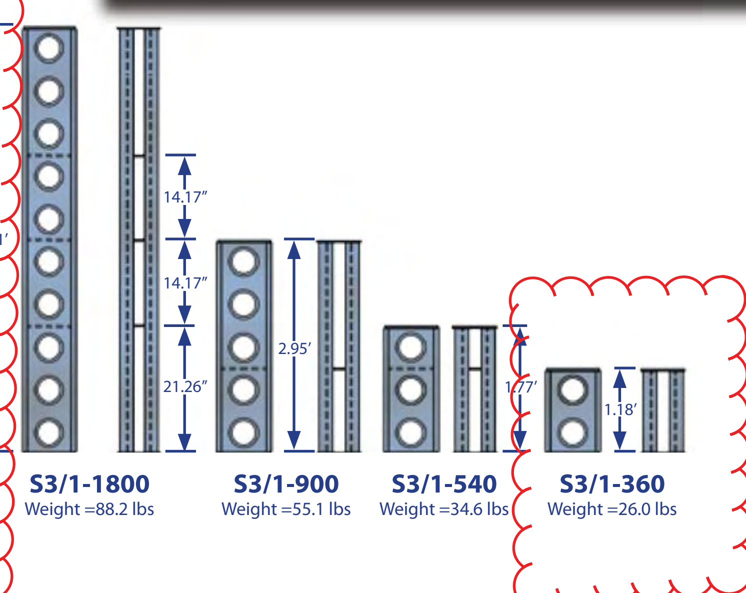


Soldier Working Specifications	
Maximum Reaction at Any Location	36 k
Maximum Positive Moment in a Simple Plan	44 k-ft
Maximum Negative Moment at Interior Supports of Continuous Spans	22 k-ft
Maximum Moment at Joint (with 6-A325 bolts)	18 k-ft
Maximum Shear Capacity	27 k

Note: Tie load can be a point load evenly distributed over a minimum area of 6″ x 6″.

Soldier Properties	
Section Modulus	10.25 in^3
Minimum Cross-Sectional Area through Lightening Holes	3.26 in^2
Maximum Cross-Sectional Area	3.88 in^2
Moment of Inertia	46.61 in^4
Minimum EI Value (30, 160 ksi)	9771 $k\text{-}ft^2$



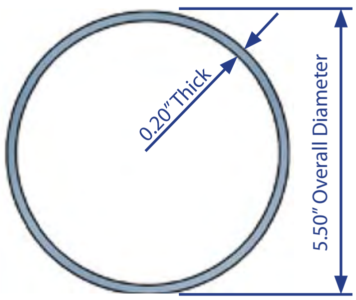


Tubular Prop Extension - Dimensions & Weights

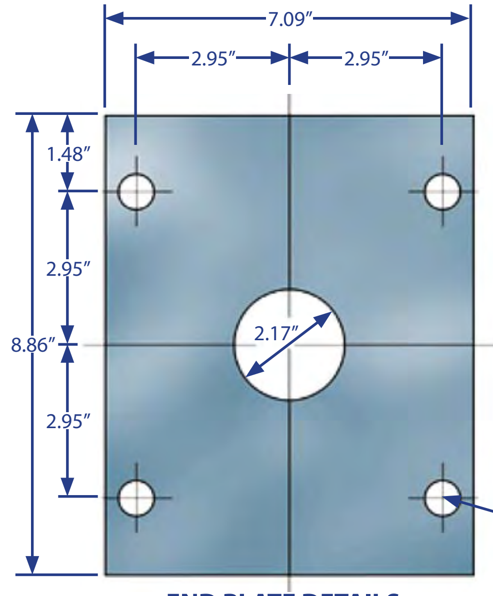
For simple propping where no bracing is required between the props, tubular prop extensions can be used instead of Mk3 Soldiers.
Note: Tubular extensions and Mk3 Soldiers should not be combined in any single prop.

Code	Length (ft)	Weight (lbs)
S3/45/0.36	1.18	28.7
S3/45/0.9	2.95	44.1
S3/45/1.8	5.91	77.2
S3/45/2.7	8.86	110.3
S3/45/3.6	11.81	143.3
S3/45/4.5	14.76	176.4

The tables giving components of props on pages 6-8 include alternatives for use of tubular prop extensions.

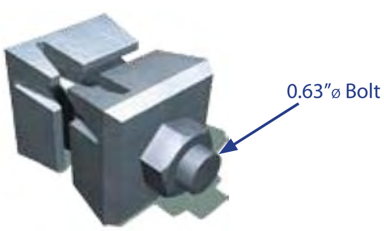


TYPICAL CROSS-SECTION



END PLATE DETAILS

Connection Details - Common Components



S3/43 Cast Shutter Beam Clip
Used to connect Soldiers to one another.
(Also Shutter Beams to Soldiers in wall formwork)
Weight = 2.2 lbs

S3/3 Soldier/Beam Clip
This captive assembly connects Soldiers to one another.
(Also Shutter Beams to Soldiers in wall formwork)
Weight = 1.2 lbs

S3/5 Mk3 Web Connector
Connects push-pull props to the Soldier. (Also Access Brackets to Mk3 Soldiers in wall formwork)
Weight = 5.5 lbs

S3/5A Mk2 Web Connector
Connects push-pull props to the Soldier. (Also Access Brackets to Mk2 Soldiers in wall formwork)
Weight = 1.5 lbs

S3/5B Double Web Connector
Connects push-pull props to the Soldier on both sides.
Weight = 6.2 lbs

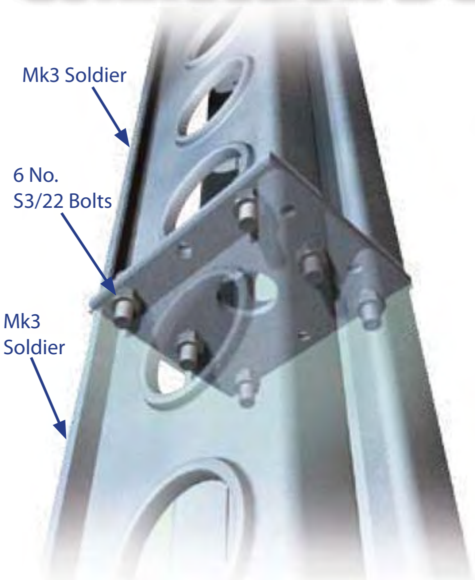
S3/30 Heavy Duty Scaffold Clamp
Connects scaffold tubes to Soldiers. (Also scaffold tubes to Shutter Beams in wall formwork)
Weight = 2.3 lbs

S3/GGC Gravlock Scaffold Clamp
Connects scaffold tubes to Soldiers. (Also scaffold tubes to Shutter Beams in wall formwork)
Weight = 2.3 lbs

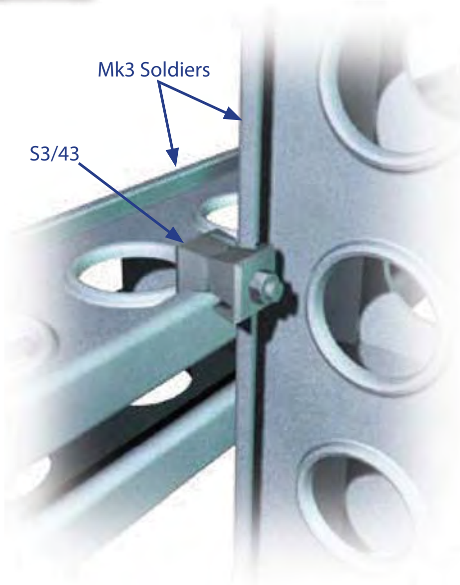
S3/21 Bolt
0.94"ø A325 - Spun galvanized finish
5.51" long - 2.36" threaded length
Weight = 1.5 lbs

S3/22 Bolt
0.63"ø A325 - Spun galvanized finish
1.77" long - 1.50" threaded length
Weight = 0.4 lbs

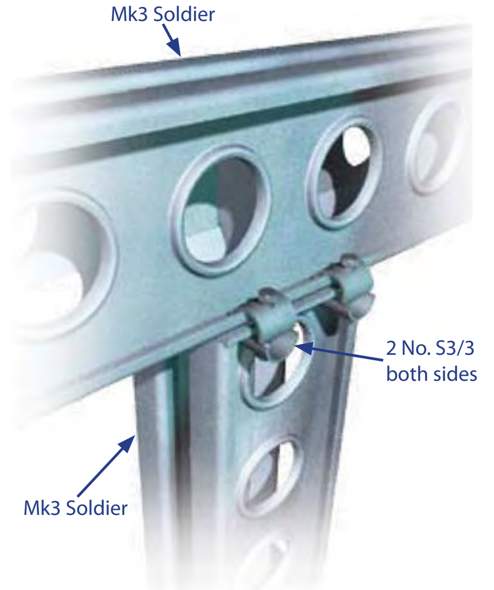
Connection Details



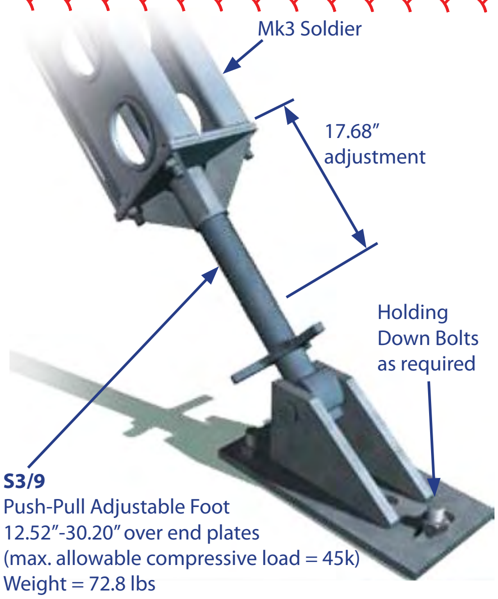
Mk3 Soldiers End Connection



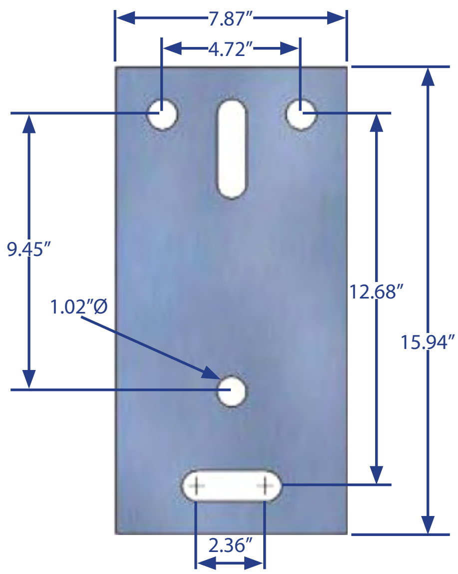
Mk3 Soldiers at 90° with S3/43



Mk3 Soldier End to Mk3 Soldier Flange with S3/3



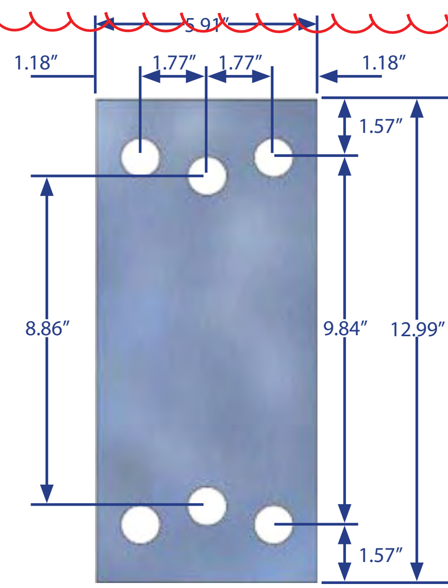
S3/9 Holding Down Detail



S3/9 End Plate Detail

S3/10 to Mk3 Soldier with S3/5

S3/10A to Mk2 Soldier Horizontal Header



S3/10A End Plate Detail

S3/10 to Mk3 Connector

Appendix H: SlenderWall Panel Takeoffs

North Elevation								
Panel Number	Quantity	Height (ft)	Width (ft)	Area (SF)	Weight (lbs)	Total Area (SF)	$/SF	Total Cost
A-1	3	17.33	5	86.65	2600	260	$ 40.00	$ 10,398.00
A-2	3	14	5	70.00	2100	210	$ 40.00	$ 8,400.00
B-1	6	8	6	48.00	1440	288	$ 40.00	$ 11,520.00
B-3	25	9	6	54.00	1620	1350	$ 40.00	$ 54,000.00
B-4	8	3.83	6	22.98	689	184	$ 40.00	$ 7,353.60
B-8	48	14	6	84.00	2520	4032	$ 40.00	$ 161,280.00
B-9	2	17.33	6	103.98	3119	208	$ 40.00	$ 8,318.40
C-1	12	17.33	3.33	57.71	1731	693	$ 40.00	$ 27,700.27
C-2	7	14	3.33	46.62	1399	326	$ 40.00	$ 13,053.60
C-3	4	20	3.33	66.60	1998	266	$ 40.00	$ 10,656.00
C-4	4	14	3.33	46.62	1399	186	$ 40.00	$ 7,459.20
D-2	4	14	4.58	64.12	1924	256	$ 40.00	$ 10,259.20
E-4	4	14	6.5	91.00	2730	364	$ 40.00	$ 14,560.00
E-5	2	9	6.5	58.50	1755	117	$ 40.00	$ 4,680.00
F-1	4	17.33	2	34.66	1040	139	$ 40.00	$ 5,545.60
F-2	8	14	2	28.00	840	224	$ 40.00	$ 8,960.00
F-3	2	9	2	18.00	540	36	$ 40.00	$ 1,440.00
G-1	8	8	10	80.00	2400	640	$ 40.00	$ 25,600.00
Total:	**154**				**Total:**	**9780**	**Total:**	**$ 391,184**

East Elevation								
Panel Number	Quantity	Height (ft)	Width (ft)	Area (SF)	Weight (lbs)	Total Area (SF)	$/SF	Total Cost
A-1	16	17.33	5	86.65	2600	1386	$ 40.00	$ 55,456.00
A-2	27	14	5	70.00	2100	1890	$ 40.00	$ 75,600.00
B-1	24	8	6	48.00	1440	1152	$ 40.00	$ 46,080.00
B-2	6	3.25	6	19.50	585	117	$ 40.00	$ 4,680.00
B-3	9	9	6	54.00	1620	486	$ 40.00	$ 19,440.00
B-4	13	3.83	6	22.98	689	299	$ 40.00	$ 11,949.60
B-5	4	6.33	6	37.98	1139	152	$ 40.00	$ 6,076.80
B-6	11	2.67	6	16.02	481	176	$ 40.00	$ 7,048.80
B-7	9	5.42	6	32.52	976	293	$ 40.00	$ 11,707.20
B-8	19	14	6	84.00	2520	1596	$ 40.00	$ 63,840.00
B-9	13	17.33	6	103.98	3119	1352	$ 40.00	$ 54,069.60
C-1	13	17.33	3.33	57.71	1731	750	$ 40.00	$ 30,008.63
C-2	44	14	3.33	46.62	1399	2051	$ 40.00	$ 82,051.20
C-3	13	20	3.33	66.60	1998	866	$ 40.00	$ 34,632.00
C-4	13	14	3.33	46.62	1399	606	$ 40.00	$ 24,242.40
D-1	6	17.33	4.58	79.37	2381	476	$ 40.00	$ 19,049.14
D-2	8	14	4.58	64.12	1924	513	$ 40.00	$ 20,518.40
E-1	0	3.67	6.5	23.86	716	0	$ 40.00	$ -
E-2	0	8.68	6.5	56.42	1693	0	$ 40.00	$ -
E-3	0	16	6.5	104.00	3120	0	$ 40.00	$ -
F-1	9	17.33	2	34.66	1040	312	$ 40.00	$ 12,477.60
F-2	24	14	2	28.00	840	672	$ 40.00	$ 26,880.00
G-1	11	8	10	80.00	2400	880	$ 40.00	$ 35,200.00
Total:	**292**				**Total:**	**16025**	**Total:**	**$ 641,007**

South Elevation								
Panel Number	Quantity	Height (ft)	Width (ft)	Area (SF)	Weight (lbs)	Total Area (SF)	$/SF	Total Cost
A-1	17	17.33	5	86.65	2600	1473	$ 40.00	$ 58,922.00
A-2	21	14	5	70.00	2100	1470	$ 40.00	$ 58,800.00
B-1	25	8	6	48.00	1440	1200	$ 40.00	$ 48,000.00
B-2	15	3.25	6	19.50	585	293	$ 40.00	$ 11,700.00
B-3	6	9	6	54.00	1620	324	$ 40.00	$ 12,960.00
B-4	6	3.83	6	22.98	689	138	$ 40.00	$ 5,515.20
B-5	6	6.33	6	37.98	1139	228	$ 40.00	$ 9,115.20
B-8	12	14	6	84.00	2520	1008	$ 40.00	$ 40,320.00
C-1	19	17.33	3.33	57.71	1731	1096	$ 40.00	$ 43,858.76
C-2	32	14	3.33	46.62	1399	1492	$ 40.00	$ 59,673.60
C-3	8	20	3.33	66.60	1998	533	$ 40.00	$ 21,312.00
C-4	8	14	3.33	46.62	1399	373	$ 40.00	$ 14,918.40
D-1	2	17.33	4.58	79.37	2381	159	$ 40.00	$ 6,349.71
D-2	2	14	4.58	64.12	1924	128	$ 40.00	$ 5,129.60
E-1	3	3.67	6.5	23.86	716	72	$ 40.00	$ 2,862.60
E-2	2	8.68	6.5	56.42	1693	113	$ 40.00	$ 4,513.60
E-3	1	16	6.5	104.00	3120	104	$ 40.00	$ 4,160.00
F-1	5	17.33	2	34.66	1040	173	$ 40.00	$ 6,932.00
F-2	10	14	2	28.00	840	280	$ 40.00	$ 11,200.00
Total:	**200**				**Total:**	**10656**	**Total:**	**$ 426,243**

West Elevation								
Panel Number	Quantity	Height (ft)	Width (ft)	Area (SF)	Weight (lbs)	Total Area (SF)	$/SF	Total Cost
A-1	16	17.33	5	86.65	2600	1386	$ 40.00	$ 55,456.00
A-2	16	14	5	70.00	2100	1120	$ 40.00	$ 44,800.00
B-1	30	8	6	48.00	1440	1440	$ 40.00	$ 57,600.00
B-2	15	3.25	6	19.50	585	293	$ 40.00	$ 11,700.00
B-3	14	9	6	54.00	1620	756	$ 40.00	$ 30,240.00
B-4	14	3.83	6	22.98	689	322	$ 40.00	$ 12,868.80
B-8	13	14	6	84.00	2520	1092	$ 40.00	$ 43,680.00
C-1	13	17.33	3.33	57.71	1731	750	$ 40.00	$ 30,008.63
C-2	13	14	3.33	46.62	1399	606	$ 40.00	$ 24,242.40
C-3	21	20	3.33	66.60	1998	1399	$ 40.00	$ 55,944.00
C-4	21	14	3.33	46.62	1399	979	$ 40.00	$ 39,160.80
D-1	5	17.33	4.58	79.37	2381	397	$ 40.00	$ 15,874.28
D-2	7	14	4.58	64.12	1924	449	$ 40.00	$ 17,953.60
F-1	5	17.33	2	34.66	1040	173	$ 40.00	$ 6,932.00
F-2	5	14	2	28.00	840	140	$ 40.00	$ 5,600.00
G-1	6	8	10	80.00	2400	480	$ 40.00	$ 19,200.00
Total:	**214**				**Total:**	**11782**	**Total:**	**$ 471,261**