Student Life Building

Senior Thesis Final Report

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Executive Summary

Northampton Community College has been experiencing a large influx in enrollment to their Monroe Campus. As a result, they have purchased a large site in Tannersville, Pa and plan to build a new campus comprised of three buildings; a classroom building, enrollment center, and the student life center. The Student Life Building will be the center of campus life with a gymnasium, cafeteria, bookstore, and fitness center and meeting rooms. In the building's basement there will also be a central plant controlling the HVAC, electric, and plumbing of the entire campus. Together with D'Huy Engineering Inc, the college designed their new campus and bid the project in 2011. Multiple prime contractors were awarded the job, and they broke ground in spring 2012. The campus will be complete in late 2014.

The design of the Student Life Building was completed with consultation from numerous groups, and is proving to be an effective and economical plan. However, while studying the buildings systems, there have been areas that could be altered and analyzed. The use of braced frames rather than a large column is a structural decision that could change the aesthetics of the building. The fire suppression system is also an area that could be altered within the building. An acoustic cloud that was chosen for its aesthetics and acoustic value has cause the fire suppression system to be doubled in multiple areas. Removing this cloud and painting the ceiling space could help the system be minimized, saving the owner a significant amount of money. The roofing membrane that the design team chose could also be changed to save maintenance costs and increases effectiveness. Finally, the delivery method of the project, multiple prime contractors, is an industry issue that could be studied. After the new systems were developed, the costs and effects of the systems were compared and the recommendations were compiled.

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Project Overview

Introduction

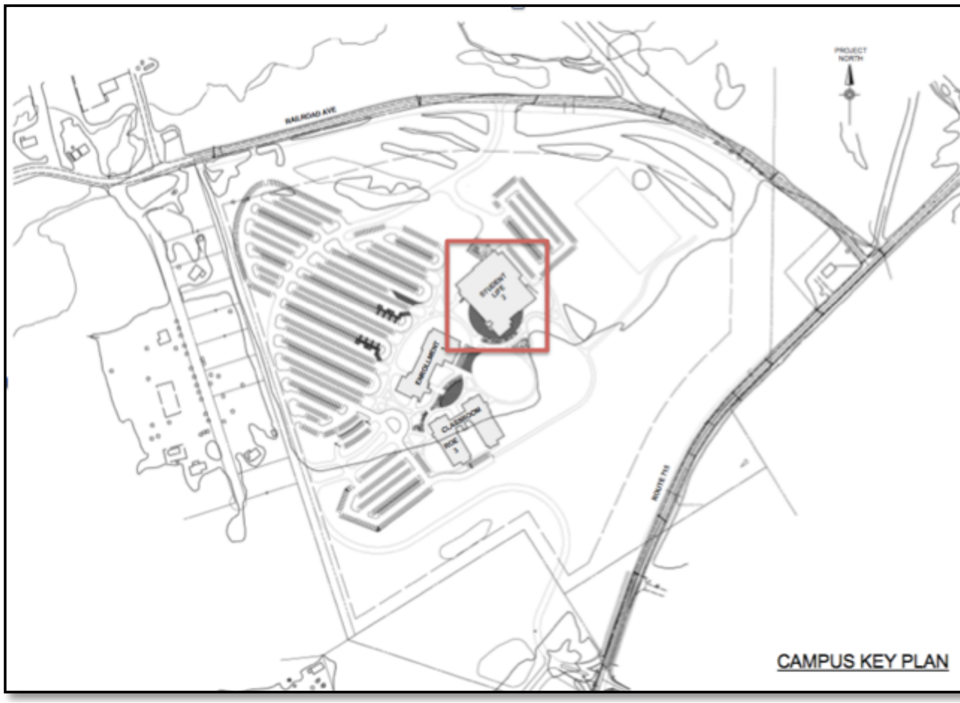


Figure 1; Site Plan

The Student Life Building is one of three buildings being constructed to form Northampton Community College's Monroe Campus. The new campus will be located in Tannersville, Pa. and it will be comprised of the Student Life Building, Classroom Roe and an Enrollment Center. The approximately 70,000 ft^2 Student Life Building will be the center of campus life – housing the fitness center, gymnasium, bookstore, cafeteria and meeting rooms—and the center of mechanical systems housing the central plant.

The building will be located on a 72 acre site that was purchased by the college in 2005. The design phase however did not begin until 2010 when NCC hired D'Huy Engineering Inc. to help formulate the design intent. MKSD Architects were given the task of producing the design, and it was completed in 2011. Construction of the campus began with preliminary site work in February of 2012, and it will be a four-year process to finalize. The expected date of completion of the Student Life Building is November 2013.

The campus is being constructed because of the overpopulation at the current Monroe Site. Funding for the project has come from student tuition, private donations, and money from the department of education. In full, the campus will cost the college about $80 million. The Student Life Building will be about $14 million of that.

Local Conditions

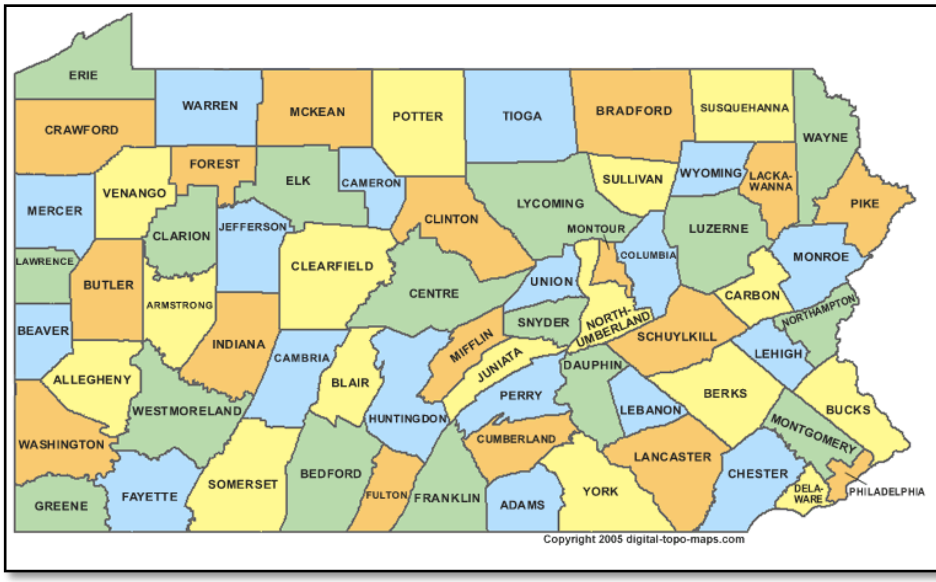


Figure 2; Pa Map

The Monroe Campus is located in Tannersville, which is in Pocono Township, in the northeastern region of Pennsylvania. The area is somewhat rural but within _ miles of New York city and about _miles north of Philadelphia. Weather in Tannersville is typical of the north east – about 15 days a year above 90 degrees, and 120 days below freezing. Annual precipitation in the area is about 48 inches with an annual snowfall of approximately 53 inches.

The 72-acre site is a greenfield which means there has been no previous construction in the area. There is a slight slope throughout the site, common of the region and it is covered with grass and clusters of trees. In order to start construction, geotechnical surveys were performed both in 2008 and 2010. The results showed that soil conditions were stable, the makeup of the soil is broken into four layers; topsoil, medium to coarse sand with some silt and clay, gravel sized rock fragments and more coarse sand, and finally intermittent layers of Siltstone and Sandstone. Water studies on site were a bit more problematic. Because of the excessive acreage, the site runs across two different watersheds. A watershed is a designated area of land that has runoff water flowing into a specific body of water. Because of the site's greenfield status an erosion and sedimentation plan report was a necessity.

Herbert, Rowland and Grubic- a civil engineering firm – was commissioned to create the erosion and sedimentation plan, and they determined that a total of 12 sediment basins would be created throughout the construction process. Ground cannot be broken in any area until the specified basins are completed. They are not all permanent, but the figure* shows the final phase of construction with permanent retention ponds. These retention ponds will have drainage lines running underground to direct excess water off the site and into the designated watershed. During construction, topsoil stockpiles will also need to be monitored carefully by the general contractor. Their design and construction is carefully outlined in the erosion control plan, because ant large form of precipitation could potentially create a runoff of topsoil into nearby roadways or bodies of water.

Client Information

Northampton Community College was founded in 1967 and since then has been helping people earn Associate's Degrees in Science, Applied Science, and the Arts. They also offer a wide range of non-credit classes that have been enriching the lives of people in the area. NCC states, *"We believe that learning thrives when there is a sense of curiosity and excitement about the world in which we live. As such, we value: excellence, innovation, sustainability, accountability, integrity, engagement, and vision."* The college's main campus in located in Bethlehem, Pa, and the existing branches are the Monroe Campus and Fowler Southside Center. In addition, there are approximately 50 smaller satellite sites that offer classes.

Figure 3; NCC logo

The existing Monroe Campus is located about 2 miles from the new campus, and has been in use since 1988. Enrollment at the Monroe Campus has steadily been increasing with an enrollment of over 2,300 in 2010 – about a _% increase from the 92-person class of 1988. Because of this growth, the new campus is being built to service about 5,000 students with enough extra space to expand if needed. Consistency throughout their campuses is important to the owner, and they have made sure that throughout the design phase, elements of each campus were brought into the new construction of the Monroe Campus. For example, the façade of the new campus will have brick and stone reflecting the designs of the main campus.

Northampton Community College is receiving funding from the Pennsylvania Department of Education Committee, Monroe County, and private fundraising efforts. Local support of the construction is very strong; Monroe County and Northeastern Pennsylvania have named it as one of the most important economic priorities in the area. Because of the support from the state, NCC will need to use a multiple prime contract method.

Like most owners, the college is very concerned with scheduling. The school year dictates the timeline of the project, and spring 2015 will be the first semester that the campus can be used. If the project is running behind, the college will lose tuition money from a significant portion of students for a whole semester. Because of the strict deadline, the owner has placed a liquidated damages clause in the contracts. For every day that the project is late, the general contractor will owe $4000, and all other contractors will owe $2000 per day. The use of liquidation damages is a very common risk management technique that helps to ensure a project's delivery date.

Project Delivery Method

The Student Life Building was combined in a bid with Classroom Roe and the Enrollment Center. The campus' package followed a traditional design-bid-build delivery method. The owner, Northampton Community College, was able to privately seek out DEI Engineering Inc. and request their services as a Construction Management Advisor. Once DEI was on board, the design requirements were developed and a request for proposal was sent to qualifying design firms. MKSD, an architecture firm out of the Lehigh Valley was chosen to design the campus, and they were able to choose their own consulting firms. The owner however only holds a contract with MKSD, and a separate contract with DEI.

The Monroe Campus is considered a public project because in addition to the school's savings, NCC received funds from both the Pennsylvania Department of Education and Monroe County. In Pennsylvania, public projects must be publically bid, and as a result are usually awarded to the lowest bidder. In addition, Pennsylvania law states that the project must be awarded to multiple prime contractors – meaning a general contractor, mechanical contractor, electrical contractor and plumbing contractor will all have equal say in the construction process.

The figure below shows the relationships between all parties involved in the project. Despite being publicly bid, the owner is able to hold a contract with D'Huy Engineering, Inc. as a third party consultant. As a result, DEI is not considered at risk on this project.

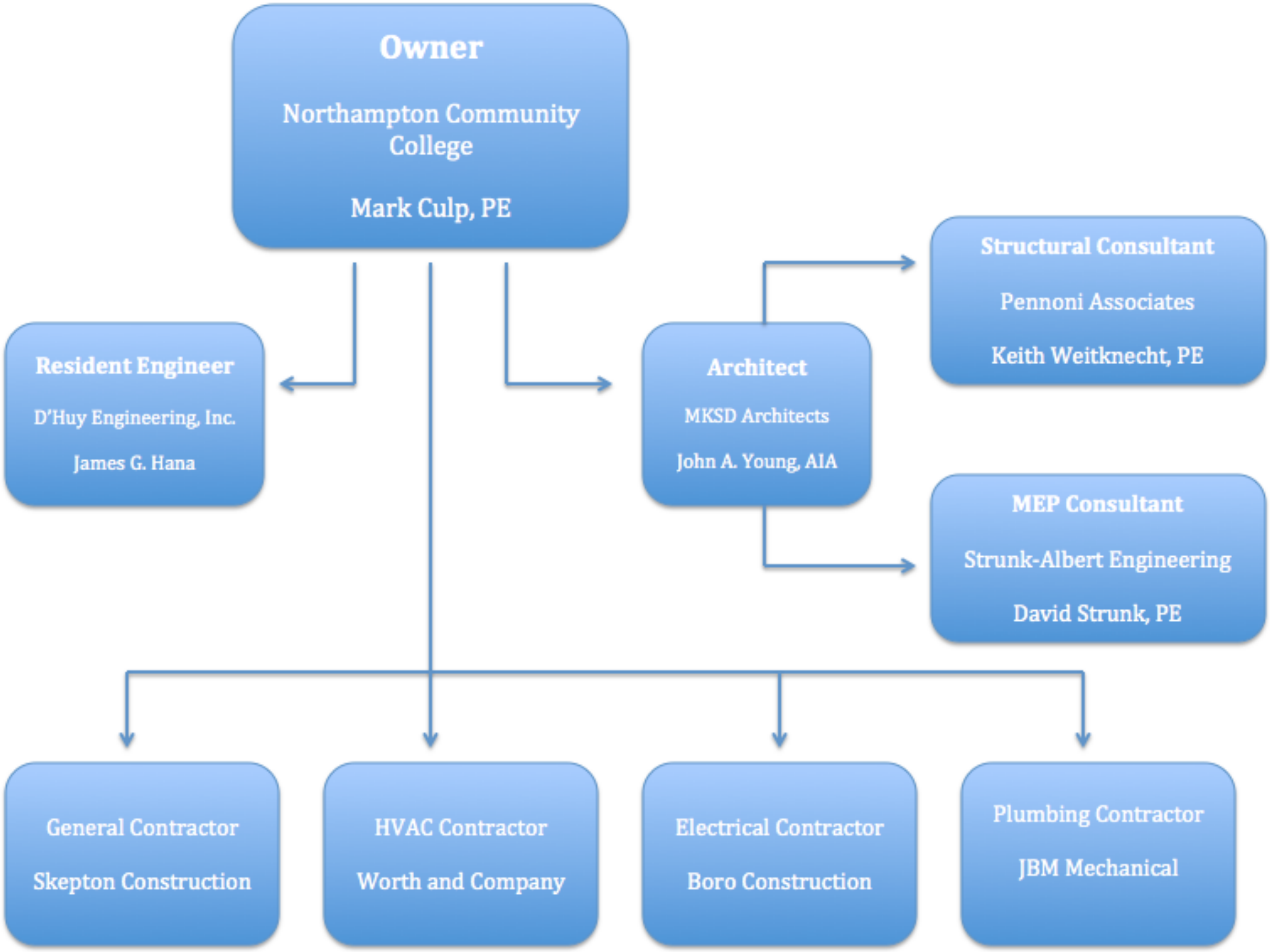
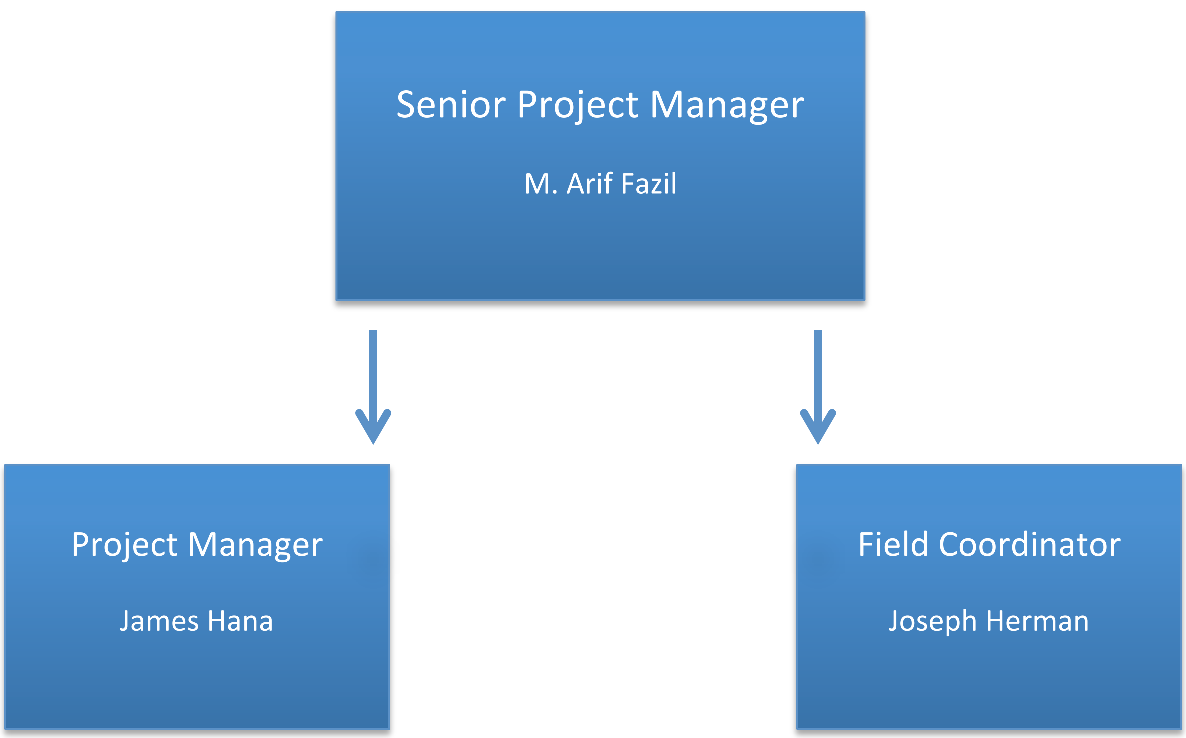


Figure 4; Project Delivery Method

Staffing Plan

The staffing plan of the CM firm, D'Huy Engineering Inc., consists of a senior project manager, project manager and field coordinator. DEI is a relatively small firm, but each team member has a vast amount of experience and they will be able to oversee the daily campus activities. The site's senior project manager, M. Arif Fazil is actually a principal of the firm, and despite not being on site daily, he will be involved in the major decisions and scheduling of the project. The project manager, James Hana, will be a larger presence on site. He has over 30 years of experience in the industry and has been a project manager at D'Huy for over 10 years. Finally, the Field Coordinator currently onsite is Joseph Herman. In the beginning of the project, Greg Kindt held this position but has since left DEI. Joseph is the newest member to the DEI team but has had many years of experience as an architect. The team is very familiar with each other because of the smaller size of the firm, and DEI is confident that they will be able to interpret the owner's needs and expectations and help to oversee daily progress.



Building Systems Overview

Structural Steel

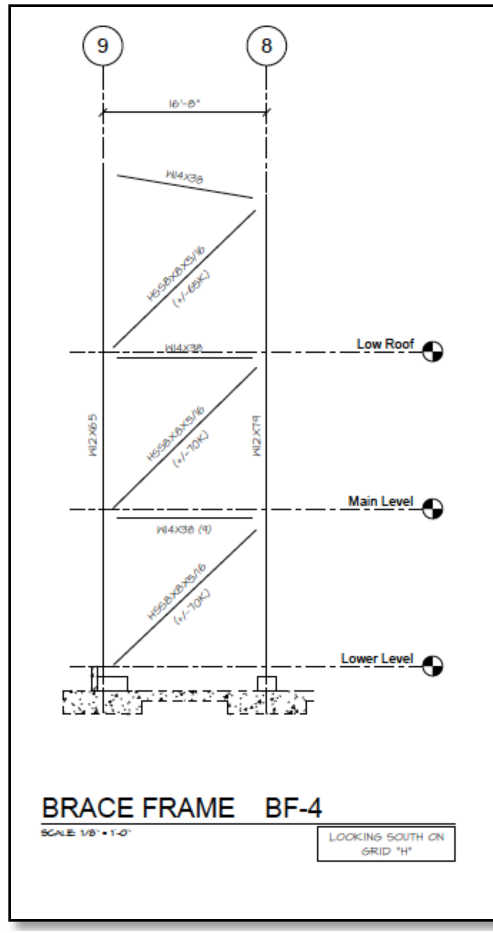


Figure 5; Brace Frame example

The Student Life Building is comprised of a structural steel framing system. It is a one story building with a basement running underneath half of the structure while the other half, is slab on grade. Design criteria for the building is shown later in figure*, but the floor load is estimated to be about 160psf and the total roof load about 57psf. The building's framing plan will be made up of three layers; the lower level that houses the mechanical rooms, the main level with the cafeteria, fitness center and bookstore, and then an extended area over the gymnasium. The breakdown can especially be seen in figure.

The lower level is framed by a system of W10x33 columns pinned into the composite slab. The slab itself is reinforced with 6x6-W2.9-2.9W.W.R at 2" from top of slab. W18x40 and W18x35 beams make up the main level flooring, and there is a variety of columns that support the roof decking. The roof system is interesting because of its varied heights and slopes. There is a mix of flat and sloped roofing that will accentuate the different areas of the building. A truss bracing system with be used to span areas of the gymnasium. An example of the system can be seen in figure*. Finally, a bracing system will be used to support lateral loads. The bracing system will only be used between certain column lines and will be discussed in the structural breadth.

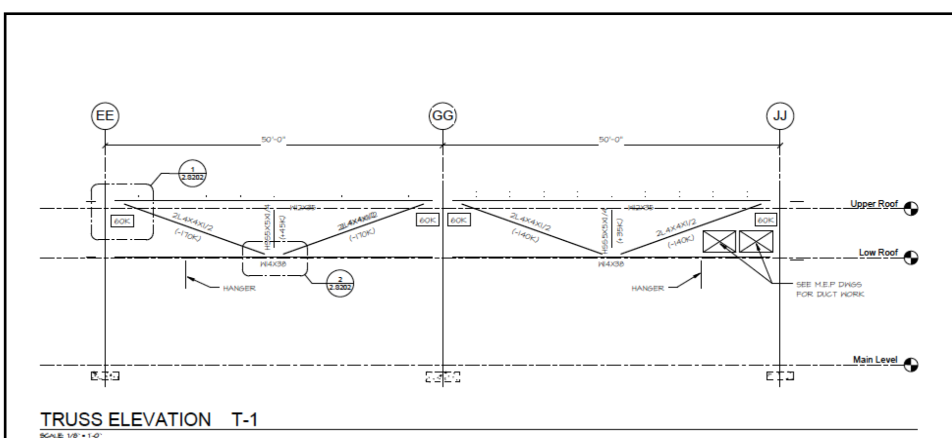


Figure 6; Roof Truss

Cast in Place Concrete

Specifications for the Student Life Building state that all concrete, including slabs, footings, foundation and building walls, need to be cast in place. The slabs will form the basement and gymnasium floors and a large foundation wall will be poured between the two halves of the building. Because it will all be cast in place, formwork is an important part of the process, and it is described in detail in the specs. All formwork design must comply with ACI 301 and ACI 117; two documents from the American Concrete Institute that describe how the formwork is to be designed, constructed and maintained.

The formwork is especially important when developing the multiple mechanical pads in the basement. The pads shown in the figure will support the heating/cooling equipment and need to be completely level to ensure the equipment's safety and maintenance.

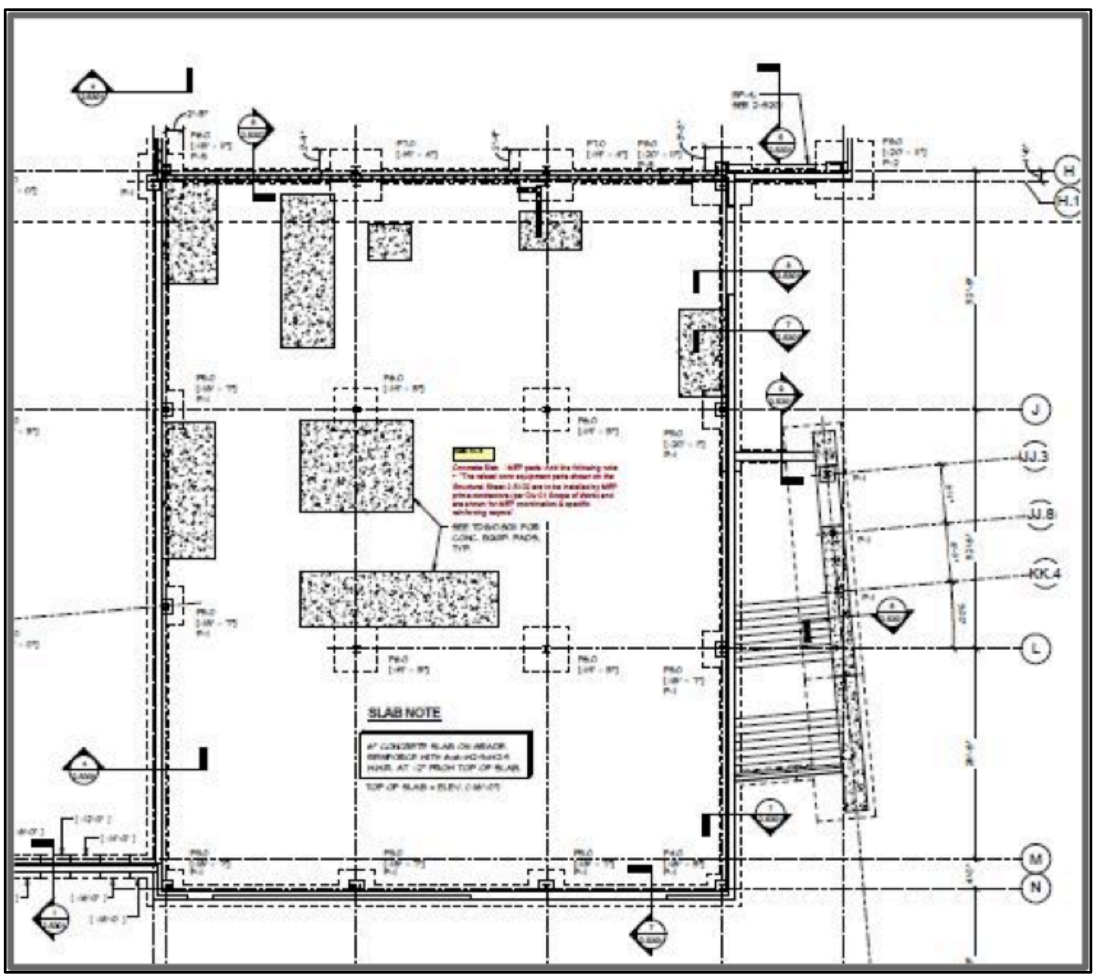


Figure 7; Mechanical Pads

Mechanical/Electrical/Plumbing

The mechanical systems of the Student Life Building are much more elaborate than that of any other gymnasium/cafeteria. The Student Life Building houses the central plant for the Monroe Campus, meaning all systems (mechanical/electrical/plumbing) will be supplied and controlled from the lower level mechanical rooms. The buildings will use a constant air volume HVAC system that will utilize two heater/chillers, supplemented by an electric boiler. The water in the system will also be fed through a geothermal well field behind the building. 160 geo-exchange boreholes will be drilled near the rear parking lot of the Student Life Building. The system will use the boreholes to cycle water through before bringing into the central plant. From the central plant, water will be sent out and back from other buildings in a system of underground piping that was placed during the initial site preparations.

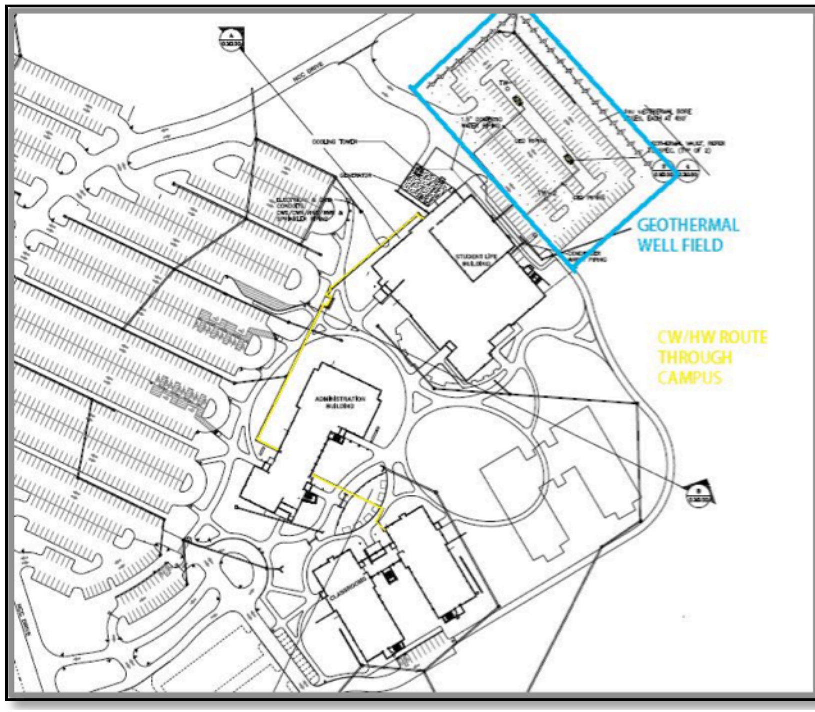
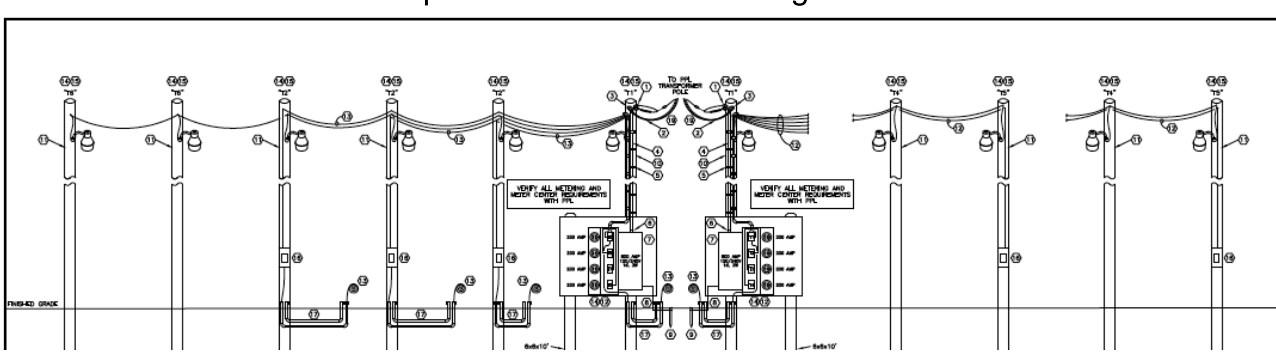


Figure 8; Campus Mechanical Plan

Electric systems of the campus will be divided into what is needed during construction, temporary electric, and what will be in place in the building's systems, permanent electric. Temporary electric needed to be set into place as soon as sitework began. Utility poles were placed along the access ways of the campus – a schematic can be seen below. Permanent systems will be fed into the central plant from the utility provider's access points. Two large transformers will take the power from 12.5kV down to 480/277 3 phase power. A backup generator will also be located in the central plant that can assist the entire campus in the even of an outage.



The entire Monroe Campus will have a wet fire suppression system that will meet NFPA standards 13 and 24. These standards dictate the sprinkler areas and the hazard groups of each building. The Student Life Building, because of its multipurpose nature, will have multiple hazard groups and a variety of sprinkler heads to support each group. The building will also have a double sprinkler head system, in areas where an acoustic ceiling cloud is present. The ceiling plenum and usable space of the building are separated by the cloud, but because of its fire rating, sprinkler heads are necessary above and below. Water will flush the system in the event of a fire, but because of the campus' somewhat remote location and large size, the water cannot come from the municipality. Instead, a 30,000 gallon water tank will be constructed and located behind the student life building to support the water needs of the system.

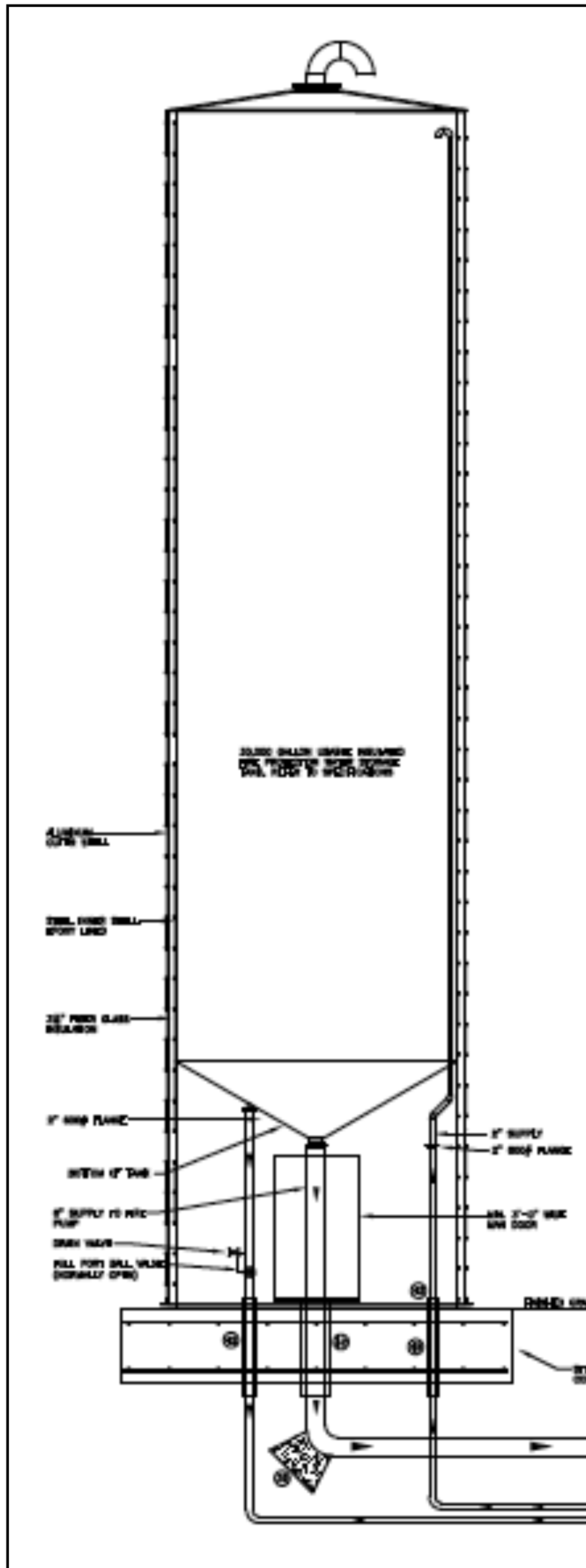


Figure 10; Fire Suppression Water Supply

Façade

Continuity between campus' is a major point of interest for Northampton Community College and they wanted the new buildings' façade to reflect this idea of college wide continuity. As a result, the student life building will have a mixture of brick, stone, and glass curtain walls. The brick masonry will be used as a structural piece but also as a veneer. The never will be attached to the structural steel at specific areas along the building. Connections can be seen in the drawings. The stone will also be used in curtain wall formation. It will be attached to the steel in the same fashion as the brick. A photo of the stone sample is shown in the figure. The areas of curtain wall will be a nod to the future. Existing campuses do not heavily use metals or glass, so the Monroe campus will bridge any future gaps. The curtain walls are described in the specs to be able to withstand a wind load of 20 psf without failure – which is defined by any breakage or excessive vibration.

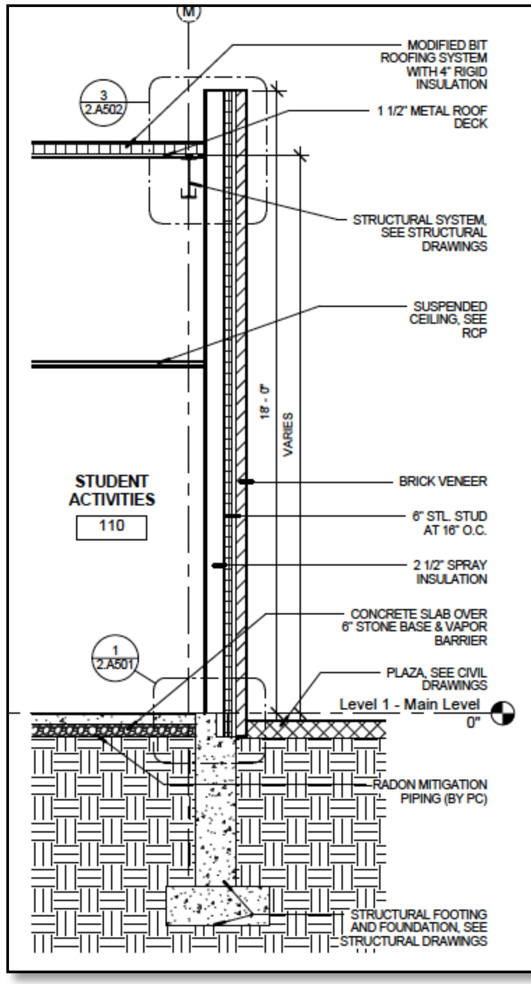


Figure 11; Facade Connections

LEED Features

Northampton Community College lists sustainability as one of their core values, stating on the website that they believe in *“Commitment to the long term health of the institution, community, economy and environment.”* Because of these beliefs, NCC has made it a necessity for all new construction to have at least a LEED silver rating.

Together with DEI and the design team, NCC initially made a LEED plan based on the v2.2 standards. This was the version current in 2008 that had a rating system based on a 69 point scale with a silver rating starting at 33 points. However, in the time between initial design plans and project bidding in 2011, the LEED standards had changed and the team needed to update their plan. The now current LEED standard is based on a 110 point scale with a silver rating of 50 points. Most of the categories in v2.2 are represented in the newer 2009 version and weighted more heavily. There is also a new category, “Regional Priority” which the team could add into their point total.

Luckily, the team was able to transfer most of their points to the new LEED checklist. The projected total changed from 33 points to 80 points – which is actually considered a platinum rating. The likelihood of receiving all the points pursued however is very unlikely so overshooting your goal is very common. The breakdown of pursued points is listed below;

Sustainable Sites

There is a prerequisite in this category regarding construction pollution prevention. The team will be using this prerequisite so they are able to use the category. ‘Sustainable Sites’ has a total point sum of 26, and the design team is expecting to use about 16 of them. Among these 16 are points for storm water design, minimization of light pollution, site development- both protecting/restoring the site and maximizing open space – and alternative transportation. The project however cannot receive any credits in a few categories because it is a greenfield, or unconstructed land, and because the site is not closely located to a community or urban development project. Also because of the site’s remote location, the possible points from alternative transportation area are being researched. The team needs to decide how beneficial it will be to provide public transportation access and bicycle storage.

Water Efficiency

Water Efficiency has a possible 10 points once it’s prerequisite – reducing water use by 20% -- is met. The Student Life Building hopes to receive about 8 points from efficient landscape techniques, and overall water use reduction.

Energy and Atmosphere

This category has three prerequisites; fundamental commissioning of the building energy, minimum energy performance, and fundamental refrigerant management. All have been met, however only 8 of the possible 35 credits will be sought. The ream will enhance refrigerant management and gain about 2 credits, and about 6 from the optimization of energy performance.

Materials and Resources

In order to qualify for any credits in this category, the project must store and collect their recyclables. Because they are doing this, the project team can also apply to receive another 3 credits from the category. The credits are from using regional materials, having a waste management system that will recycle or salvage 50% of the waste, and using 10% of building material that is considered recycled products.

Indoor Environmental Quality

Prerequisites for the Indoor Environmental Quality category include reaching the minimum in air quality performance and having environmental tobacco smoke control. The indoor air quality is one of the most important aspects to the owner. The project manual that they created with DEI in the early design phases outlines the importance of IEQ and the happiness of their students and employees. Out of the possible 15 points in the category, the team will pursue 12. The project will use all low-emitting materials which will bring about 4 credits, have an indoor air quality management plan during construction and before tenant move in, 2 points. The Student Life Building will also contain systems that are easily controlled for thermal comfort and lighting, and have an overall thermal comfort that has been designed and approved.

Innovation in Design

This category is a way for a project team to go above and beyond what is outlined in the LEED manuals. Out of the possible 6 credits in this area, the team will be receiving 2. One for an innovation in design and one for having a LEED accredited AP on staff.

Regional Priority Credits

Regional Priority Credits are like the bonus points of the LEED credits. There are 4 available and the Student Life Building and the Monroe Campus want to receive 3 of them. They will be based off of the zip code of the project.

Construction Overview

Site Layout

Construction of the Monroe campus was broken into 3 phases. During each phase, different prep areas are used, as well as different areas of material stockpiles and contractor working spaces. The figures below show that the site is located off of Rt 715 and access roads were created early to allow workers and future visitors onto the lot.

Figure 13; Site Overview

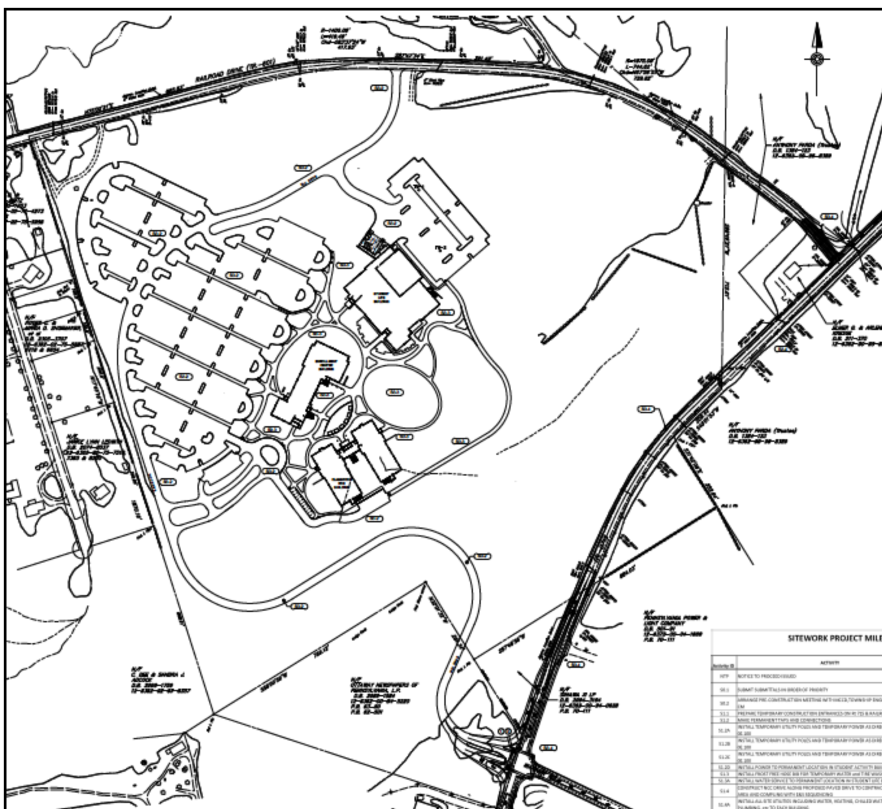
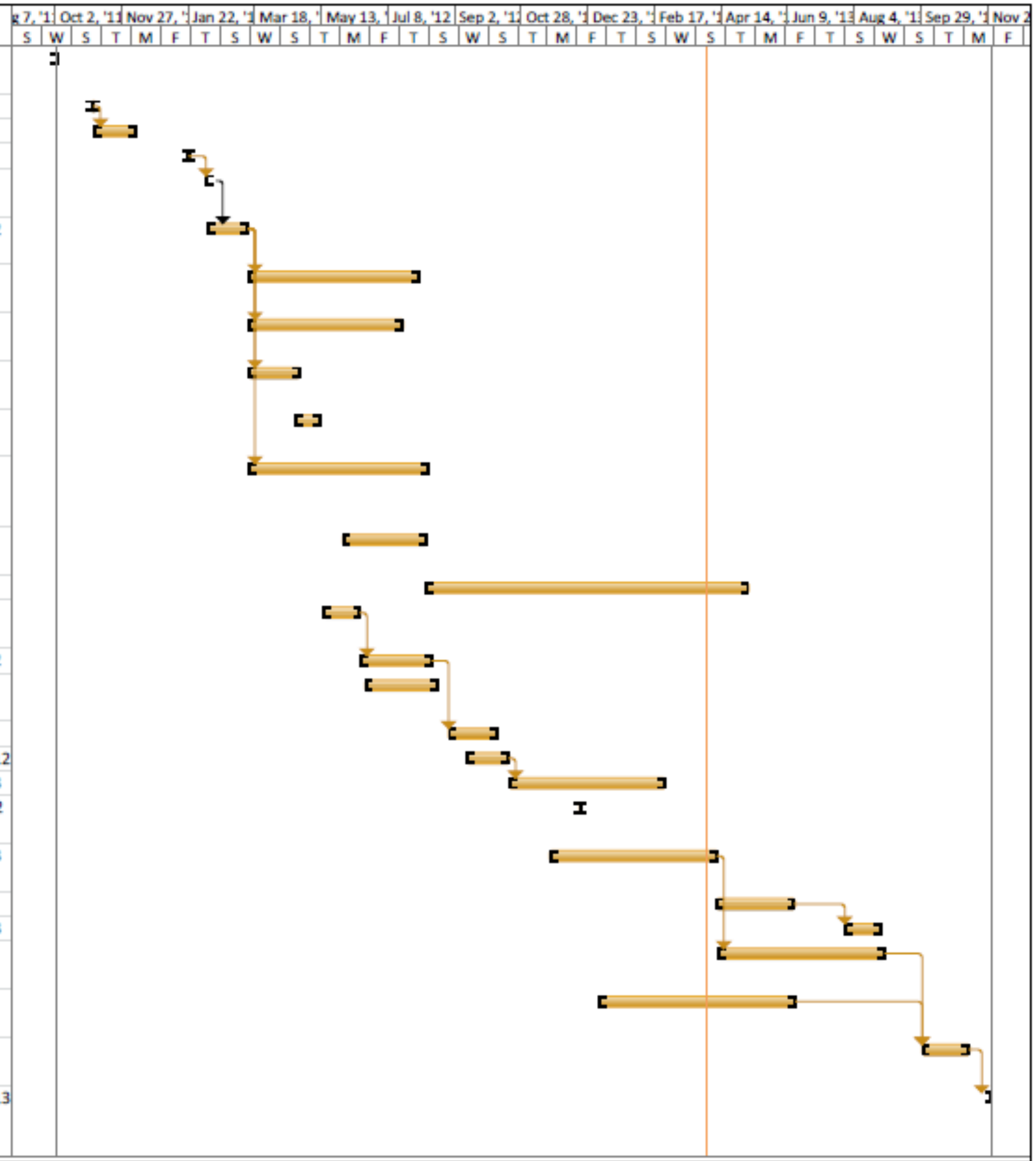


Figure 14; Site overview from drawings

Project Schedule

ID	Task Name	Duration	Start	Finish
1	Design Documents Complete			Tue 10/4/11
2	NCC sends OPR	1 day	Thu 11/3/11	Thu 11/3/11
3	Bids Due	25 days	Fri 11/4/11	Thu 12/8/11
4	Notice to Proceed	1 day	Sun 1/22/12	Sun 1/22/12
5	Submittals in order of proirity	ongoing	Mon 2/6/12	
6	Prepare Temp Constr Entances	25 days	Tue 2/7/12	Mon 3/12/12
7	Install Temporary Utility Poles and Temp Power	103 days	Tue 3/13/12	Thu 8/2/12
8	Install Water Service to Permanent Location	94 days	Tue 3/13/12	Fri 7/20/12
9	Construct NCC Drive to Contractor Staging Area	31 days	Tue 3/13/12	Tue 4/24/12
10	Install Contractor Staging Area	16 days	Sat 4/21/12	Fri 5/11/12
11	Install Geo-Exchange Field, Associated Site Work	109 days	Tue 3/13/12	Fri 8/10/12
12	Install Sediment Basin C and Complete NCC Drive	51 days	Thu 5/31/12	Thu 8/9/12
13	Install Site Storm Sewer	193 days	Thu 8/9/12	Mon 5/6/13
14	Prepare Sub Grade for Building Pad	23 days	Tue 5/15/12	Thu 6/14/12
15	Place Foundations	42 days	Fri 6/15/12	Mon 8/13/12
16	Install MEP &Plum Underground Rough-In	45 days	Tue 6/19/12	Sat 8/18/12
17	Erect Steel Framing	30 days	Tue 8/28/12	Sun 10/7/12
18	Place SOG	26 days	Wed 9/12/12	Wed 10/17/12
19	Construct Exterior Shell	93 days	Thu 10/18/12	Mon 2/25/13
20	Building to be Watertight	1 day	Sun 12/16/12	Sun 12/16/12
21	Begin Interior Partitions, MEP Rough-in	101 days	Wed 11/21/12	Wed 4/10/13
22	Install Ceiling Grid	48 days	Wed 4/10/13	Fri 6/14/13
23	Install Finished Ceilings	22 days	Sat 7/27/13	Mon 8/26/13
24	Complete All Interior Wall Finsihes	101 days	Thu 4/11/13	Thu 8/29/13
25	Start Up and Commision Central Plant	120 days	Tue 1/1/13	Sat 6/15/13
26	Completeion of All Construction Activities	30 days	Mon 9/30/13	Fri 11/8/13
27	Obtain Certificate of Occupancy- Substantial Completion			Wed 11/27/13



The new Monroe Campus of Northampton Community College began its design phase in late 2011. Actual construction of the campus began in spring ‘12 when the site was prepared. A large amount of site work needed to be completed on the project. The work comprised of creating access roads in May 2012 and then preparing the grade for the buildings foundation in August Before excavation began, the sediment basins, staging areas and temporary facilities need to be created. Site work for the rest of the campus is ongoing; however the Student Life Building could begin pouring footings and slabs in July ‘12.

The shell of the building consists of the footings and slab, steel erections, and finally the exterior facades. The overall timeline for the shell is about a year -- June ’12-June’13. It will begin with building pad construction in July, move to foundations the next month, and then underground rough-ins of MEP systems will begin. This is an integral step in order for the future systems of the building to perform well. The milestone set for completion of the slab is January 2013, however by that time the structural steel should also be complete.

Some interior work, like forming metal stairs, can begin prior the slab milestone. However, interior wall partitions will not begin until February 2013. Interior MEP rough-in will occur almost simultaneously and once they have been inspected, drywall can be placed in late February. Finishes like painting and wall covering will not start until spring 2013 and will carry over into the summer. The milestone set for completion of interior walls finishes is November 11, 2013.

The building should be completed by late November 2013. This gives time for quality assurance inspections and for the systems to be tested. The certificate of occupancy will be obtained in January 2014 and Northampton Community College will have full use of their facilities. The detailed schedule is located in the appendix.

General Conditions Estimate

The general conditions of the Student Life Building are a large part of the general conditions of the entire campus. For example, the Construction Managers', and prime contractors' trailers have been placed and will remain in the same position until the third building is completed and handed over to the owner. The temporary utilities and equipment are also going to be used during the construction of each building. For the estimate below, only the construction period pertaining to the Student Life Building was considered. The amount, $2.6 million, reflects a percentage of the buildings overall cost, $18.5 million. The percentage of the total building cost is around 12% which is high for general conditions, but considering the permit values were included, the pricing is appropriate.

The Construction Manager's project team is comprised of a field coordinator, project manager and senior project manager. These terms weren't fully represented in the RSMeans data, so the field coordinator is equivalent to the field engineer and the superintendent is used as the senior project manager. The minimum rate was used for the senior project manager because he will be overseeing various jobs and will not be onsite daily.

Project Personnel		Unit	Quantity	Rate	Cost
01 31	**Proj. Mgmt and Coordination**				
01 31 13.20 0120	Field Engineer, Max	Week	83	1500	124500
01 31 13.20 0200	Project Manager, Average	Week	83	2150	178450
01 31 13.20 0240	Superintendent, Min	Week	83	1825	151475
01 31 13.20 0160	General Laborer (2)	Week	80	1425	114000
Total					$568,425

The estimates for temporary facilities, services, equipment and utilities were also calculated with the RSMeans data. The temporary facilities, i.e. trailers, were only considered as the CM's cost. The multiple prime contractors and sub-contractors will have trailers onsite at various times of construction. The total for having three trailers with air conditioning, and electricity for the duration of the project is approximately $25,000.

Temporary Facilities & Services		Unit	Quantity	Unit Rate	Cost/Unit	Total Cost
01 52 13.20	*Office and Storage Space*					
01 52 13.20 0350	Office trailer. 32'X8' (rent) (3)	month	19	190	3610	10830
01 52 13.20 0700	air conditioning	month	19	46	874	2622
01 52 13.40	*Field Office Expense*					
01 52 13.40 0160	Lights/HVAC	month	19	152	2888	8664
01 52 13.40 0120	Office Supplies(2)	month	19	75	1425	2850
01 74 13.20 0020	Final Cleanup	job		0.30%	555,000	555,000
01 41 26	*Regulatory Requirements*					
01 41 26.50 0100	Permits, Most Cities	job		0.50%	925,000	925,000
Total					$1,488,797	$1,504,966

The final estimate that was compiled for the general conditions dealt with temporary utilities and equipment. The temporary heating was only considered for the CM's trailers and the temporary lighting should cover then square footage of the Student Life Building. The signage and temporary fencing quantities were taken from the information on the phasing drawings.

Temporary Utilities & Equipment		Unit	Quantity	Unit Rate	Duration	Cost
01 51 13	*Temporary Electricity*					
01 51 13.80 0350	Temporary Lighting	CSF Flr	700	38.38	19	510454
01 51 13.80 0100	Temporary Heating	CSF Flr	7.68	15.17	19	2213.6064
01 56 26	*Temporary Fencing*					
01 56 26.50 0100	Chain link, 6' high	L.F	6500	4.48		29120
01 58 13.50 0020	Project Signage	S.F	65	34		2210
Total						543997.61

Assemblies Estimate

The superstructure of the Student Life Building was analyzed to create a detailed unit estimate. Instead of creating takeoffs for the entire building, a typical section was observed and the details of that section could then be scaled to relate to the entire building. The price estimated for the small section is about $99,600. Scaled to reflect the overall structure it would be about $996,500. This price however varies from the actual superstructure cost that could be found by creating a full takeoff. The difference in prices occurred because the building has varying spaces and rooflines. These spaces are all framed differently and have unique roof heights and designs. For example the gymnasium has a much higher roof height at 41.5' than the campus store, which has a roof height of only about 16'. In the areas where the roof height is extended, there are truss-bracing systems in place. This allows for larger spans between columns. Finally, because the lower level only runs through the spine of the building, the first floor framing only exists there. The surrounding gym and cafeteria are on a slab on grade foundation.

Figure 15; Typical Structural Bay

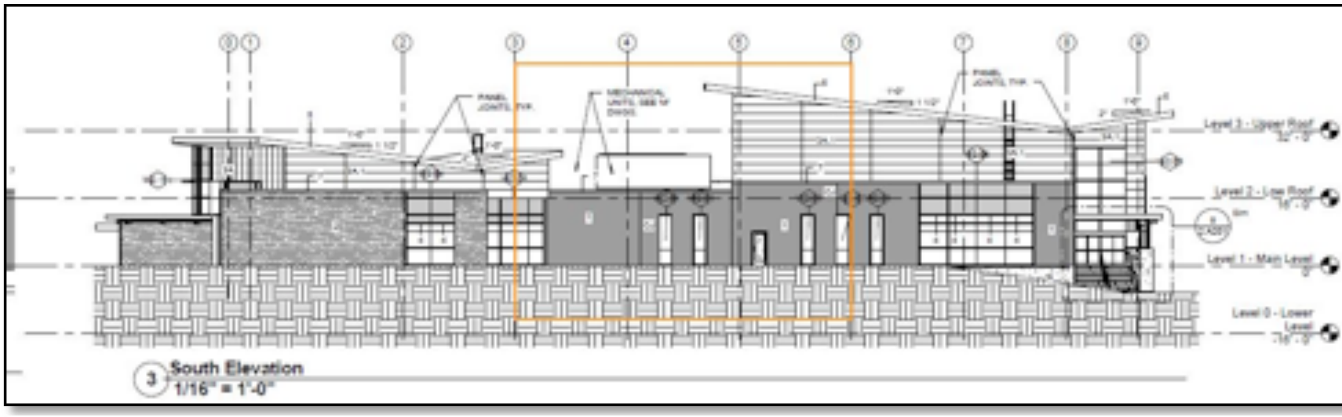


Figure 16;Typical Bay Section

The area chosen to represent a typical bay was partly under the low roof and partly under the high roofline of the gym. It was also had one area with the lower level foundation, framing, metal deck, floor slab, and roof framing, and then a second section with only the slab on grade and roof framing. The area chosen as a typical bay lies between column lines 3-6 and A-E. The overall floor area in the section is 6,968ft^2 and is called out in orange on the floor plan provided.

Estimate	Total Cost($)	Total Area(ft^2)
Typical Bay	99,635.41	6,968
Extrapolated Square Foot	996, 400	68,000

From the square foot extrapolation, other pricing quantities can be inferred. For example, the labor and material prices can be separated and scaled accordingly. Labor for the typical section is about $11,900 and materials were $84,500 in the section. These amounts will vary from the actual price but the process could be a useful tool in the overall superstructure budget.

Braced Wall Analysis (Structural Breadth)

Problem Identification

The Student Life Building has a structural steel frame. Although not visible from the outside of the structure, the steel frame is broken into two separate, fire rated areas; the gymnasium and the rest of the building. Both steel structures use braced frames at numerous locations along their exterior. The use of these braced frames however hinders the construction in two ways; expansion of the building most be done around the frames- i.e. doors cannot be placed there, and the frames interfere with the placement of an exterior curtain wall. The figures below display the location of the braced frames and their designated design.

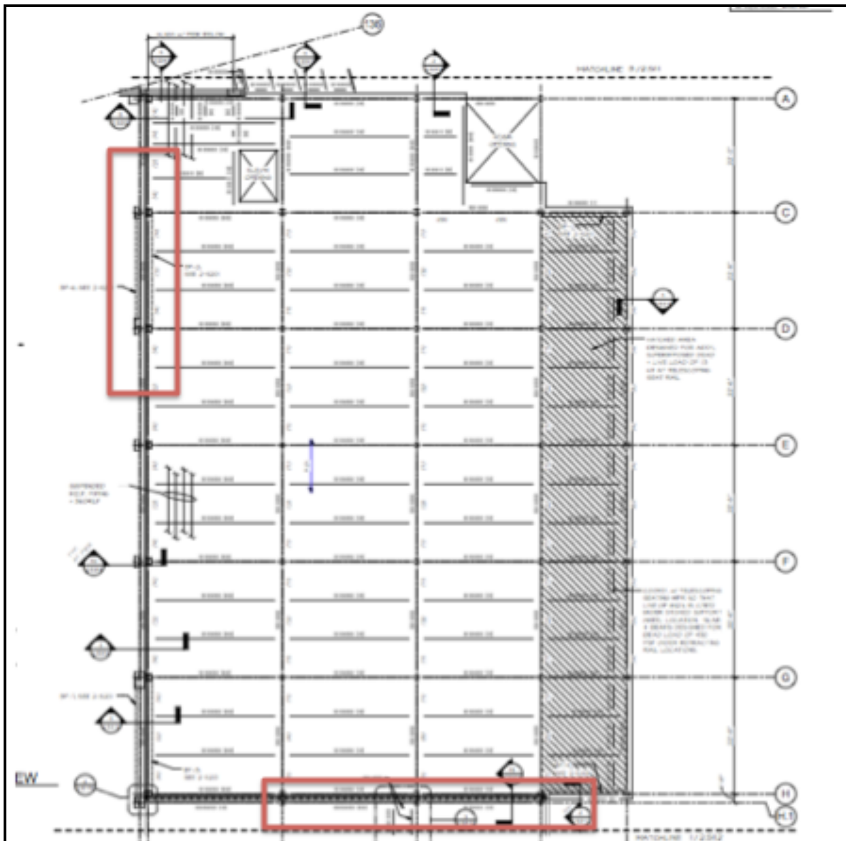


Figure 17; Braced Fame Locations

Student Life Building

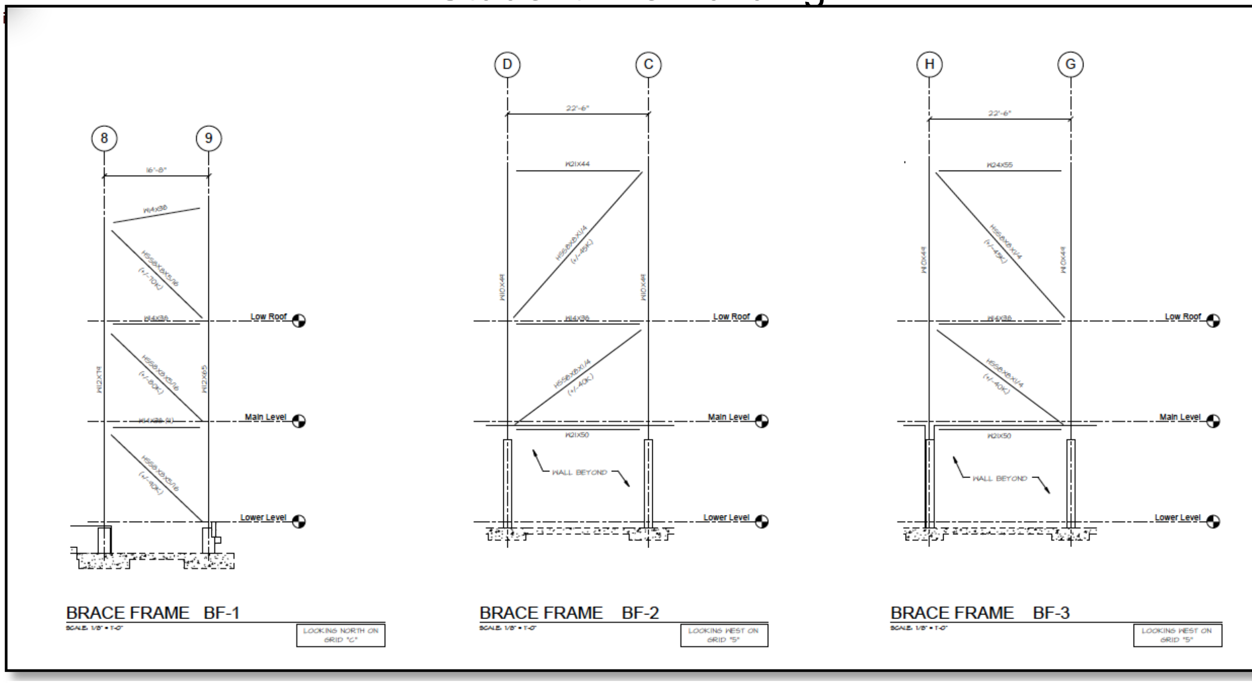


Figure 19; Braced Frames 1-3

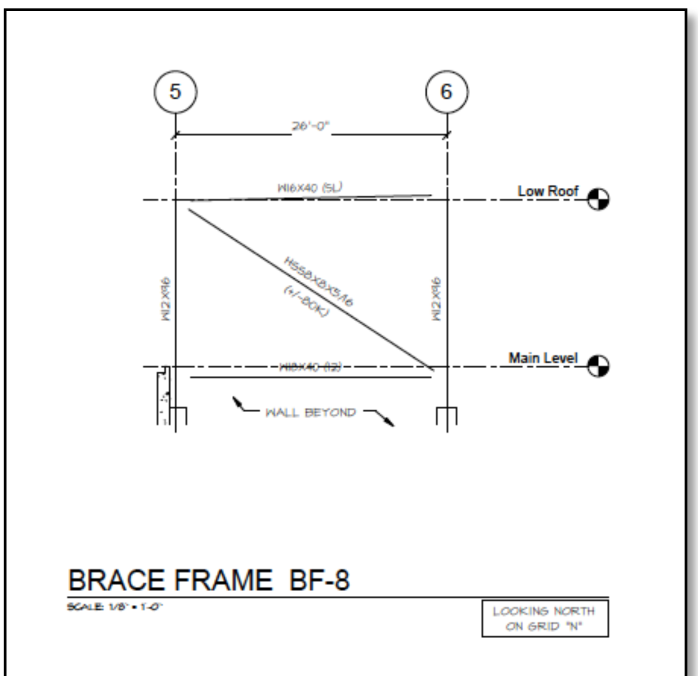


Figure 18; Bracced Frame 8

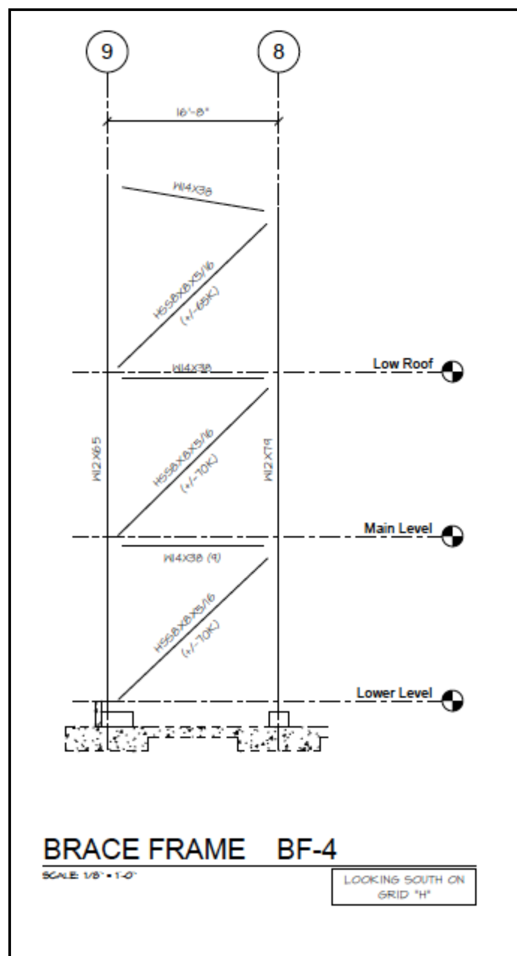


Figure 20; Braced Frame 4

Research Goal

The choice to use braced frames was a decision based on cost. The design team knew that using large columns in place of the braced framing system would raise the overall cost, and could possibly change the size of the crane used. However, replacing the columns would change the aesthetics of the building. The benefits of this redesign would not be a cost savings, but rather a decision to continue the architectural design that the team has worked so hard to continue throughout the campus.

Proposed System

Instead of the braced frames, larger columns will be placed at the locations shown in the figure. These larger columns will have moment connections that will support the lateral loads.

Load Calculations

The design criterion for the Student Life Building has been calculated based on the 2009 International Building Code. The specifics can be seen in the tables below but the overall floor load will be about 160 psf and total roof load will be about 57 psf. When determining the roof load, the snow load would be the governing factor because the live load is smaller. Once the total load – both of the floor and roof was determined, each column was sized using the steel construction manual, table 1.1. The process of sizing is outlined in the figure.

ROOF DESIGN LOADS	
DEAD LOAD	
ITEM	VALUE (PSF)
ROOFING	7
ROOF DECK	2
FRAMING	6
MECHANICAL & MISC.	7
FUTURE SOLAR PANELS	5
LIVE LOAD	
BASIC LIVE LOAD	20

FLOOR LOADS	
ITEM	VALUE (PSF)
FINISH	1
4 1/2" N.W. CONC. SLAB	42
MTL. DECK	3
FRAMING	6
MECH'L & MISC.	7
DEAD LOAD	59
LIVE LOAD	100
TOTAL	159

SNOW DESIGN LOADS ASCE 7-05			
ITEM	SYMBOL	VALUE	REFERENCE
GROUND SNOW LOAD	P_g	40 PSF	FIGURE 7-1
SNOW EXPOSURE FACTOR	C_e	1.0	TABLE 7-2
SNOW LOAD IMPORTANCE FACTOR	I_s	1.1	TABLE 7-4
THERMAL FACTOR	C_t	1.0	TABLE 7-3
ROOF SNOW LOAD (*)	P_f	30.8 PSF	SECTION 7.3

L = length $K = .5$

r_x, r_y } from table 1.1 in Steel Manual

$$F_e = \frac{\pi^2 (29000)}{\left(\frac{.5(L)}{r_x \text{ or } r_y}\right)^2}$$

$$F_{CR} = .654^{\wedge}\left(\frac{50}{F_e}\right) \times 50$$

$$\phi P_n = F_{CR}(\phi)(\text{wt from 1.1})$$

System Estimates

To estimate the current price of steel, a takeoff of the members in the braced frames was performed. Their weights were calculated and the total weight of steel for the frames was about 30 tons.RS Means cost data was used to then price each piece- this information can be seen in full in the appendix and a summary is shown in the table. The quantity of steel needed for the current system cost about $84,000. In comparison, the proposed system includes about 24 tons. The proposed system however was determined without a large wind load factor and this assumption mat have a negative impact of the design. Factoring in a larger wind load, the total weight may be much larger, and the total price may increase from the estimated $98,300. The full estimate is provided in the appendix, but the tables provided show the column sizes used in the current and proposed plan.

Student Life Building

Frame	Location	Size	Length	Unit Weight (lb/ft)	Total Weight (tons)
Current System					
BF 1	8 and 9	W14X38	16.6	38	0.3154
		HSS8X8X5/16	21.5	31.84	0.34228
		W14X38	16.67	38	0.31673
		HSS8X8X5/16	21.5	31.84	0.34228
		W14X38	16.67	38	0.31673
		HSS8X8X5/16	21.5	31.84	0.34228
		W12X79	48	79	1.896
		W12X65	50.77	65	1.650025
BF 2	d and c	W24X55	22.5	44	0.495
		HSS8X8X1/4	32.3	25.82	0.416993
		W14X38	22.5	38	0.4275
		HSS8X8X1/4	26.4	25.82	0.340824
		W21X50	22.5	50	0.5625
		W10X49	57	49	1.3965
		W10X49	57	49	1.3965
BF 3	h and g	W24X55	22.5	55	0.61875
		HSS8X8X1/4	32.3	25.82	0.416993
		W14X38	22.5	38	0.4275
		HSS8X8X1/4	26.4	25.82	0.340824
		W21X50	22.5	50	0.5625
		W10X49	57	49	1.3965
		W10X49	57	49	1.3965
BF 4	9 and 8	W14X38	16.6	38	0.3154
		HSS8X8X5/16	21.5	31.84	0.34228
		W14X38	16.67	38	0.31673
		HSS8X8X5/16	16.67	31.84	0.2653864
		W14X38	16.67	38	0.31673
		HSS8X8X5/16	21.5	31.84	0.34228
		W12X65	48	65	1.56
		W12X79	50.77	79	2.005415
BF 5	4 and 4.9	W16X40	25	40	0.5
		HSS8X6X3/8	29	32.58	0.47241
		W10X49	16	49	0.392
		W10X49	16	49	0.392
BF 6	C and D	W12X50	22.5	50	0.5625
		HSS8X6X3/8	27	32.58	0.43983
		W10X49	16	49	0.392
		W10X49	16	49	0.392
BF 7	G and H.1	W21X50	24.17	50	0.60425
		HSS8X6X3/8	27	32.58	0.43983
		W10X49	16	49	0.392
		W10X49	16	49	0.392
BF 8		W16X40	26.25	40	0.525
		HSS8X8X5/16	30.8	31.84	0.490336
		W18X40	26	40	0.52
		W12X96	16	96	0.768
		W12X96	16	96	0.768
					29.6234864

Proposed System				
Beams	**Lengths (L.F)**	**Unit Weight (lb/ft)**	**Total Weight(lb)**	**Total Weight (ton)**
W24X55	22.5	55	1237.5	0.61875
	22.5	55	1237.5	0.61875
Total Length	45	55	2475	1.2375
W14X38	21.5	38	817	0.4085
	21.5	38	817	0.4085
	21.5	38	817	0.4085
	22.5	38	855	0.4275
	22.5	38	855	0.4275
	16.6	38	630.8	0.3154
	16.67	38	633.46	0.31673
	16.67	38	633.46	0.31673
Total Length	159.44	38	6058.72	3.02936
W21X50	22.5	50	1125	0.5625
	22.5	50	1125	0.5625
	22.5	50	1125	0.5625
	24.17	50	1208.5	0.60425
Total Length	91.67			
W16X40	25	40	1000	0.5
	26.25	40	1050	0.525
Total Length	51.25	40	2050	1.025
W18X40	26	40	1040	0.52
Total Length	26	40	1040	0.52
Columns				
W12x72	51	72	3672	1.836
	49	72	3528	1.764
	51	72	3672	1.836
Total Length	151	72	10872	5.436
W12x87	49	87	4263	2.1315
Total	49	87	4263	2.1315
W12x120	17.5	120	2100	1.05
	17.5	120	2100	1.05
Total Length	35			
W10x60	44	60	2640	1.32
	44	60	2640	1.32
	44	60	2640	1.32
	44	60	2640	1.32
	17.5	60	1050	0.525
	17	60	1020	0.51
	17.17	60	1030.2	0.5151
	17.17	60	1030.2	0.5151
	17.17	60	1030.2	0.5151
	17.17	60	1030.2	0.5151
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Final Recommendations

The structural system of the Student Life Building was designed to be the most economical option. Large structural steel columns greatly impact the overall budget, and the braced frames are supporting a considerable amount of lateral load. After comparing the cost of both systems, pricing of the proposed steel does not seem to reflect the amount of load that system inevitably has to support. This could be attributed to the assumed wind load factor. Increasing these factors and taking them into account when sizing the columns would undoubtedly increase the pricing even more.

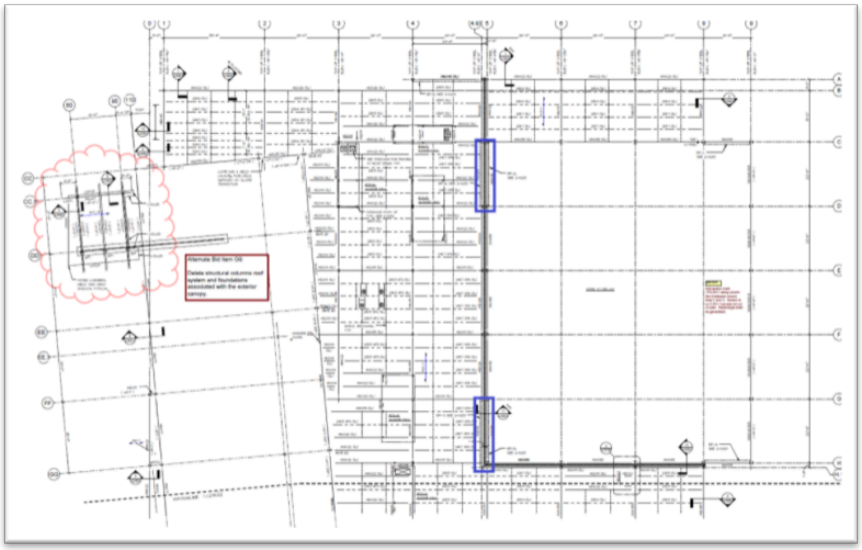


Figure 21; Interior Bracing

In conclusion, the proposed design could be mixed with the braced system to form the most appealing structure. Leaving braced frames 2,3,6, and 7, and resizing the columns in the other braced frames would be the best option. This would keep lateral support at the largest braced frames, but would also allow for expansion at the exterior of the building. Finally, it would increase the aesthetic appeal of the curtain walls that are located near braced frames 1 and 4. The current design has a brace going diagonally through both of those locations; brace frame 1 can be seen in the photo.

Fire Suppression Redesign (Mechanical Breadth)

Problem Identification

The Student Life Building houses an unusual fire suppression system. The system's requirements are not unusual – the governing regulations are the national fire protection agency's standard for installation of a sprinkler system. The unusual aspect of the system is its double layer of sprinkler heads. This redundancy is due to an acoustic cloud that has been chosen to cover most areas of the building and is shown by the shaded areas of the figure. The separation of the ceiling plenum and occupied space requires the double system, which will greatly increase the cost and installation time of the overall system.

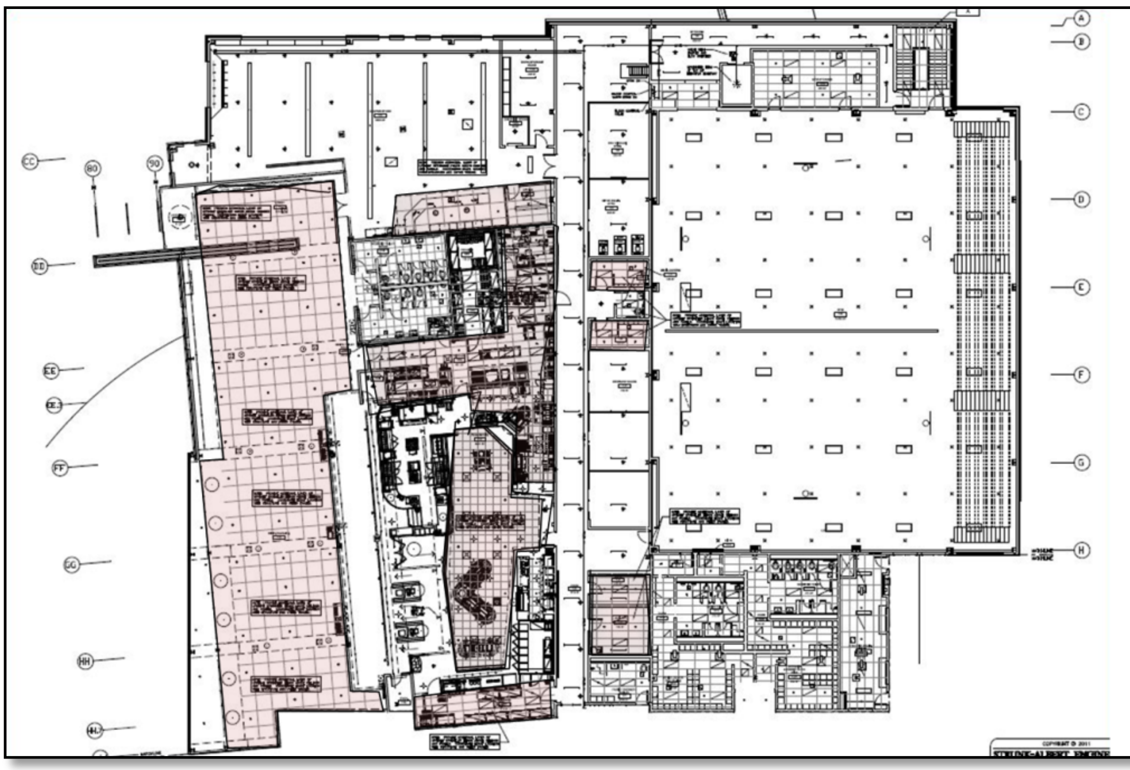


Figure 22; Double sprinkler head areas

Research Goal

Through research of the NFPA 13 2007 edition, and consultation with the project team, the current fire suppression system will be studied and modified. The goal is to keep the wet system design, but to remove the need for double sprinkler heads. Creating this new fire suppression system will significantly reduce costs.

System Requirements

The fire suppression system for each of the buildings is being bid under the plumbing package. JBM Mechanical was responsible for choosing the fire protection specialists, Precision Fire Protection. Precision fire then produced the calculations and design. The campus' system begins at the Student Life Building where water from the 30,000 gallon above ground tank is brought into the building. Because of the campus' location and size, this tank is a necessity. The figure shows a rough design of the building connection. In case of fire in another building on campus, water will leave the Student Life Building's pump room and be fed across campus through an underground sprinkler service main.

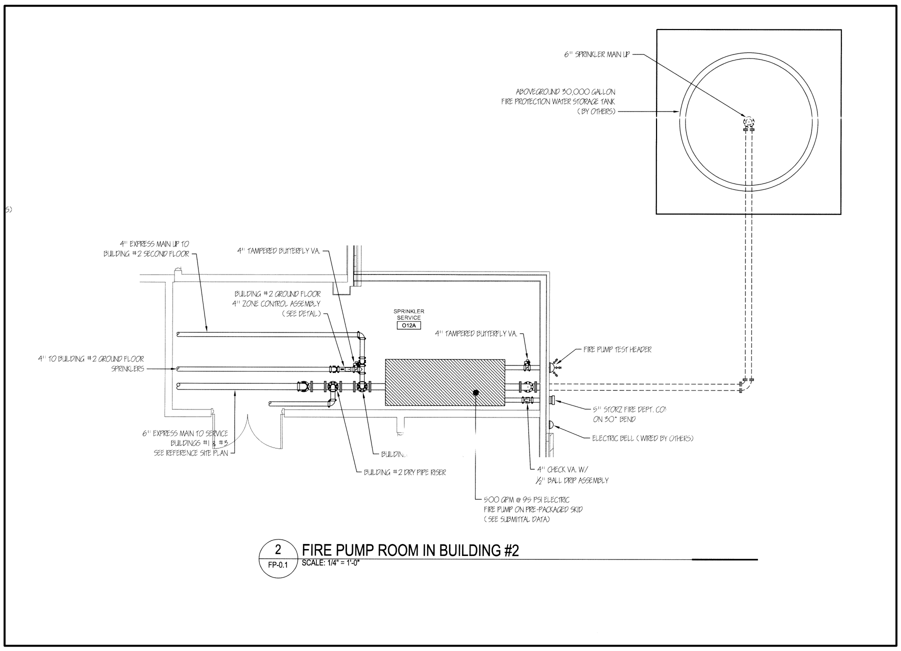


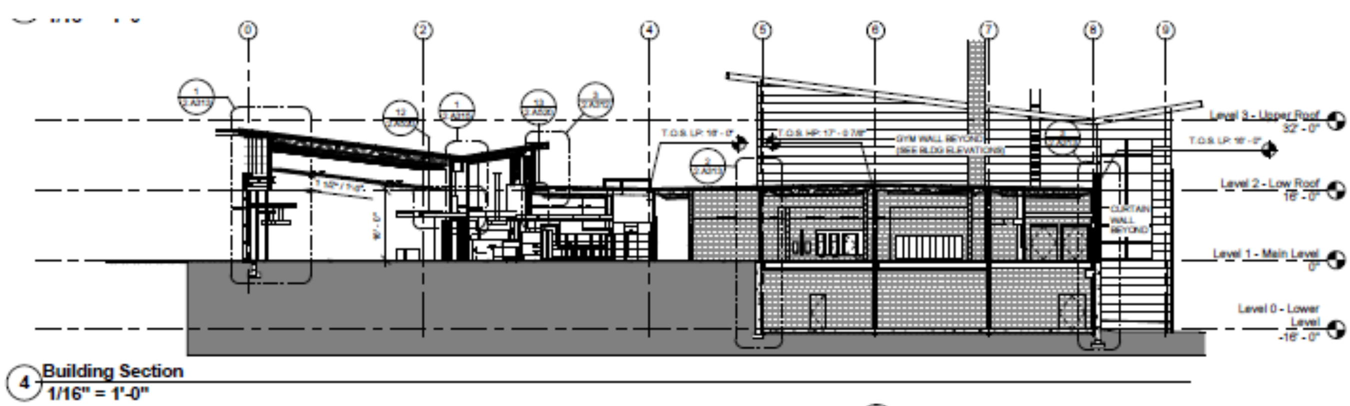
Figure 23; Piping into Building

According to code, the Student Life Building needs to be broken up into 5 areas with different hazard levels; the dining area, gymnasium, and fitness center are light hazard, the food service area and basement mechanical space is ordinary hazard group 1, and on the main floor the specified area is ordinary hazard group 2. The three levels of hazard groups, Light/Medium/Extra, are defined by a number of characteristics including combustibility of contents, quantity of a combustible, heat release rates, and storage height to name a few. The square footage of each section is also taken into account when sprinkler coverage is determined. The table shows a summary of the hydraulic calculations performed for the current system.* It is important to realize the large quantity of sprinkler heads being used, and to understand that this is because of the acoustic cloud present throughout the building.

System Estimates

Precision Fire Protection produced design data for the current system, and a takeoff was performed to determine the breakdown of piping and sprinkler heads. The results of the takeoff can be seen in the table, and in the appendix. Total cost of the current system would be approximately $235,900. This pricing does not include the network of piping throughout the campus, or the water storage tank because these items cannot be changed in the proposed system.

The proposed system has multiple factors. As described earlier, the acoustic cloud is the reason for the double system, so the first step in designing a new fire suppression system would be to remove the cloud. Removing the cloud is a design decision that would need to be approved by the architect and design team, but it would greatly help reduce the overall cost. For the sake of this analysis, it’s assumed that a change in ceiling design would be approved. An alternative to the ceiling tiles would be spray-painting the ceiling and mechanical space. A unit estimate for the painting process was performed and the total cost would be about $8,000. This is a much less expensive than the ceiling grid and tile, which would be approximately $100,000. If the client desired acoustic treatments, wall panels could be utilized and the money for the panels could be taken from the $100,000 savings.



Acoustic Ceiling				
Item Description	**Takeoff Quantity**	**Unit**	**Unit Price**	**Total**
Detailing	5000	S.F	2	$10,000.00
Acoustic Tiles 2X2	12100	S.F	2	$24,200.00
Acoustic Tiles 4X4	7200	S.F	2	$14,400.00
Suspended Grid 2X2	12100	S.F	3	$36,300.00
Suspended Grid 4X4	7200	S.F	3	$21,600.00
			Total	$106,500.00

Quantity	LineNumber	Description	Crew	Daily Output	Labor Hours	Unit	Material	Labor	Total	Ext. Total
19300	099123740880	Paints & Coatings, walls & ceilings, interior, concrete, drywall or plaster, zero voc latex, 2 coats, smooth finish, spray	1 Pord	1625	0.01	S.F.	$ 0.11	$ 0.18	$ 0.29	$ 5,597.00
1	099123740880	Paints & coatings, walls & ceilings, interior, zero voc latex, for work 8'-15' high, add		0	0	S.F.	$ -	$ 0.02	$ 0.02	$ 347.40

Total **$5944.40**

Pipe Diameter (in)	Length (ft)
1	1265.99
1.25	4815.21
2.25	584.83
3	586.68
4	395.4
6	96.58

Sprinkler Type	Basement	First Floor	Total
Upright	152	122	274
Sprigged Upright	43	151	194
Pendant Drop	2	172	174

Sprinkler Type	Basement	First Floor	Total
Upright	152	122	274

The proposed wet system is very similar to the current wet system. The hazard areas, sprinkler coverage, and the piping to sprinklers would be the same. The number of sprinklers would be the main difference in the estimates. This information can be seen in the tables. The new system would cost about $187,000. This is based a square foot estimate for the 68,000ft^2 building. This price, like the current system estimate does not include the supply tank or rough in work for piping to the adjacent buildings.

Final Recommendations

The current fire suppression system, despite its repetitiveness, is a necessity because of the design choices of the team. If cost savings were something the owner was genuinely concerned with, the proposed system would be an obvious decision. The acoustic cloud is not a necessity, but a design decision. Likewise, an exposed ceiling plenum would be a design decision that could give the building a more industrial look. Using the proposed system would also shorten the overall installation time of the fire suppression system. Having a standard sprinkler head would help the installer to create a more streamlined process and leave little room for error.

The system analysis shows that either system would be sufficient for local and national standards, but both have different benefits. The two systems are ultimately forcing the owner to decide between price and aesthetics.

Roofing Membrane Analysis

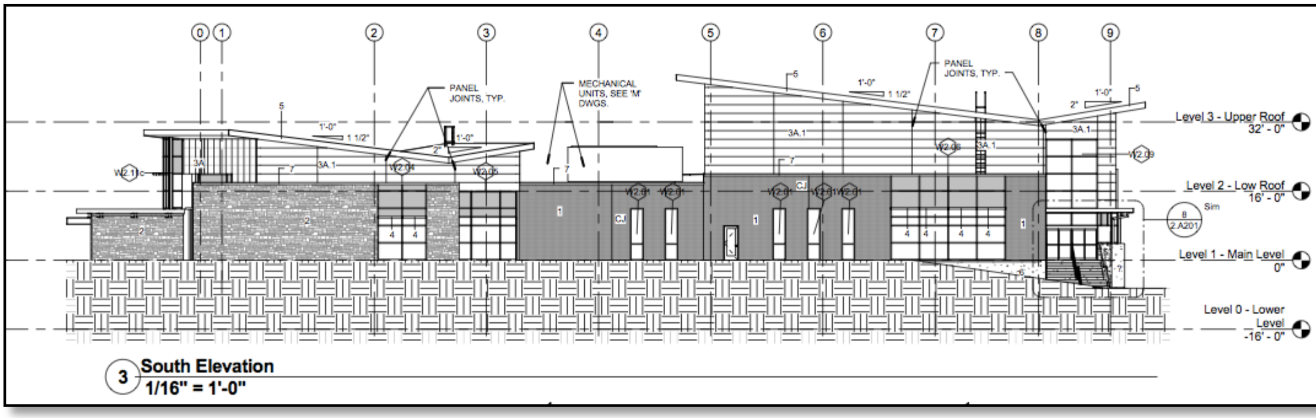


Figure 24; Roof Layers

Problem Identification

As can be seen in the building's plans, the roofline of the Student Life Building is broken into numerous sections. The areas of high, pitched roofs center over the gymnasium and cafeteria whereas a lower relatively flat roof areas cover the fitness center and corridors. The roof design is stable; however the roofing materials may cause some maintenance issues in the future. There are three types of roof systems that will be used on the Student Life Building. The system in question is the single-ply TPO roofing. The mixture of slope, weather, and the newness of the TPO system could negatively affect the performance of the roofing system and lead to failure or excessive repair costs.

Research Goal

The use of the single-ply TPO roofing system was chosen by designers because of the initial cost benefits and the product's adherence to sustainable design. The proposed design change is to replace the single-ply TPO sections with a modified bitumen roofing system. This replacement may lessen maintenance costs in the future, and be a more effective roofing membrane for the building.

Project Specifications

The design for the Student Life Building calls for three different roofing systems. The single-ply TPO with 4" rigid insulation will cover the higher pitched roofs, the modified bitumen roofing with the same 4" of rigid insulation will cover the lower roof areas and finally the sloped areas over the entrances and vestibules will be a single-ply TPO. The breakdown of these areas can be seen in the figure.

The specifications outline both the single-ply and modified bitumen roofing systems. Some key points of the specifications are displayed in the table. The key points of the specifications state that there must be a hot applied SBS Modified Bitumen System that complies with the Garland Company's design basis and a TPO system that can be manufactured by multiple companies, but must comply with the LEED credit guidelines. Both systems must also comply with numerous ASTM standards that deal with material testing.

Single-Ply TPO System

TPO, or thermoplastic polyolefin is a synthetic compound that is somewhat new to the roofing industry. Its use became popular in the early 1990s after manufactures realized it could be an alternative to PVC roofing. TPO systems consist of three layers, a polymer base, a reinforced fabric center, and TPO compounded top. The breakdown of the system can be seen in the figure. The products popularity is due to its energy efficiency, the ability to be welded at the seams, and its lower initial cost when compared to other single-ply systems. TPO systems are an energy star rated product because of their reflectivity and resistance to absorbing UV rays. Because of this, they can help decrease a buildings heating and cooling costs throughout the year. The lower initial costs can be attributed to the manufacturing process.

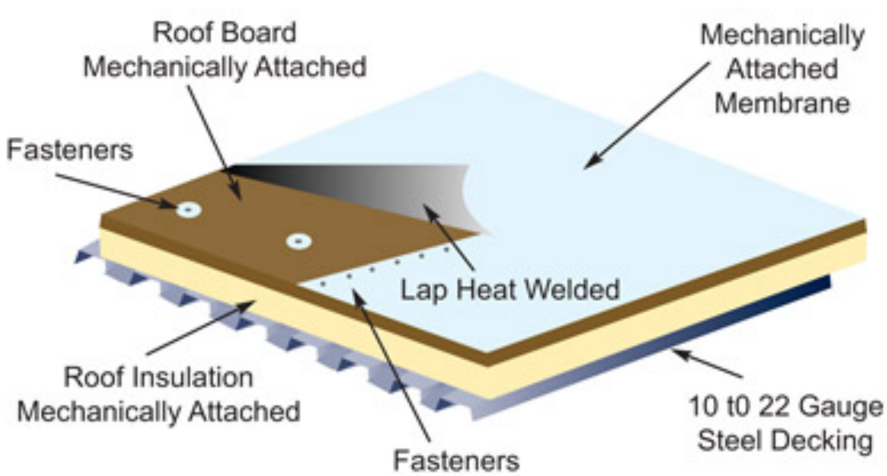


Figure 25; Single Ply TPO

Modified Bitumen Roofing System

Modified Bitumen Systems, (MBS) are sometimes considered a single ply system, however they are more of a cross between that and a built up roof. Modified Bitumen is asphalt that has been mixed with an agent to improve its durability. Specifically, the modifications give the asphalt more rubber like qualities, allowing it to withstand freeze/thaw cycles and any building settling/movement. Modified Bitumen Systems have been proven effective in the area and have been used heavily for the past 30 years. The MBS are composed of a base, membranes, underlayments, and reinforcements, which are fused together to ensure protection against the elements. An example of the composition of a MBS can be seen in the figure. The overall composition of the MBS can be chosen depending on a building's needs, but the governing factor is the type of membrane; Styrene Butadiene Styrene (SBS) or Atactic Polypropylene (APP). Depending on the membrane, the system will be either cold or hot formed, or torched. SBS membranes offer more variation and can either be cold formed or formed with hot asphalt. The APP membrane systems are installed with a torch method.

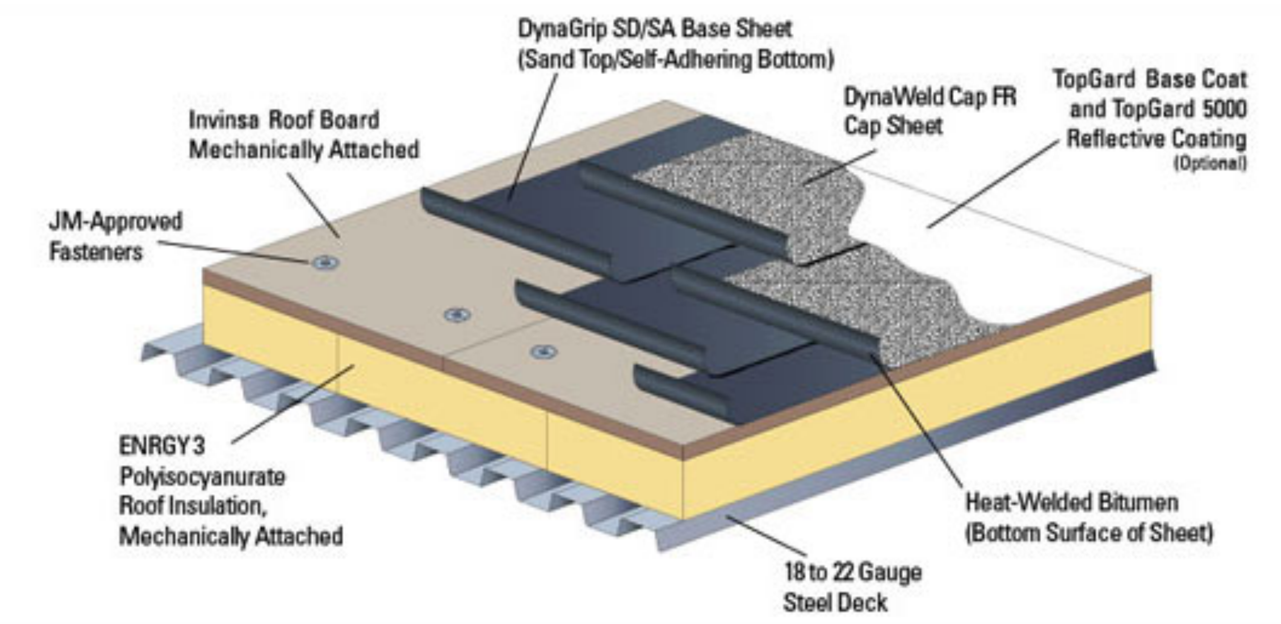


Figure 26; Modified Bitumen System

Current System

As described, the current roofing system uses a combination of three roofing systems. Two single-ply and one modified bitumen system. The breakdown of the roofing was shown in figure. Square footage of the building's footprint is about 49,335 SF but because of the pitched roofs, the overall surface area covered by roofing membranes will be about 52,700 SF. This can be divided between the three roofing systems as it is seen in the table. Roof type 1B is modified bitumen, 2B and 2A are single ply TPO.

Roof Type	Roof Section	Area (ft2)
1B	3	6190
1B	4	7467
1B	5	4926
1B	9	940
1B	10	920
1B	11	770
	SUM	21213
2B	1	11549.7
2B	2	4556.72
2B	6	3020.94
2B	7	10748.75
	SUM	29876.11
2A	8	501
2A	12	644
2A	13	440
	SUM	1585

Proposed System

Initial interviews with the project team drew the conclusion that the single-ply TPO system would not be a long-term roofing solution for the Student Life Building. Because of their experience with projects in the area, some team members felt that modified bitumen system would be the best roofing option. The modified bitumen system could be carried throughout the entire building, allowing for a more uniform installation process and an easier training process for the building's maintenance crew.

Like the current areas of bitumen roofing, the proposed roofing system will be made up of a base sheet, capsheet, type III asphalt, tri-base premium, mineral flashing sheet, and a final pyramic coating. All materials are either a Garland product, or Garland approved as per the specifications.

Cost Comparisons

After researching the current and proposed systems, a cost comparison was performed to determine the possible savings that would come about from switching systems. The current roofing system would cost about $246,800 whereas proposed modified bitumen system would be about $307,500. The full estimate is located in Appendix*

Final Recommendations

After the cost data was compared, it is obvious that the current mix of single-ply TPO and modified bitumen would be the cheaper system to install. However, when possible repair costs are factored into the pricing, the scenario with the modified bitumen roof seems more beneficial. When a section of the TPO system is compromised, the entire square needs to be replaced. The bare material cost of a square (a 100ft2 section) is about $77. Factoring in labor and equipment, replacing one square of TPO can cost up to $140.

Single-ply TPO is a fairly new product in the construction industry, and it's life cycle and long-term benefits have not sufficiently been studied. In the product's early years, there were numerous problems with tears at the seams and through the membrane itself. This can be attributed to the differences in manufacturing process and experimental recipes. Recently, there has been more standardization within the production process, but installation and training is still a variable that will greatly influence its effectiveness.

The familiarity and continuity of the modified bitumen system could also be beneficial to the constructability of the project. Most roofing companies have been using the modified bitumen as a standard for over 30 years. As a result, their employees are more skilled at its installation. Industry studies have shown a correlation between a repetitive process and schedule compaction, and the installation of the modified bitumen system would include a very repetitive process. Laborers would not need to switch between installation of separate systems, and productivity could be increased. Choosing the single-ply TPO system would greatly help the green building process and save money during the construction process, however, the product's uncertainty raise red flags. It seems that it would have been the safer decision to choose a roofing system completely comprised of the modified bitumen.

Foundation Wall Constructability (Project Delivery Research)

Problem Identification

Despite the hours of planning and development that went into the Student Life Building's design, constructability issues undoubtedly arose onsite. While conducting team interviews, it became obvious that early in the building's development the construction around the foundation wall located between column lines 4.9 and 5 would be an area of concern. This seemingly small issue was magnified and resulted in a serious schedule delay because of the delivery method of the project. As described earlier, the Monroe Campus was a design-bid-build project with multiple prime contractors – a delivery method mandated by the state that often causes similar problems.

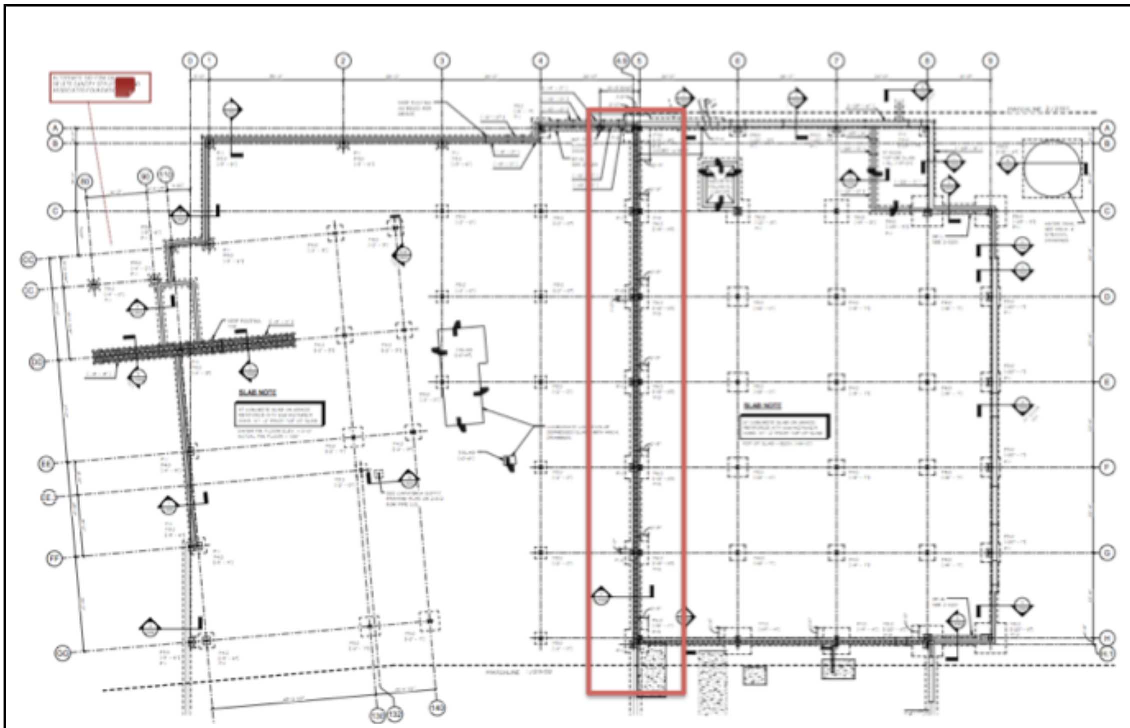


Figure 27; Foundation wall

Research Goal

The goal of this analysis is to study the history behind the use of multiple prime contracts, their effects on a project's success, and to determine the feelings of industry professionals toward their use. By studying these aspects of the contract method, a more desirable delivery method can be determined.

Multiple Prime Contracts; Brief History

A multiple prime delivery approach utilizes multiple contracts; specifically the contracts are between the owner and general contractor, HVAC contractor, electrical contractor and plumbing contractor. The separate contractors are viewed as equals' onsite meaning their design decisions are also weighted equally because they hold equal contracts with the owner, but hold no written contract with each other. The relationship can be seen in the delivery system figure.

The decision to use a multiple prime delivery method is in most cases a mandatory one. The Pennsylvania Separation Act of 1913 states that in public projects worth more than $4,000, the bid packages must be separated between the four trades, and publically bid. Generally, the bids are then awarded to the lowest qualified bidder. Separation of the bid packages is supposed to assure that less markup will occur, therefor saving taxpayers money in public projects. Also, the act gives small local subcontractors an opportunity to bid on projects directly, increasing their ability to break into new markets. A drawback to multiple prime contracts is that it places all risk on the owner. If the owner is not familiar with construction, they are able to use a third party consultant, like DEI, however unlike other delivery methods, the construction management firm will not hold any risk.

Since its enactment, there have been many discussions of the appropriateness of the separation act, and its effects on the industry. Some revisions have been made, leaving boroughs, counties, townships, third-class cities and second-class townships out of its general jurisdiction. However, when dealing with schools and school districts, the act is in effect for all parties. Another change that has been discussed is increasing the amount of the projects worth. In 1913, a $4000 project would have a much more significant impact on the community than it would today. Because of this discrepancy, some groups have been pushing to increase the amount to $90,000, but as with any change, there are groups opposing the increase stating that it will negatively impact small contractors.

Effects on Student Life Building

Problems with the delivery method arose early in the construction of the Student Life Building. The foundation wall shown above was supposed to be poured, followed by the steel erection of the first floor framing, the plumbing rough in, and finally the securement of the foundation wall. There is a significant amount of plumbing rough in to be done alongside and under the wall while the erection gang is in their final phasing, however because it is not a retaining wall, it cannot be backfilled until all work is complete. This was the initial sequencing plan that the team had discussed, but once construction began so did disagreements.

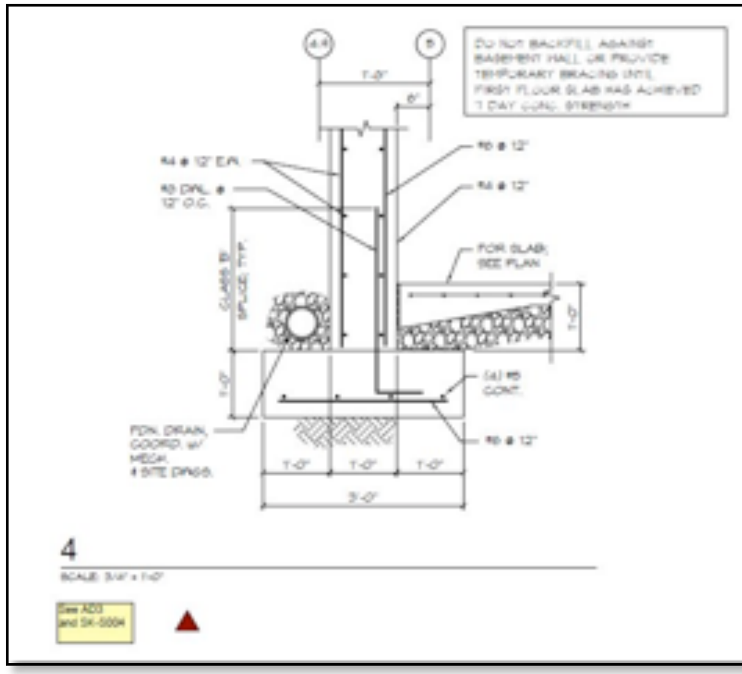
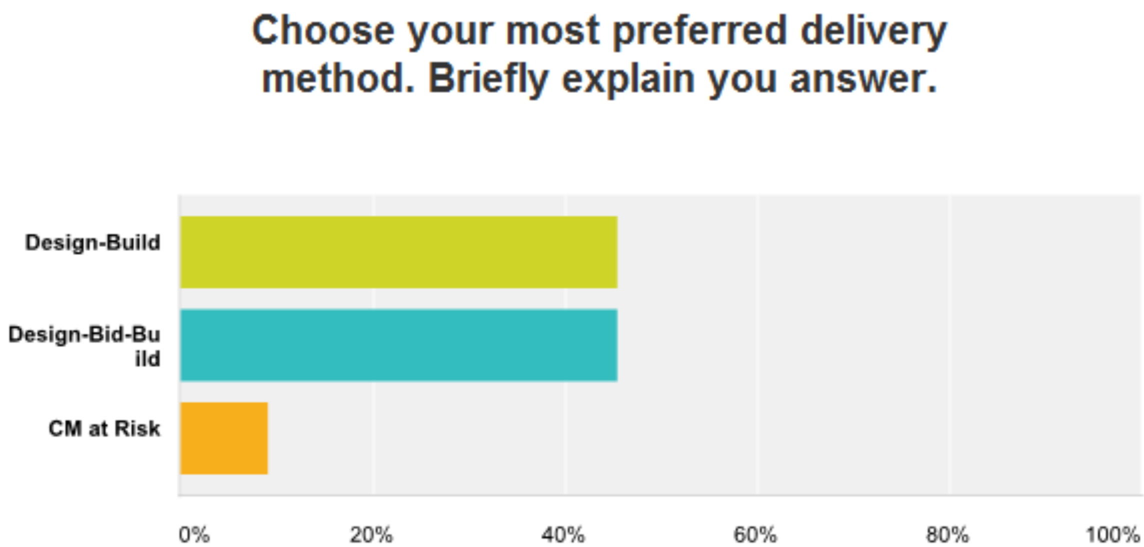


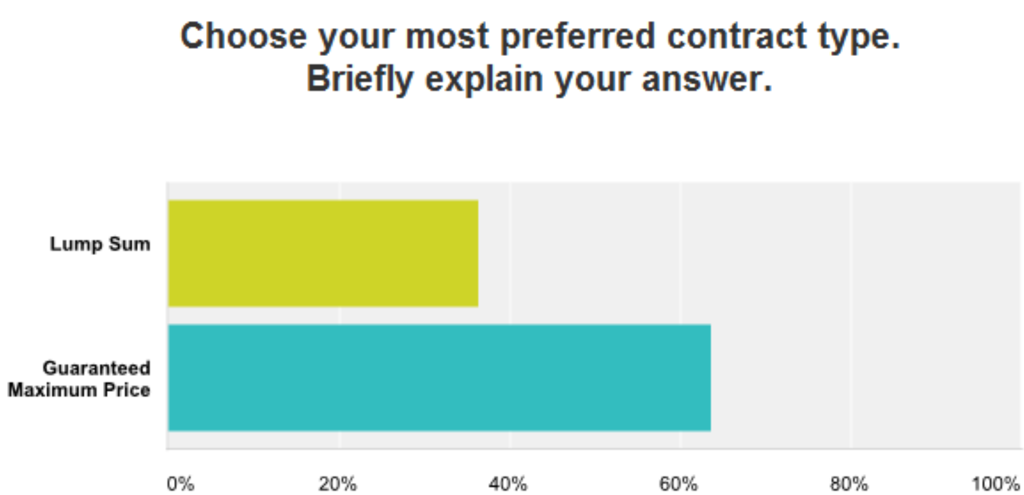
Figure 28; Underground Rough-In

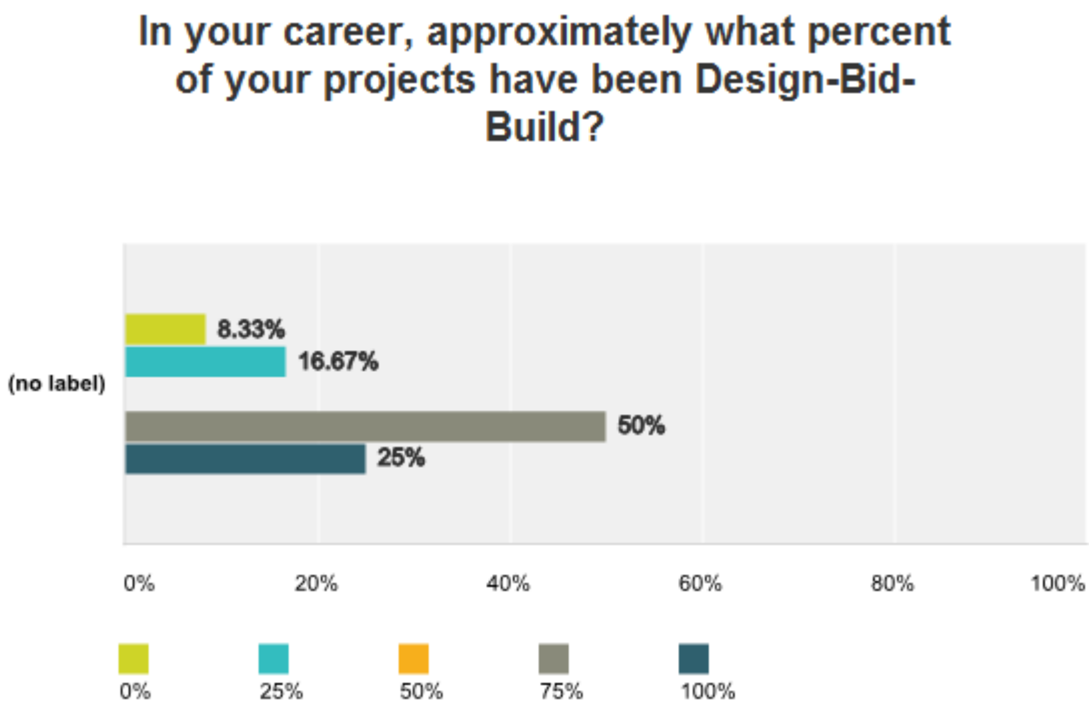
The plumbing contractor realized that his laborers would be installing the work underneath the erection crew, but the basement is not a large area and the logistics of both crews had not been fully developed. Because of the tight space, the plumbing contractor had concerns about the safety of his crew and equipment and refused to continue as planned. In a multiple prime scenario, each contractor has equal say, so construction came to a halt as the contractors, with the help of the CM agency (DEI) negotiated a new plan of action. Negotiations continued for about a week, and finally all parties agreed that plumbing work could be placed before the steel.

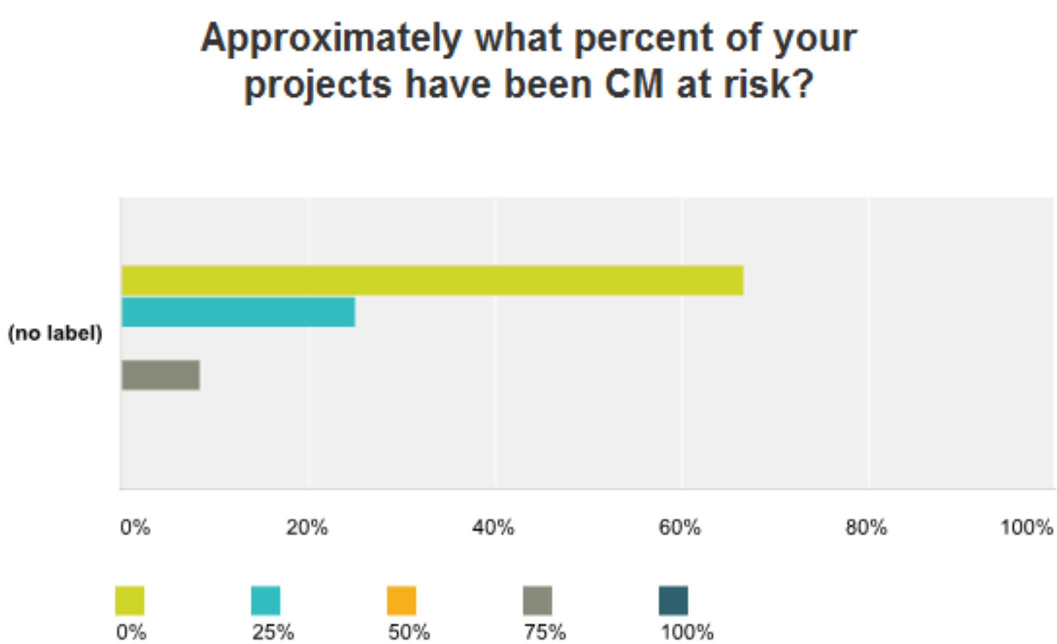
Industry Research

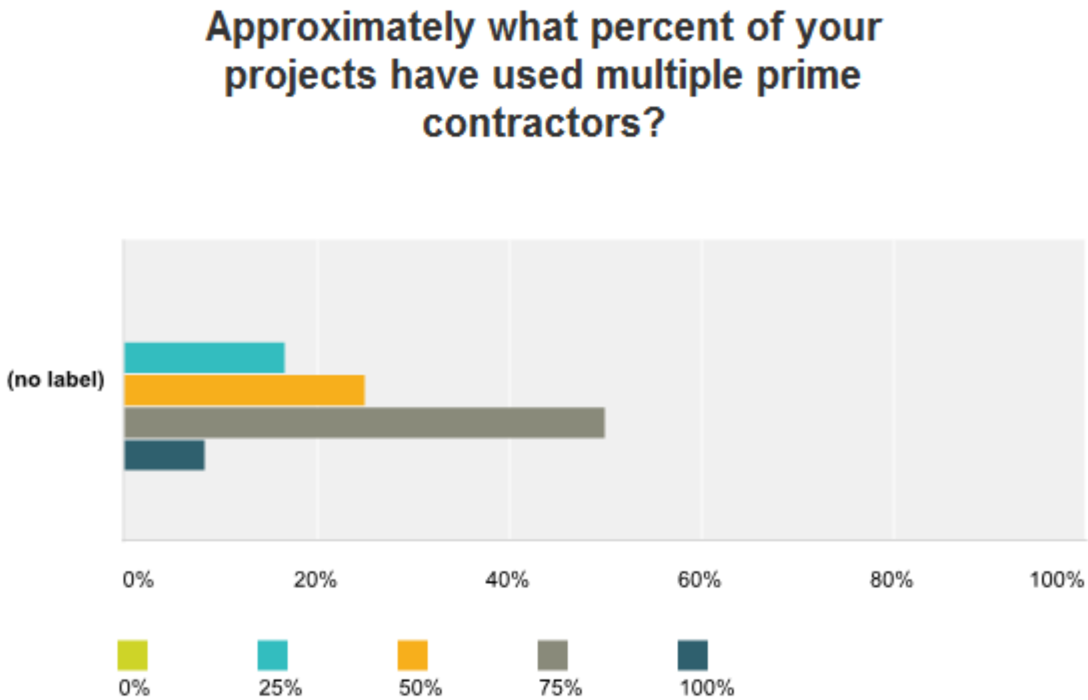
In order to understand the feelings of industry professionals regarding contract delivery methods, a survey was created and sent to numerous industry professionals. Their positions ranged from owner to contractor with a majority being contractors and construction managers. A sample of the survey is in the appendix. Once their results were submitted, they were analyzed and plotted to show the following;

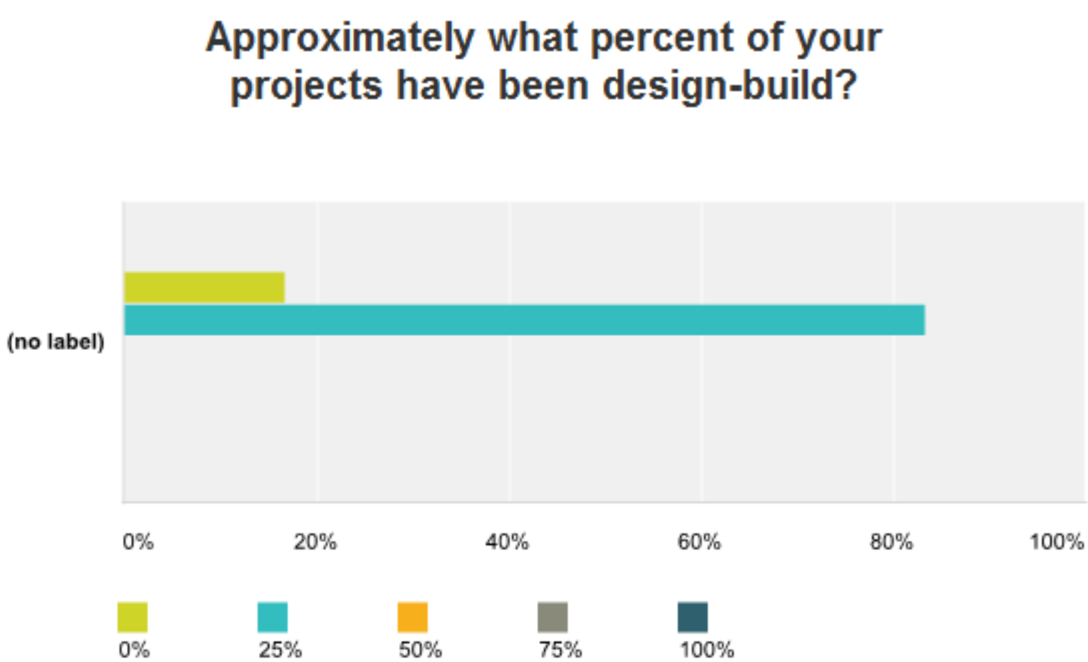


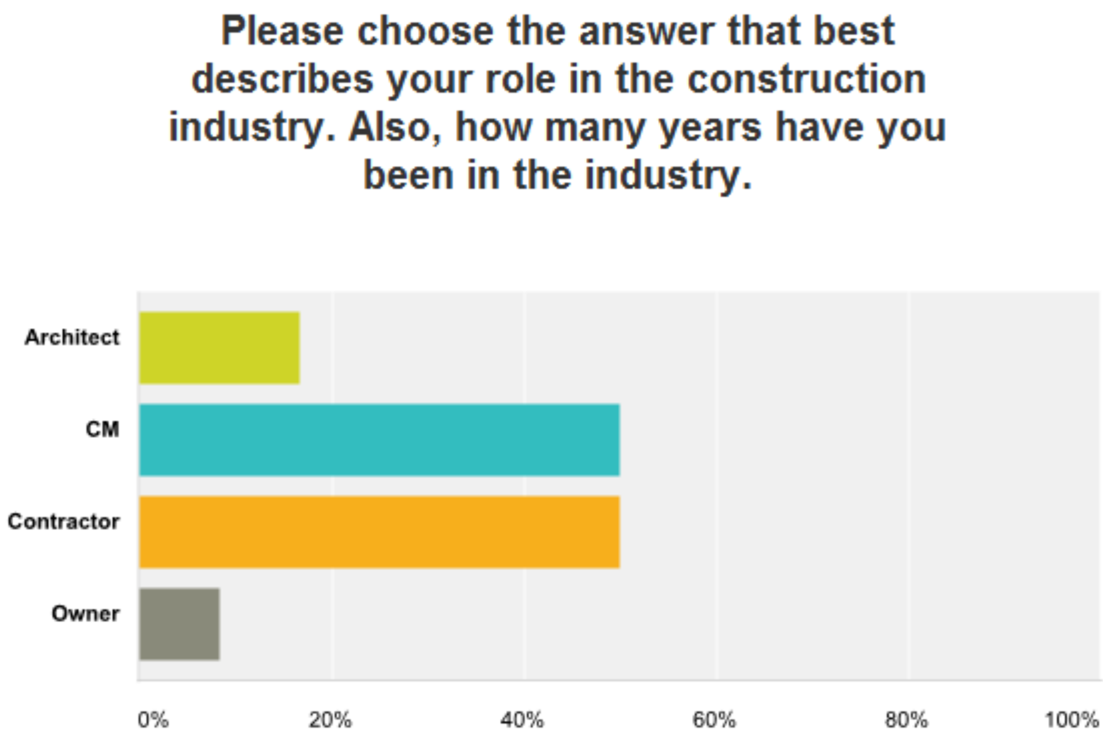



In your career, approximately what percent of your projects have been Design-Bid-Build?
(no label)
8.33%
16.67%
50%
25%
0%
20%
40%
60%
80%
100%
0%
25%
50%
75%
100%


Approximately what percent of your projects have been CM at risk?
(no label)
0%
20%
40%
60%
80%
100%
0%
25%
50%
75%
100%


Approximately what percent of your projects have used multiple prime contractors?
(no label)
0%
20%
40%
60%
80%
100%
0%
25%
50%
75%
100%


Approximately what percent of your projects have been design-build?
(no label)
0%
20%
40%
60%
80%
100%
0%
25%
50%
75%
100%



Final Recommendations

The survey was taken by a majority of professionals working in Pennsylvania. The results showed that a large majority of those polled are familiar with the design-bid-build delivery method and that they are also familiar with projects utilizing multiple prime contractors. However, they show an interest in moving away from multiple prime contracts and would prefer a guaranteed maximum price contract with one single general contractor.

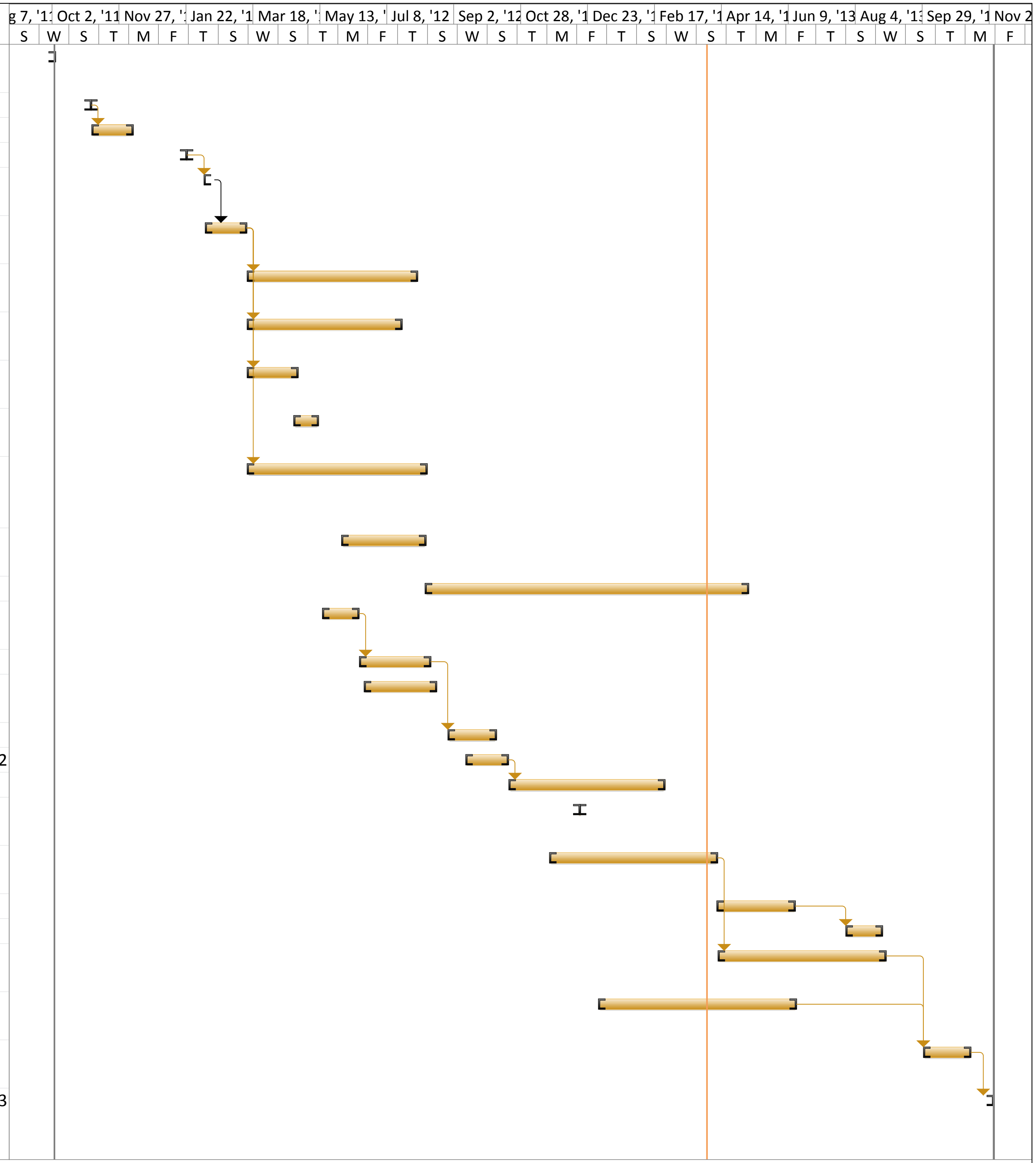
The likelihood of making a statewide shift toward a different mandated contract type is not probable, but individual projects have often repealed the mandated multiple prime method. If industry professionals feel strongly about the switch, they could support groups that are trying to change the qualifying contract types or amount. They could also advise owners to appeal the mandate in court. Ultimately, the use of multiple prime contracts, helps small contractors but can cause disagreements between contractors and stall a projects overall delivery date. If multiple prime contracts are being used, it is necessary to have a third party mediator that will help resolve these disagreements.

Appendix A

Summary Schedule

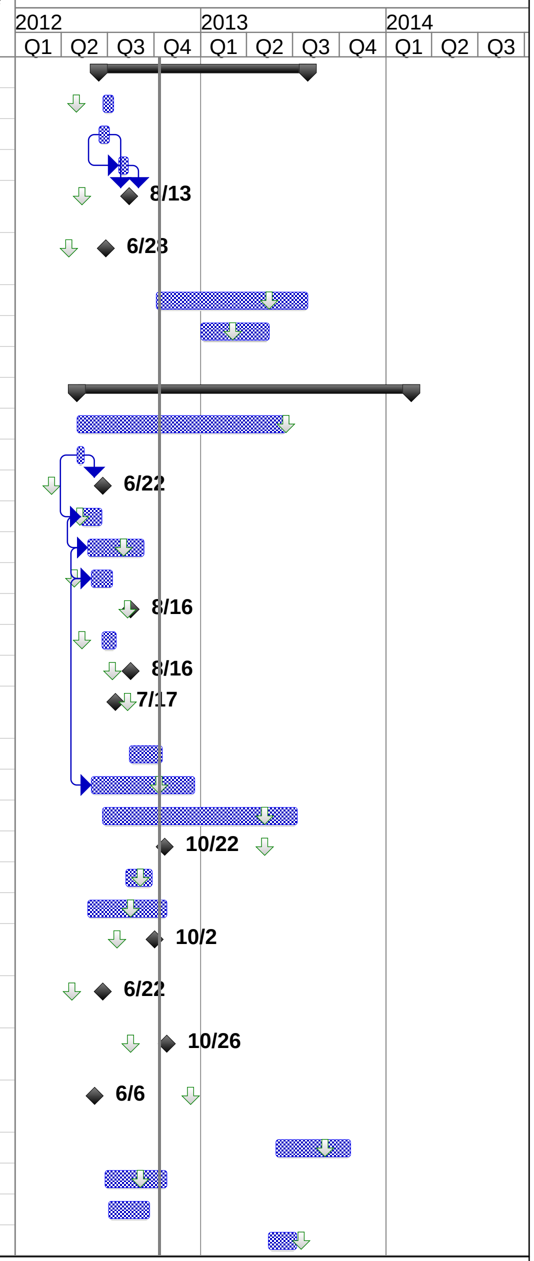
Detailed Schedule

ID	Task Name	Duration	Start	Finish
1	Design Documents Complete			Tue 10/4/11
2	NCC sends OPR	1 day	Thu 11/3/11	Thu 11/3/11
3	Bids Due	25 days	Fri 11/4/11	Thu 12/8/11
4	Notice to Proceed	1 day	Sun 1/22/12	Sun 1/22/12
5	Submittals in order of proirity	ongoing	Mon 2/6/12	
6	Prepare Temp Constr Entances	25 days	Tue 2/7/12	Mon 3/12/12
7	Install Temporary Utility Poles and Temp Power	103 days	Tue 3/13/12	Thu 8/2/12
8	Install Water Service to Permanent Location	94 days	Tue 3/13/12	Fri 7/20/12
9	Construct NCC Drive to Contractor Staging Area	31 days	Tue 3/13/12	Tue 4/24/12
10	Install Contractor Staging Area	16 days	Sat 4/21/12	Fri 5/11/12
11	Install Geo-Exchange Field, Associated Site Work	109 days	Tue 3/13/12	Fri 8/10/12
12	Install Sediment Basin C and Complete NCC Drive	51 days	Thu 5/31/12	Thu 8/9/12
13	Install Site Storm Sewer	193 days	Thu 8/9/12	Mon 5/6/13
14	Prepare Sub Grade for Building Pad	23 days	Tue 5/15/12	Thu 6/14/12
15	Place Foundations	42 days	Fri 6/15/12	Mon 8/13/12
16	Install MEP &Plum Underground Rough-In	45 days	Tue 6/19/12	Sat 8/18/12
17	Erect Steel Framing	30 days	Tue 8/28/12	Sun 10/7/12
18	Place SOG	26 days	Wed 9/12/12	Wed 10/17/12
19	Construct Exterior Shell	93 days	Thu 10/18/12	Mon 2/25/13
20	Building to be Watertight	1 day	Sun 12/16/12	Sun 12/16/12
21	Begin Interior Partitions, MEP Rough-in	101 days	Wed 11/21/12	Wed 4/10/13
22	Install Ceiling Grid	48 days	Wed 4/10/13	Fri 6/14/13
23	Install Finished Ceilings	22 days	Sat 7/27/13	Mon 8/26/13
24	Complete All Interior Wall Finsihes	101 days	Thu 4/11/13	Thu 8/29/13
25	Start Up and Commision Central Plant	120 days	Tue 1/1/13	Sat 6/15/13
26	Completeion of All Construction Activities	30 days	Mon 9/30/13	Fri 11/8/13
27	Obtain Certificate of Occupancy- Substantial Completion			Wed 11/27/13

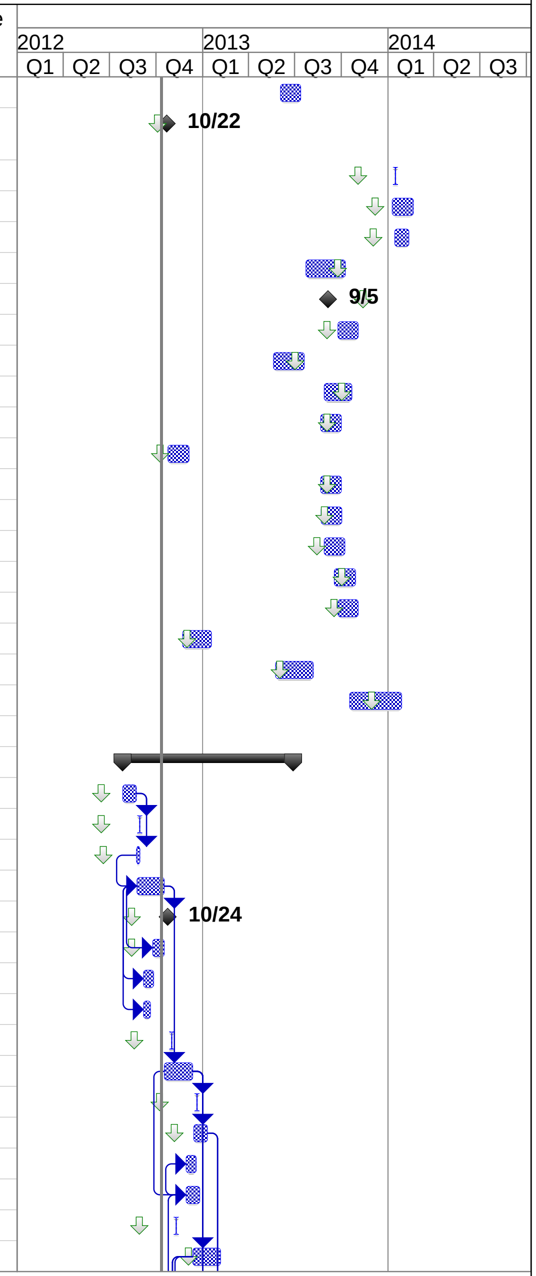


NORTHAMPTON COMMUNITY COLLEGE

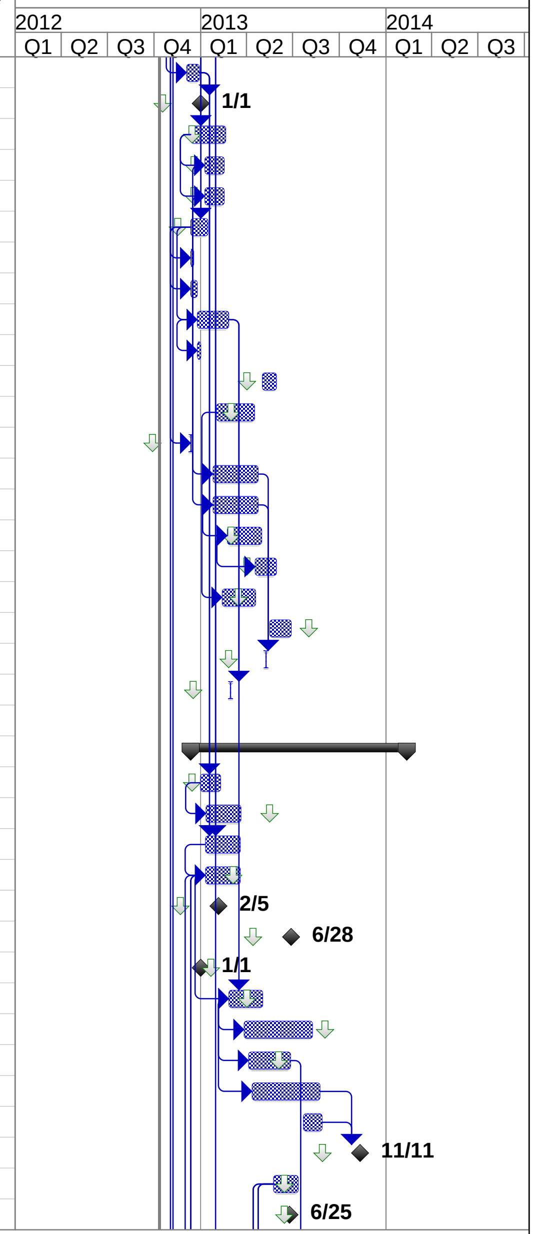
ID	Task Name	Duration	Original Baseline Start	Original Baseline Finish
1	**TEMPORARY CONSTRUCTION**	**301 days**	**Thu 5/31/12**	**Mon 7/30/12**
2	temporary fence	15 days	Fri 6/22/12	Thu 7/12/12
3	mobilize job trailers	15 days	Thu 6/14/12	Wed 7/4/12
4	EC. temporary electric to job tailers	15 days	Mon 7/23/12	Fri 8/10/12
5	**MILESTONE INSTALL CONTRACTOR STAGING AREA & CONNECT POWER TO OFFICE TRAILERS**	1 day	Mon 8/13/12	Mon 8/13/12
6	**MILESTONE INSTALL TEMP UTILITY POLES & TEMP POWER AS SHOWN ON OE.100**	1 day	Thu 6/28/12	Thu 6/28/12
7	EC temporay electric and lighting in buildings	218 days	Mon 10/15/12	Tue 7/30/13
8	**MILESTONE PROVIDE TEMPORARY HEAT**	99 days	Tue 1/1/13	Wed 5/15/13
9				
10	**SITE WORK**	**484 days**	**Wed 5/2/12**	**Wed 2/19/14**
11	site layout	300 days	Wed 5/2/12	Sun 6/17/12
12	install rock construction entrance	10 days	Wed 5/2/12	Tue 5/15/12
13	**PREPARE CONSTRUCTION ENTRANCES ON RT 715 & RR AVE**	1 day	Fri 6/22/12	Fri 6/22/12
14	erosion controls	30 days	Wed 5/9/12	Fri 6/1/12
15	site clearing and strip topsoil	80 days	Wed 5/23/12	Mon 9/10/12
16	temporary basins A&B and swales	30 days	Wed 5/30/12	Tue 7/10/12
17	**MILESTONE INSTALL SEDIMENT BASIN C.**	51 days	Thu 8/16/12	Mon 10/22/12
18	Install paving binder access roads and staging areas	20 days	Wed 6/20/12	Tue 7/17/12
19	**MILESTONE INSTALL ADDITIONAL STAGING AREAS**	29 days	Thu 8/16/12	Sat 9/22/12
20	**MILESTONE INSTALL GEO-EXCHANGE FIELD, ASSOCIATED SITEWORK & E&S CONTROLS**	105 days	Tue 7/17/12	Sun 12/5/21
21	Electrical Ductbank	50 days	Mon 8/13/12	Tue 10/16/12
22	excavation cut/fill	150 days	Wed 5/30/12	Wed 12/19/12
23	storm sewer	280 days	Thu 6/21/12	Mon 7/9/12
24	**MILESTONE INSTALL STORM SEWER**	193 days	Mon 10/22/12	Fri 7/12/13
25	sanitary sewer	40 days	Mon 8/6/12	Wed 9/26/12
26	water system	115 days	Wed 5/23/12	Thu 10/25/12
27	**MILESTONE WATER SERVICE TO PERMANENT LOCATION IN STUDENT LIFE BUILDING**	1 day	Tue 10/2/12	Tue 10/2/12
28	**MILESTONE INSTALL TEMPORARY WATER TO CONTRACTOR STAGING AREA**	1 day	Fri 6/22/12	Fri 6/22/12
29	**MILESTONE MAKE WATER TAP IN RT715 AND EXTEND WATER LINE ONTO NCC SITE**	1 day	Fri 10/26/12	Fri 10/26/12
30	**INSTALL ALL SITE UTILITIES INCLUDING WATER, HEATING. CHILLED WATER, ELECTRICAL TO BUILDINGS**	189 days	Wed 6/6/12	Tue 2/19/13
31	Site grading and excavation	109 days	Wed 5/29/13	Tue 10/22/13
32	concrete curb 2012	91 days	Tue 6/26/12	Thu 10/25/12
33	EC site lighting	60 days	Tue 7/3/12	Tue 7/3/12
34	concrete curb 2013	40 days	Tue 5/14/13	Mon 7/8/13



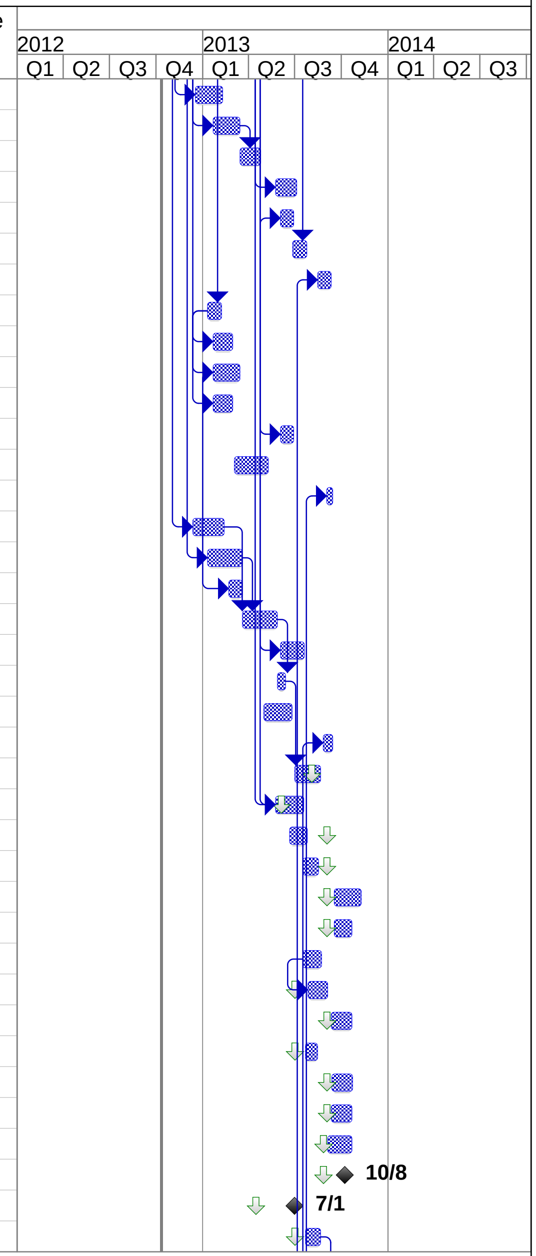
ID	Task Name	Duration	Original Baseline Start	Original Baseline Finish
35	EC site lighting	30 days	Mon 6/3/13	Mon 6/3/13
36	**MILESTONE CONTINUE CONSTRUCTION OF NCC DRIVE FROM 27+00 TO 1+50**	40 days	Mon 10/22/12	Fri 12/14/12
37	**MILESTONE INSTALL FINAL PAVING FOR PARKING LOTS AND DRIVES**	1 day	Wed 1/15/14	Wed 1/15/14
38	site linestriping & signage	30 days	Thu 1/9/14	Wed 2/19/14
39	concrete bumper blocks	20 days	Tue 1/14/14	Mon 2/10/14
40	concrete sidewalks & ramps	60 days	Tue 7/23/13	Tue 10/8/13
41	**MILESTONE INSTALL WALKWAY SURFACES & LANDSCAPING**	1 day	Thu 9/5/13	Thu 9/5/13
42	unit pavers	30 days	Tue 9/24/13	Sat 11/2/13
43	exterior masonry seat walls and site walls	45 days	Mon 5/20/13	Fri 7/19/13
44	exterior site railings	40 days	Wed 8/28/13	Mon 10/21/13
45	timber guide rail	30 days	Wed 8/21/13	Wed 8/21/13
46	segmented retaining wall	30 days	Wed 10/24/12	Tue 12/4/12
47	site benches	30 days	Wed 8/21/13	Mon 9/30/13
48	bus shelters	30 days	Thu 8/22/13	Tue 10/1/13
49	flagpoles	30 days	Wed 8/28/13	Mon 10/7/13
50	parking control equipment	30 days	Tue 9/17/13	Mon 10/28/13
51	relocate available boulders	30 days	Tue 9/24/13	Sat 11/2/13
52	Landscaping trees and shrubs fall 2012	42 days	Thu 11/22/12	Thu 1/17/13
53	landscaping trees and shrubs spring 2013	55 days	Fri 5/24/13	Tue 8/6/13
54	landscaping trees and shrubs fall 2013	76 days	Thu 10/17/13	Mon 1/27/14
55				
56	**BUILDING SHELL CONSTRUCTION**	**246 days**	**Fri 7/27/12**	**Thu 6/27/13**
57	construct the building pad	20 days	Fri 7/27/12	Wed 8/22/12
58	**B.2 MILESTONE COMPLETE SUB GRADE FOR BUILDING PAD**	1 day	Wed 8/29/12	Tue 8/28/12
59	layout for foundations	5 days	Thu 8/23/12	Wed 8/29/12
60	footing excavation and concrete foundations	40 days	Fri 8/24/12	Tue 10/16/12
61	**B.3 MILESTONE COMPLETE CONCRETE FOUNDATIONS**	1 day	Wed 10/24/12	Wed 10/24/12
62	waterproofing	18 days	Mon 9/24/12	Tue 10/16/12
63	PC underground sanitary/storm rough-in	15 days	Thu 9/6/12	Tue 9/25/12
64	EC deep underground rough in	10 days	Thu 9/6/12	Wed 9/19/12
65	**B.4 MILESTONE COMPLETE MECH & PC UNDERGROUND ROUGH IN**	1 day	Wed 10/31/12	Wed 10/31/12
66	erect structural steel and deck	40 days	Wed 10/17/12	Tue 12/11/12
67	**B.5 MILESTONE COMPLETE STRUCTURAL STEEL**	1 day	Thu 12/20/12	Thu 12/20/12
68	pour concrete slab on deck	20 days	Fri 12/14/12	Wed 1/9/13
69	EC rough in stone under slab	15 days	Thu 11/29/12	Tue 12/18/12
70	stone under slab	20 days	Thu 11/29/12	Tue 12/25/12
71	**B.4A MILESTONE COMPLETE COMPLETE EC UNDERGROUND ROUGH IN**	1 day	Fri 11/9/12	Fri 11/9/12
72	CMU walls	40 days	Wed 12/12/12	Mon 2/4/13



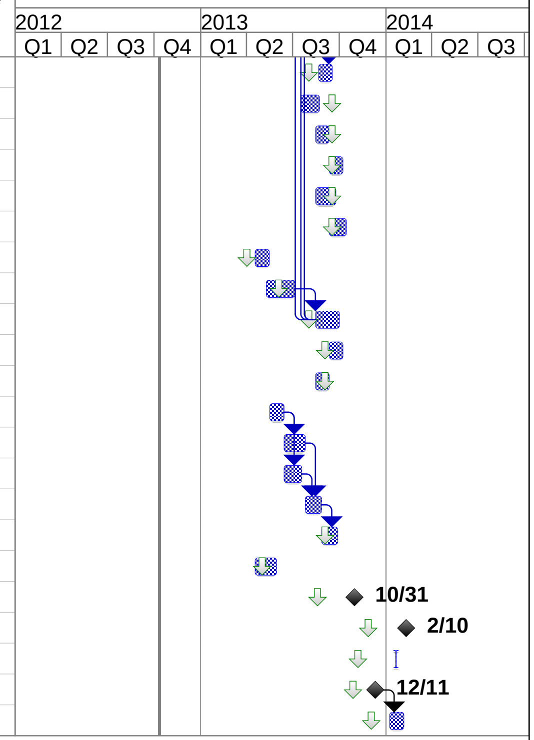
ID	Task Name	Duration	Original Baseline Start	Original Baseline Finish
73	Pour concrete slab on grade	20 days	Tue 12/4/12	Fri 12/28/12
74	**B.6 MILESTONE COMPLETE CONCRETE SLAB ON GRADE**	1 day	Tue 1/1/13	Tue 1/1/13
75	cold formed metal framing and sheathing	50 days	Wed 12/12/12	Mon 2/18/13
76	spray urethane insulation	28 days	Wed 1/9/13	Fri 2/15/13
77	air barrier membrane	28 days	Wed 1/9/13	Wed 1/9/13
78	wood blocking & sheathing on roof	25 days	Wed 12/12/12	Mon 1/14/13
79	HVAC set roof curbs	5 days	Wed 12/12/12	Mon 12/17/12
80	PC Set Roof Drains	10 days	Wed 12/12/12	Mon 12/24/12
81	roofing	45 days	Tue 12/25/12	Sun 2/24/13
82	HVAC Set roof top equipment	5 days	Tue 12/25/12	Mon 12/31/12
83	metal roof ladders	20 days	Thu 5/2/13	Wed 5/29/13
84	aluminum windows & curtain walls	55 days	Fri 2/1/13	Tue 4/16/13
85	deliver steel lintels	1 day	Wed 12/12/12	Wed 12/12/12
86	masonry veneer	65 days	Fri 1/25/13	Tue 4/23/13
87	insulated metal wall panels	65 days	Fri 1/25/13	Tue 4/23/13
88	metal soffit and fascia	50 days	Fri 2/22/13	Tue 4/30/13
89	roof metal edges	30 days	Thu 4/18/13	Wed 5/29/13
90	Exterior Caulking	50 days	Tue 2/12/13	Thu 4/18/13
91	aluminum entrance doors/sliding doors	30 days	Fri 5/17/13	Thu 6/27/13
92	**B.9 MILESTONE COMPLETE EXTERIOR SHELL**	1 day	Thu 5/9/13	Thu 5/9/13
93	**B.10 MILESTONE BUILDING TO BE WATER TIGHT**	1 day	Thu 2/28/13	Thu 2/28/13
94				
95	**BUILDING FINISHES**	**314 days?**	**Sat 4/5/14**	**Mon 2/10/14**
96	metal stairs	30 days	Mon 12/31/12	Fri 2/8/13
97	interior railings	50 days	Fri 1/11/13	Wed 3/20/13
98	interior h.m. frames	50 days	Thu 1/10/13	Tue 3/19/13
99	interior metal stud framing	50 days	Thu 1/10/13	Thu 1/10/13
100	**B.13 MILESTONE BEGIN INTERIOR PARTITIONS & MEP ROUGH INS**	1 day	Tue 2/5/13	Tue 2/5/13
101	**B.14 MILESTONE COMPLETE WALL ROUGH INS AND INSPECTIONS**	1 day	Fri 6/28/13	Fri 6/28/13
102	**B.7 MILESTONE INSTALL MEP ABOVE CEILING ROUGH IN**	69 days	Tue 1/1/13	Thu 4/4/13
103	interior drywall and spackling	50 days	Mon 2/25/13	Thu 5/2/13
104	interior caulking	100 days	Wed 3/27/13	Thu 8/8/13
105	ceramic & porcelain wall & floor tile	60 days	Fri 4/5/13	Fri 4/5/13
106	painting	100 days	Fri 4/12/13	Fri 8/23/13
107	wall coverings	30 days	Mon 7/22/13	Tue 8/27/13
108	**B.19 MILESTONE COMPLETE ALL INTERIOR WALL FINISHES AND TRIM**	1 day	Mon 11/11/13	Mon 11/11/13
109	acoustical ceiling grid	35 days	Fri 5/24/13	Thu 7/11/13
110	**B.15 MILESTONE INSTALL CEILING GRID**	1 day	Tue 6/25/13	Tue 6/25/13



ID	Task Name	Duration	Original Baseline Start	Original Baseline Finish
111	PC AG san/rw	40 days	Mon 12/17/12	Fri 2/8/13
112	PC overhead pipe rough in	40 days	Mon 1/21/13	Thu 3/14/13
113	PC insulation	30 days	Fri 3/15/13	Wed 4/24/13
114	PC drop sprinkler heads	30 days	Fri 5/24/13	Thu 7/4/13
115	PC casework fixtures	20 days	Mon 6/3/13	Fri 6/28/13
116	PC toilet fixtures	20 days	Thu 6/27/13	Wed 7/24/13
117	PC kitchen equipment hookups	20 days	Thu 8/15/13	Tue 9/10/13
118	HC hangers	20 days	Thu 1/10/13	Wed 2/6/13
119	HC pipe install	30 days	Mon 1/21/13	Thu 2/28/13
120	HC Duct install	40 days	Mon 1/21/13	Thu 3/14/13
121	HC ATC rough-in	30 days	Mon 1/21/13	Thu 2/28/13
122	HC GRD install	20 days	Mon 6/3/13	Fri 6/28/13
123	HC Equipment & Final Connections	50 days	Mon 3/4/13	Thu 5/9/13
124	HC kitchen equipment hook ups	10 days	Mon 9/2/13	Fri 9/13/13
125	EC rough in walls	45 days	Wed 12/12/12	Fri 2/1/13
126	EC Overhead rough in	50 days	Thu 1/10/13	Tue 3/19/13
127	EC cable tray	20 days	Sat 2/2/13	Tue 3/19/13
128	EC wiring	50 days	Wed 3/20/13	Mon 5/27/13
129	EC light fixtures	35 days	Mon 6/3/13	Fri 7/19/13
130	EC wiring devices	12 days	Tue 5/28/13	Wed 6/12/13
131	EC fire alarm & security	40 days	Wed 5/1/13	Tue 6/25/13
132	EC kitchen equipment hook ups	15 days	Mon 8/26/13	Fri 9/13/13
133	EC hook-ups and final connections	40 days	Mon 7/1/13	Tue 8/20/13
134	p.l. casework millwork	40 days	Fri 5/24/13	Thu 7/18/13
135	resilient tile floor and base	25 days	Fri 6/21/13	Thu 7/25/13
136	seamless vinyl flooring	25 days	Wed 7/17/13	Fri 8/16/13
137	carpet tile	40 days	Tue 9/17/13	Fri 11/8/13
138	rubber stair treads/riser & landings	25 days	Tue 9/17/13	Mon 10/21/13
139	install doors and hardware	30 days	Wed 7/17/13	Thu 8/22/13
140	interior glass	30 days	Sat 7/27/13	Tue 9/3/13
141	wood wall panels	30 days	Wed 9/11/13	Mon 10/21/13
142	visual display surfaces	20 days	Mon 7/22/13	Wed 8/14/13
143	signage	30 days	Thu 9/12/13	Tue 10/22/13
144	install wood ceiling	30 days	Wed 9/11/13	Mon 10/21/13
145	drop acoustical ceiling tiles	35 days	Wed 9/4/13	Mon 10/21/13
146	**B.17 MILESTONE INSTALL FINISHED CEILINGS**	23 days?	Tue 10/8/13	Wed 11/6/13
147	**B.18 MILESTONE ENERGIZE PERMANENT POWER**	1 day	Mon 7/1/13	Mon 7/1/13
148	toilet compartments	25 days	Mon 7/22/13	Tue 8/20/13

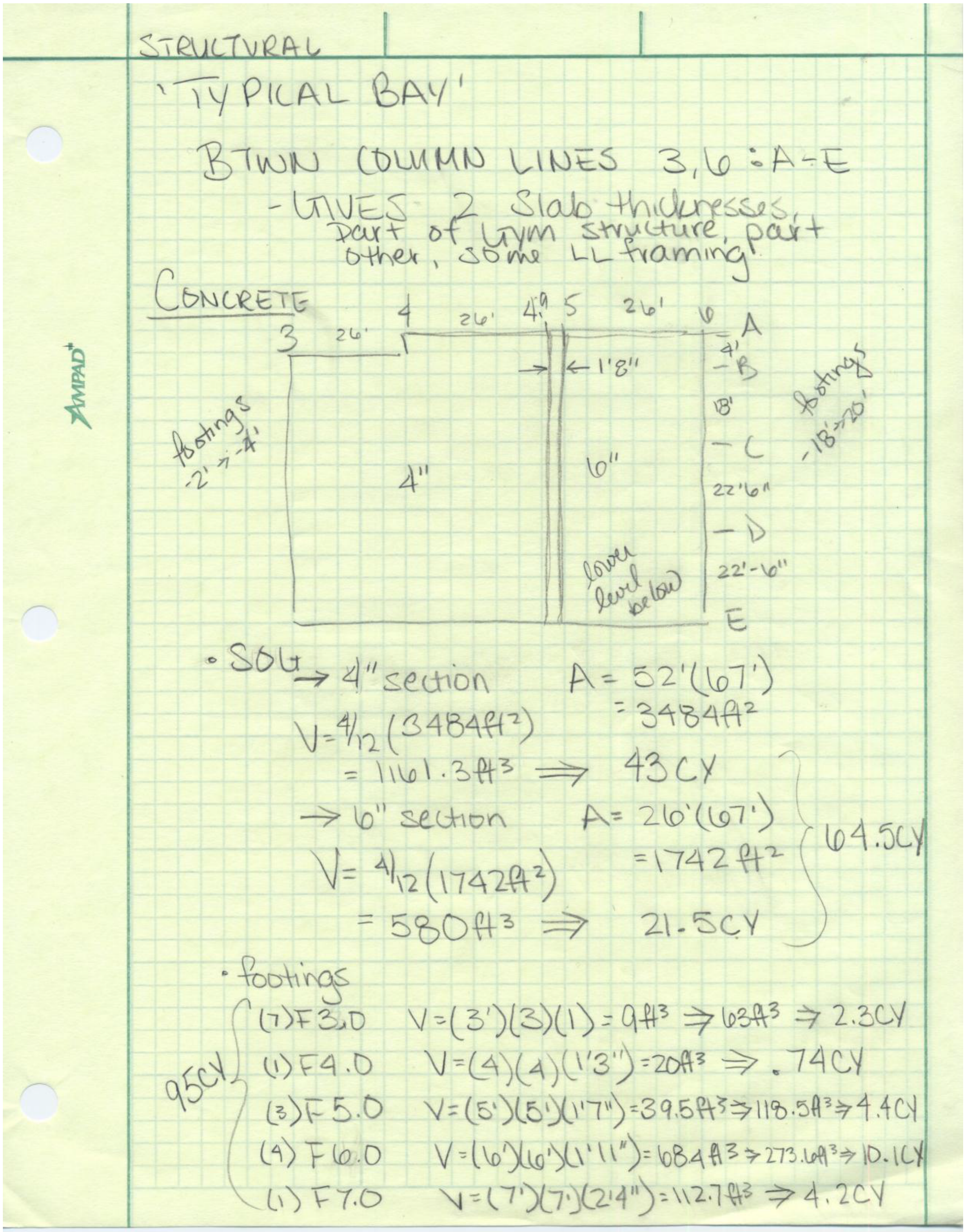


ID	Task Name	Duration	Original Baseline Start	Original Baseline Finish
149	toilet accessories	20 days	Wed 8/21/13	Mon 9/16/13
150	fire protection specialties	30 days	Wed 7/17/13	Thu 8/22/13
151	motorized projection screens	20 days	Thu 8/15/13	Tue 9/10/13
152	roller window shades	20 days	Wed 9/11/13	Mon 10/7/13
153	wire mesh partitions	30 days	Thu 8/15/13	Mon 9/23/13
154	metal lockers	25 days	Wed 9/11/13	Mon 10/14/13
155	install hood and walk-ins	20 days	Thu 4/18/13	Wed 5/15/13
156	Kitchen Tile	40 days	Fri 5/10/13	Thu 7/4/13
157	install and setup food service equipment	35 days	Thu 8/15/13	Mon 9/30/13
158	glass wall folding partition	20 days	Wed 9/11/13	Mon 10/7/13
159	loading dock equipment	20 days	Thu 8/15/13	Tue 9/10/13
160	Paint Gym Ceiling	20 days	Fri 5/17/13	Thu 6/13/13
161	gymnasium equipment	30 days	Fri 6/14/13	Thu 7/25/13
162	gymnasium dividers	25 days	Fri 6/14/13	Thu 7/18/13
163	resilent athletic floor	25 days	Fri 7/26/13	Mon 8/26/13
164	telescoping bleachers	25 days	Tue 8/27/13	Fri 9/27/13
165	hydraulic elevators	30 days	Thu 4/18/13	Wed 5/29/13
166	**B.21 MILESTONE START-UP AND COMMISSION EQUIPMENT AND SYSTEMS**	1 day	Thu 10/31/13	Wed 10/3/12
167	**B.23 MILESTONE COMPLETION OF ALL CONSTRUCTION ACTIVITIES**	1 day	Mon 2/10/14	Mon 2/10/14
168	**B.24 MILESTONE OBTIAN CERTIFICATION OF OCCUPANCY**	1 day	Mon 1/20/14	Mon 1/20/14
169	**B.22 MILESTONE PUNCHLIST PREPARATION AND COMPLETION**	21 days	Wed 12/11/13	Tue 1/7/14
170	closeout and warranties	20 days	Wed 1/8/14	Tue 2/4/14



Appendix B

Steel Assemblies Estimate



STRUCTURAL

'TYPICAL BAY'

BTWN COLUMN LINES 3,6 : A-E

- GIVES 2 Slab thicknesses, part of Gym structure, part other, some LL framing

CONCRETE

• SOG → 4" section A = 52'(67') = 3484 ft²

V = 4/12 (3484 ft²) = 1161.3 ft³ ⇒ 43 CY

→ 6" section A = 26'(67') = 1742 ft²

V = 4/12 (1742 ft²) = 580 ft³ ⇒ 21.5 CY

64.5 CY

• footings

(7) F3.0 V = (3')(3)(1) = 9 ft³ ⇒ 63 ft³ ⇒ 2.3 CY

(1) F4.0 V = (4)(4)(1'3") = 20 ft³ ⇒ .74 CY

(3) F5.0 V = (5')(5')(1'7") = 39.5 ft³ ⇒ 118.5 ft³ ⇒ 4.4 CY

(4) F6.0 V = (6')(6')(1'11") = 68.4 ft³ ⇒ 273.6 ft³ ⇒ 10.1 CY

(1) F7.0 V = (7')(7')(2'4") = 112.7 ft³ ⇒ 4.2 CY

95 CY

• floor slab on metal deck
between column 5-6
$A = 26'(67') = 1742 ft^2$
$V = (2\frac{1}{2}'')(1742 ft^2) = 362.9 ft^3$
$\Rightarrow 13.4$ CY

• roof slab ⇒ none

<u>REINFORCING BARS</u>

4" SOG 6x6-W2.4xW2.4 W.W.R
⇒ $3484 ft^2$
6" SOG 6x6-W2.4xW2.4 W.W.R
⇒ $1742 ft^2$

footings.

F3.0	5, #5 E.W
	10 bars @ 2.75'/bar
F4.0	8 #5 E.W
	16 bars @ 3.75'/bar
F5.0	9 #6 E.W
	18 bars @ 4.75'/bar
F6.0	10 #7 E.W
	20 bars @ 5.75'/bar
F7.0	14 #7 E.W
	28 bars @ 6.75'/bar

Steel

Columns

A	W10x49 (2) @ 32'
	W10x33 (2) @ 52'
B	W10x33 (1) @ 16'
C	W10x33 (2) @ 32'
	W10x49 (2) @ 37.5'
	W12x65 (2) @ 55'
D	W10x33 (3) @ 48'
	W10x49 (2) @ 62.5'
E	W10x33 (4) @ 64'
	W10x49 (1) @ 42'

Beams

Main Level Framing

W18x40	8x26' ⇒ 208'	
W12x19	2x15' ⇒ 30'	
W18x35	2x26' + 18' ⇒ 76'	
W12x26		6'
W21x50	5x22'	110'
W16x26	22+26	48'
W14x22	2x6'	12'
W18x40		22'

LOW ROOF FRAMING PLAN

W12x26		26'
W16x40	1	25'
W 14 x 22	12x26'	312'
W 16 x 31	18+3(22)	84'
W 16 x 26		110'
W 12x19	2x26	52'
W 14x38	44+26	70'

SLOPED ROOF FRAMING PLAN

W18x35	26'
W24x55	22.5'
W12x44	22.5'

Support Joists

STEEL SUMMARY

	PIECES	ΣLENGTH	WEIGHT (TONS)
W10x49	7	200'	4.9
W10x33	12	215'	3.5
W12x65	2	63'	2.04
W12x19	4	82'	.78
W12x26	2	32'	.42
W12x44	1	23'	.51
W14x22	14	360'	3.9
W14x38	2	70'	1.3
W16x26	8	160'	2.08
W16x31	4	85'	1.32
W16x40	1	50'	1

BASE PLATES

BP-1 t = 3/4" A = 1 ft² A4, A5, A6, B3, C3, C4, D3, D4, E3, E4, E4.9

BP-2 t = 1" A = 1 ft² C4.9, C5, D5, D6, E5, E6

BP-3 t = 1 1/4" A = 2.56 ft² A4.9, C6, D4.9

BP-4 t = 2" A = 2.56 ft²

Appendix C

Structural Calculations

L = length $\quad K = .5$

$r_x, r_y \}$ from table 1.1 in Steel Manual

$$F_e = \frac{\pi^2 (29000)}{\left(\frac{.5(L)}{r_x \text{ or } r_y} \right)^2}$$

$$F_{CR} = .654^{\wedge}\left(\frac{50}{F_e}\right) \times 50$$

$$\phi P_n = F_{CR}(\phi)(\text{wt from } 1.1)$$

C8

$L = 49$

$K = .5$

$r_x = 5.31$ $r_y = 3.04$

$$F_e = \frac{\pi^2(29000)}{\left(\frac{.5(49)}{3.04}\right)^2} = 4406.69$$

$945.7 \geq 156.29$

C5

$L = 44$

$K = .5$

$r_x = 4.39$ $r_y = 2.57$

now W10x49
try W10x60

$$F_e = \frac{\pi^2(29000)}{\left(\frac{.5(44)}{2.57}\right)^2} = 3149.4$$

$.654^{\wedge}\left(\frac{50}{3149.4}\right) \times 50 = 49.6$

$\phi P_n = 49.6(17.7)(.9)$
$= 791.14$

$791.14 \geq 126.90$

D5

$L = 44$ $K = .5$

now 10x49
try 10x60

$r_x = 4.39$ $r_y = 2.57$

$$F_e = \frac{\pi^2 (29000)}{\left(\frac{.5(44)}{2.57}\right)^2} = 3149.4$$

$$.654^{\wedge}\left(\frac{50}{3149.4}\right) \times 50 = 49.6$$

$$\phi P_n = 49.6(17.7)(.9) = 791.14$$

$\phi P_n = 791.14 \geq 126.89$ OK

H5

$L = 44$

now W10x49
try W10x60

H9

$L = 51$
$K = .5$

now W12x65
try W12x72

$r_x = 5.31$ $r_y = 3.04$

$$F_e = \frac{\pi^2 (29000)}{\left(\frac{.5(51)}{3.04}\right)^2} = \frac{286218.5}{70.4} = 4065.6$$

$$.654^{\wedge}\left(\frac{50}{4065.6}\right) \times 50 = 49.7$$

$$\phi P_n = 49.7(21.1)(.9)$$

$= 943.8 \geq 100.36$ OK

H8

$L = 49$ now W12x79

$K = .5$ try W12x87

$r_x = 5.34$ $r_y = 3.07$

$$F_e = \frac{\pi^2 (29000)}{\left(\frac{.5(49)}{3.07}\right)^2} = \frac{286218.5}{63.7} = 4493.22$$

$$.654^{\left(\frac{50}{4493.22}\right)} \times 50 = 49.76$$

$$\phi P_n = 49.76(25.6)(.9)$$
$$= 1146.6$$

$1146.6 \geq 127.15$ ok

A4.9

$L = 17.5$ now W10x49

$K = .5$ try W10x60

$r_x = 4.39$ $r_y = 2.57$

$F_e = 24691$

$.654^{50/24691} \times 50 = 49.9$

$\phi P_n = 49.9(17.7)(.9)$

$= 795.8 \geq$ ok

A4

$L = 17$ $r_x =$ $r_y = 2.57$ now W10x49

$K = .5$ W10x60

$F_e = 26165$

$.654^{50/Fe} \times 50 = 49.9$

$P_n = 795.8$

Phi Pn	Column to use	Height	Column
945.82	W12x72	51	C9
945.7	W12x72	49	C8
791.14	W10x60	44	C5
791.14	W10x60	44	D5
791.14	W10x60	44	G5
791.14	W10x60	44	H5
943.8	W12x72	51	H9
1146.6	W12x87	49	H8
795.8	W10x60	17.5	A4.9
795.8	W10x60	17	A4
795.8	W10x60	17.17	C4.9
795.8	W10x60	17.17	D4.9
795.8	W10x60	17.17	G4.9
795.8	W10x60	17.17	H4.9
	W12x120	17.5	N5
	W12x120	17.5	N6

Appendix D

Fire Suppression Estimate

BASEMENT

Pipe Types: 1", 1 1/4", 1 1/2"
2 1/2", 3", ~~4"~~, 6"

1 1/4"; ✓5(9+9+10+10+10+2'4"+7'4"+10'+10')+
✓2(9+9+6'9 1/2"+10'+10'+5'10"+3'2"+8+8+12)+
✓2(12+4'1")+7'8"+7'8"+9'+9'+4'3"+10+10+5'10"
✓+3'2"+8'+3'10"+5'6"+2'6"+2(4'1 1/2"+12')
✓+2(10+5'2"+4'10"+8'6"+8'+8')+
✓2(10'+5'2"+4'10")+6'6+7'+2'3"+4'6"
✓+8'+5'+10+5'2"+4'10"+6'6"-1'8"+
6(~~8+8+8+10+8+~~3'5"+4'7"+10'+10'+10'+8)

1; 10'+6'8"+4'+5'2"+8'6"+3'6"+14'+4'6"+5'6"+
+4'7"+2'2"+7'+8'

3; 5'1"+13'+13+13+13+13+101'3"+52'6"

4; 5'1"+13'+13+13+13+13+75+10'10"+4(13)+11'8"+
9'8"+8'+5'1"+2'8"

2 1/4; 6'4"+48'11"+5'10"+6'4"+4'10"+34'8"

6; 58'9"+15'6"+22'4"

1 1/4"	1"	2 1/4"	3"
388.3	83.67'	106.91'	224.67'
+163.6			
95.6			
55.2			
88.98			
60.23			
41.16			
528			
1421.07			

4"	6"
245'	96.58'

FIRST FLOOR 1", 1 1/4", 2 1/4", 4", 3",

1"; √7'5½" + 6'7" + 6'1" + 7'5½" + 7'9" + 4'11" + 8+8
10 + 5'9" + 4'3" + 3(8 + 5'9" + 4'3") + 3(4'11") + 5'6" + 5'4"
√+ 4'8" + 4' + 2' + 3'6" + 6'2" + 8'2" + 2' + 4'4" + 9' + 1' + 5'8" + 9'4"
√+ 9'2" + 5'7" + 8' + 9'4" + 6'8" + 4'5" + 8' + 7'9" + 3'10" + 10'8" + 3'7"
√+ 9'8' + 5'7" + 10' + 8' + 3'4" + 2'2" + 8'2" + 12 + 4'8" + 5'4" + 6'8"
√+ 2'7" + 1'9" + (6'9" + 2'3")2 + 4'4" + 3(8' + 5'4") + 8' + 6' + 12'8"

1 1/4"; √2(10'6" + 10'6" + 10'6" + 10'6" + 3'6") + 7'10" + 13'
√6(13 + 5'7" + 7'5" + 13 + 12 + 13 + 13 + 9'1" + 3'11' + 13')
√2(13 + 5 + 8 + 13 + 12 + 13 + 13 + 8'6" + 4'6" + 13')
√2(8 + 9 + 10'6" + 9 + 6'3") + 6'8" + 10 + 10 + 6 + 8'8' + 12' +
√3'5" + 5'7½" + 3'2" + 2'1" + 6'6" + 6'6" + 2' + 9 + 5'1" + 5'4" + 2' +
√3'8" + 5'1" + 10 + 6'6" + 6'6" + 5'9" 3'9" + 13'6" + 13'6" + 9'9"
√+ 13' + 12'4" + 9'5" + 11'11" + 12 + 13'6" + 10'7" + 6'6" + 10' + 7' + 5'11"
√+ 9'9" + 11'10" + 12' + 13'6" + 13'6" + 9'2" + 4'3" + 13' + 12'6"
√+ 12'6" + 12'6" + 12'6" + 15 + 14 + 14 + 17' + 7'6" + 4'5" + 13' + 12'
√+ 13' + 12 + 12 + 13'6" + 13'6" + 8'2" + 4'6" + 13 + 12'6" + 12'6"
√+ 12'6" + 17' + 7'6" + 4'5" + 13' + 12' + 13' + 12' + 13' + 13'8" + 13'
√+ 9'2" + 4'4" + 13' + 13'6" + 12'6" + 12'6" + 12'6" + 7'10" + 7'9"
√+ 4'9" + 13' + 13' + 13' + 12' + 13 + 13'6" + 13'6' + 9'2" + 4'4" + 13
√+ 13'6" + 12'6" + 12'6" + 12' + 10'6" + 13' + 13' + 12'5" + 15' + 10

3"; √3 + 13 + 11'2" + 13 + 5'10' + 6'10' + 6'2" + 10' + 1'8" + 5'3" + 6'10" + 9'3"
√+ 2'9" + 6'10" + 2'9" + 6'10" + 6'11" + 4'7" + 6'4" + 6'9" + 3'3" + 6'1" + 8'11"
√+ 5'4" + 4'8" + 7' + 5'3" + 2'1" + 8'6' + 8 + 4'2"

4"; 4'8", 12'3", 5'2' + 57'9" + 14' + 49'1" + 5'4" + 2'2"

FIRST FLOOR (CONT'D)

2 1/4"; 8'6" + 5'5" + 9' + 9'6" + 9'1 1/2" + 1'4" + 9'2" + 3'10"
+ 10'4" + 5'6 + 7'10' + 21'9" + (9'7" + 3'8" + 2' + 14'1"
+ 13'1" + 13'1" + 13'1" + 14'1")2 + 10'6" + 9'10 1/2" + 3' + 1' +
5'9 1/2" + 9'10" + 3'1" + 5'9" + 12'7" + 4'10" + 2'7" + 2'10" + 9'10'
+ 2'7" + 2'7" + 3'8" + 5(13') + 9'7" + 2(3'8")

1"; (Cont'd) 4(10'6" + 5'10" + 5'1" + 10'7" + 1'3") + 9'11 1/2" + 11'11"
+ 3'7" + 8'5" + 10' + 10' + 8'5' + 3'7" + 7' + 3'11' + 3'1 1/4"
+ 6'3" + 13'11' + 2'3" + 7'3" + 2(11'11") + 12'7" + 10' 1/2"
+ 3'8" + 4'8" + 5'8" + 4'8" + 2'7' 11'11" + 10 + (12' + 11'6")6
+ 11'2" + 2'1" + 13' + 2'7" + 12'2" + 12'2" + 11'5" + 8'7"
+ 2'3" + 2'10' + 9'8" + 2(4'8") + 8' + 1' + 10' + 10' +
+ 10 + 10 + 4'8" + 12 + 7'8" + 8' + 5 + 5 + 3'8" + 9'9"
+ 4 + 4 + 5'6" + 4(3'9")

1 1/4"; 5(11'6") + 16 + 14'8" 7'8" + 5'5" + 8'4' + 9'3" + 16'3" + 9'5"
+ 5'1 1/2" + 7'3" + 3' + 9'3" + 5'1 + 4'10" + 9'4" + 3'8" + 4'10" + 4'2"
+ 3'8" + 4'4" + 10' + 4'4 + 9'8" + 16'7" + 11' + 16'9" + 4'4" + 9'3"
+ 9'3' + 13'3" + 6 + 3 + 4' + 4' + 5 + 12' + 7'6" + 10'2" + 4'2"
+ 6(13' + 5'7") + (13' + 5')2 + 2(10'6" + 10'6")
+ 2(13'11") + 4'2" + 3' + 2'8" + 3'4" + 6'2" + 11'11 + 2'10"
+ 3'8" + 3'7" + 6 + 12 + 10 + 6'6" + 10 + 10 + 10'6" + 4'5" + 8"
+ 2'4" + 2'1" + 8' + 3'5" + 4'3" + 11' + 2(12'6") + 3'4" + 9'2"
+ 9'9" + 11' + 12 + 13 + 3'2" + 8'3" + 14'11"
+ 15 + 10 + 4'7" + 10'4" + 2(12'6") + 6'2" + 8'4" + 11
+ 12 + 13 + 3'2" + 8'9" + 14'11" + 13 + 12'6" + 9'2" + 9'8" + 11
+ 12 + 13 + 3'2" + 6'9" + 14'11" + 12'6" + 14' + 9'1" + 12'8"
+ 9'2" + 9'9" + 11'6" + 11'6" + 13'3" + 8'1" + 8' + 4'5 + 10 + 11

FIRST FLOOR CONT'D

3"; 12'1" + 12'1" + 12'1" + 6'2" + 11 + 1'7' + 2'9" + 4'7"
+ 4'8" + 7'10" + 1 + 1'+ 5 + 4'7" + 11'11" + 12'4" + 3'1"
+ 9' + 11' + 2' + 2'7" + 24 9 3" + 2'9" + 10 + 6'9" +
5.3"

1; 5'6" + 9'8" + 4'9" + 5'2"

1 1/4; 5'10" + 11'11" 12'

2 1/4; + 18'11" + 7'4" + 3'

1"

148.06
59.82
76.99
73.57
93.25
154.8
58.02
76.10
184.14
73.14
53.09
104.26
25.08

1182.32'

1 1/4"

111.83
618
206
138.84
48.57
112.17
99.49
134.42
104.66
121.09
164.29
97.4
113.42
144.42
56.48
89.91
143.07
189.48
61.85
84.67

68.75
61.08
98.6
107.16
98.08
96.66
29.75

3394.14'

2 1/4"

55.82
245.04
57.06
90.75

29.25

477.92'

3"

89.98
61.99
44.99
62.06
42.41
60.58

362.01'

4"

150.4'

6"

22.33'

Ceiling Paint

Tannersvill Pa

Unit Cost Estimate

Quantity	LineNumber	Description	Crew	Daily Output	Labor Hours	Unit	Material	Labor	Equipment	Total	Ext. Total	Mat. O&P	Labor O&P	Total O&P	Ext. Mat. O&P	Ext. Labor O&P	Ext. Equip. O&P	Ext. Total O&P
19300	099123740880	Paints & Coatings, walls & ceilings, interior, concrete, drywall or plaster, zero voc latex, 2 coats, smooth finish, spray	1 Pord	1625	0.01	S.F.	$ 0.11	$ 0.18	$ -	$ 0.29	$ 5,597.00	$ 0.12	$ 0.27	$ 0.39	$ 2,316.00	$ 5,211.00	#REF!	$ 7,527.00
1	099123740880	Paints & coatings, walls & ceilings, interior, zero voc latex, for work 8'-15' high, add		0	0	S.F.	$ -	$ 0.02	$ -	$ 0.02	$ 347.40	$ -	$ 0.03	$ 0.03	$ -	$ 521.10	$ -	$ 521.10
Total											**$5944.40**				**$2316.00**	**$5732.10**	**$.00**	**$8048.10**

Braced
Frames

1

2

3

4

5

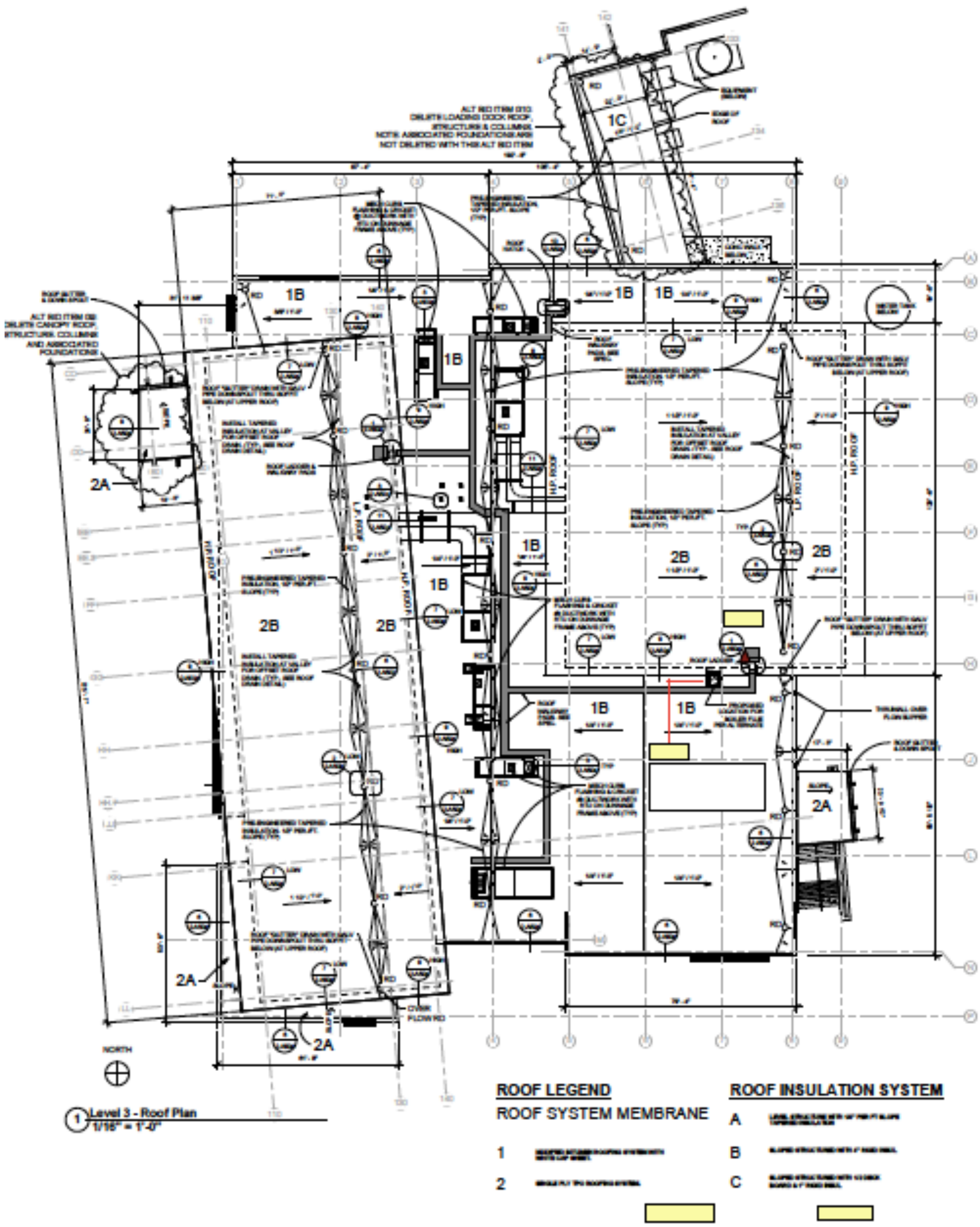
6

7

8

Appendix E

Roof Information



Roof Section	Roof Type	Length	Width	Area ft2
1	2B	225.58	51.2	11,549.70
2	2B	225.58	20.2	4,556.72
3	1B			6190
4	1B			7467
5	1B			4926
6	2B	120.5	25.07	3,020.94
7	2B	120.5	89.5	10784.75
8	2A			501
9	1B			940
10	1B			920
11	1B			770
12	2A			644
13	2A			440
				52,710.10

Roof Type	Roof Section	Area (ft2)
1B	3	6190
1B	4	7467
1B	5	4926
1B	9	940
1B	10	920
1B	11	770
	SUM	21213
2B	1	11549.7
2B	2	4556.72
2B	6	3020.94
2B	7	10748.75
	SUM	29876.11
2A	8	501
2A	12	644
2A	13	440
	SUM	1585

Current Roofing

Tannersville **Pa**

Data Release : Year 2011

Unit Cost Estimate

Quantity	LineNumber	Description	Crew	Daily Output	Labor Hours	Unit	Material	Labor	Equipment	Total	Ext. Mat.	Ext. Labor	Ext. Equip.	Ext. Total	Mat. O&P	Labor O&P	Equip. O&P	Total O&P	Ext. Mat. O&P	Ext. Labor O&P	Ext. Equip. O&P	Ext. Total O&P
21213	75216101100	SBS modified bituminous membrane, granule surface cap sheet, polyester reinforced, 160 mils, mopped	G1	2000	0.03	S.F.	$0.77	$0.96	$0.20	$1.93	$16,334.01	$20,364.48	$4,242.60	$40,941.09	$0.85	$1.59	$0.23	$2.67	$18,031.05	$33,728.67	$4,878.99	$56,638.71
298.76	75423100200	Thermoplastic Polyolefin Roofing, 60 mils, heat welded seams, fully adhered	G5	25	1.6	Sq.	$77.00	$53.00	$6.75	$136.75	$23,004.52	$15,834.28	$2,016.63	$40,855.43	$85.00	$88.50	$7.40	$180.90	$25,394.60	$26,440.26	$2,210.82	$54,045.68
21213	72216101946	Roof Deck Insulation, extruded polystyrene, 4" thick, R20, 25 PSI compressive strength	1 Rofc	1000	0	S.F.	$2.50	$0.29	$-	$2.79	$53,032.50	$6,151.77	$-	$59,184.27	$2.75	$0.49	$-	$3.24	$58,335.75	$10,394.37	$-	$68,730.12
29876.11	72216101932	Roof Deck Insulation, install polystyrene insulation, 4" thick, R20, 15 PSI compressive strength	1 Rofc	1000	0	S.F.	$1.52	$0.29	$-	$1.81	$45,411.69	$8,664.07	$-	$54,075.76	$1.67	$0.49	$-	$2.16	$49,893.10	$14,639.29	$-	$64,532.40
15.85	75423100200	Thermoplastic Polyolefin Roofing, 60 mils, heat welded seams, fully adhered	G5	25	1.6	Sq.	$77.00	$53.00	$6.75	$136.75	$1,220.45	$840.05	$106.99	$2,167.49	$85.00	$88.50	$7.40	$180.90	$1,347.25	$1,402.73	$117.29	$2,867.27
Total											**$139,003.17**	**$51,854.65**	**$6,366.22**	**$197,224.04**					**$153,001.75**	**$86,605.32**	**$7,207.10**	**$246,814.18**

Proposed Roof Estimate

Tannersville **Pa**

Data Release : Year 2011

Quantity	LineNumber	Unit	Material	Labor	Equipment	Total	Ext. Mat.	Ext. Labor	Ext. Equip.	Ext. Total	Mat. O&P	Labor O&P	Equip. O&P	Total O&P	Ext. Mat. O&P	Ext. Labor O&P	Ext. Equip. O&P	Ext. Total O&P
52711	075216102000	S.F.	$0.77	$1.52	$0.32	$2.61	$40,587.47	$80,120.72	$16,867.52	$137,575.71	$0.85	$2.53	$0.36	$3.74	$44,804.35	$133,358.83	$18,975.96	$197,139.14
51126	072216101932	S.F.	$1.52	$0.29	$0.00	$1.81	$77,711.52	$14,826.54	$0.00	$92,538.06	$1.67	$0.49	$0.00	$2.16	$85,380.42	$25,051.74	$0.00	$110,432.16
Total							**$118298.99**	**$94947.26**	**$16867.52**	**$230113.77**					**$130184.77**	**$158410.57**	**$18975.96**	**$307,571.30**

Appendix F

Industry Research

Survey

Using an online survey;

1. Choose your most preferred delivery method.
    a. Design Build
    b. Design Bid Build
    c. Design at Risk
2. Choose your most preferred contract type.
    a. Lump Sum
    b. Guaranteed Maximum Price
3. In your career, approximately what percent of your projects have ben Design-Bid-Build?
    a. 0%
    b. 25%
    c. 50%
    d. 75%
4. In your career, what percent of your projects have been CM at risk?
    a. 0%
    b. 25%
    c. 50%
    d. 75%
5. In your career, what percent of your projects have used multiple prime contracts
    a. 0%
    b. 25%
    c. 50%
    d. 75%
6. Approximately what percent of your projects have been design-build?
    a. 0%
    b. 25%
    c. 50%
    d. 75%
7. Who do you feel benefits the most from a lump sum contract? Briefly explain.

8. Who do you feel benefits the most from a GMP contract? Briefly explain.

Please choose the answer that best describes your role in the construction industry. Also, how many years have you been in the industry?

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