Thesis Final Paper

University Medical Center of Princeton

Plainsboro Road, Township of Plainsboro, New Jersey

David Bodnar CM
Chris Magent
4/7/2010

David Bodnar CM
University Medical Center at Princeton Replacement Hospital
Plainsboro, NJ

Owner: Princeton HealthCare System
Architects: HOK/RMJM Hillier – A Joint Venture
Construction Manager: Turner Construction Company
Cost: $321 Million Overall
Dates of Construction: March 2009 - March 2012
Project Delivery Method: Traditional
Size: 209,525 square feet
Stories Above Grade: 7 stories / 121 ft

Architecture

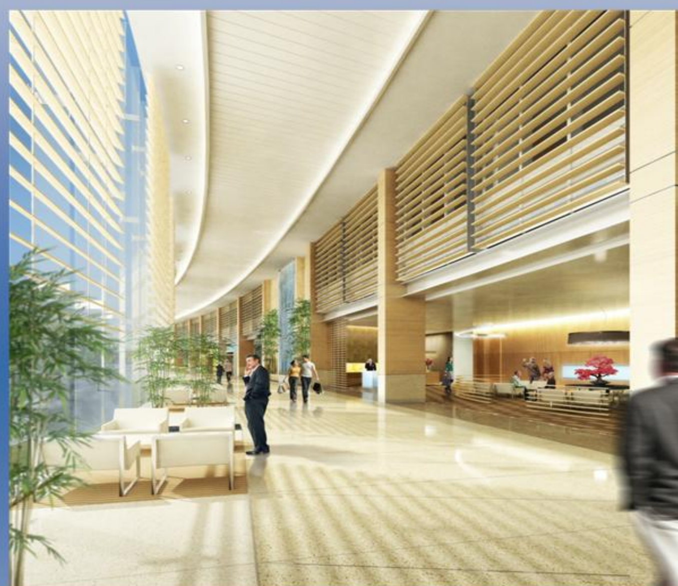
- Curtain wall system for exterior of building especially in south entrance
- Masonry used on exterior
- State of the art facilities
- Interior renovation done to existing Building #2

Structure

- Superstructure: Structural Steel Framing
- Substructure: Cast in Place Concrete footing and foundation walls for the foundation
- Floor and Roof: Cast in Place Concrete on Composite Steel Deck
- Roofing System: EPDM membrane

MEP

- 17 Air Handling Units with 11 of them being 100% outside air
- Standpipe sprinkler fire suppression is to be used in the building
- The building uses a diesel engine emergency generator
- Interior lighting is mostly fluorescent lighting fixtures



http://www.engr.psu.edu/ae/thesis/portfolios/2010/djb5038/index.html

Table of Contents

Appendix

Acknowledgements

I would like to thank these fallowing people for their help over this past year in helping me make this project possible

Turner Construction

Chris Auer, Project Manager

Princeton HealthCare Systems

Penn State Faculty

Professor Chris Magent

Professor Robert Holland

Professor Kevin Parfitt

Serious Materials

Superior Walls

Fellow Penn State AE Students

Justin Harzing

Stephen Perkins

Zachary Yarnall

Brett Robinson

Last I most importantly would me my family and my friends who helped me to keep moving forward and to never give up on your dreams.

Executive Summary

This document is a technical analysis on the University Medical Center of Princeton. Background information on the building is provided along with information about the owner, local conditions, building systems, structural estimate, and general conditions estimate. The building itself is a $321 million overall project in Plainsboro, NJ. The University Medical Center of Princeton has four different building being constructed or renovated at once. The main focus of this thesis and of all of the analytical topics is in affect of the Bed Tower.

There are four analyses all with a main focus on sustainability. The first analytical topic is a more efficient curtain wall system by changing the windows for a better U-value. The second analytical topic is implementing a greywater system and looking at the benefits of recycling greywater. Third analytical topic is looking at the comparison between using a cast in place concrete foundation wall system that is already in place as opposed to using a pre-cast foundation wall system. The last analytical topic was looking at green roofs and the benefits of implementing a green roof on the project.

Introduction of Building

The new University Medical Center of Princeton Replacement Hospital is owned by the Princeton HealthCare System. The new hospital is to be built in Plainsboro, NJ, with the architects being a joint venture between HOK and RMJM Hillier and the construction management team being Turner Construction Company. The project is to have a traditional delivery method with a cost of $321 million and construction is to be from March 2009 – March 2012. The building is to be constructed in five segments, Central Utility Plant (CUP), Diagnostic and Testing building (D&T), Bed Tower West (BTW), Bed Tower East (BTE), and Building #2 (Bldg. #2). The project is to be a size of about 209,525 square feet with main focus on the building will be the two bed towers (BTE and BTW) which is seven stores and approximately 121 feet high. Building #2 will be renovation with some minor demolition to the interior.

Figure 1 - Building Segments

Client Information

Princeton HealthCare System is the owner of the University Medical Center of Princeton. This project is a relocation project for new space for more advanced medical service, better access for patience, and overall more room for growing community. Another major reason for relocation is so that there is no disruption during the construction process since the old hospital would still be in used during the construction of the new hospital. Since this is a relocation project the only sequencing that the owner had to worry about is with Building #2. Building #2 will still be in used when construction starts and renovation will not begin till after nine month after the noticed to proceed date. I should also be noted that the owner is saving tremendous amount of money renovating Building # 2.

According to the Princeton HealthCare System their project mission for the University Medical Center of Princeton is

"Princeton HealthCare System will bring together compassion, clinical expertise and technology to provide outstanding care and value to the community we serve. By creating a culture of excellence among those who serve our patients, we will ensure that each patient has the best possible experience. We will create and maintain a safe, state-of-the-art teaching and healing environment that is visually pleasing, sophisticated and ecologically responsible."

Overall Princeton HealthCare System is hoping to develop a state-of-the art medical center that is top in the country for patient satisfaction, technology, and overall patient services. From my observation of looking into the Princeton HealthCare System I fell that these goals are most important aspects of the project for the Princeton HealthCare System.

Local Conditions

The site of the new University Medical Center of Princeton will be built on a new site that will be redeveloped. The site that is being redeveloped is the FML facility in Plainsboro Township, NJ. For the new hospital all of the existing building except for Building #2 will be removed to build the new hospital. Below is an existing aerial view of the site. It should be noted that the building to the right is Building #2 and is circled in Figure 1 below.

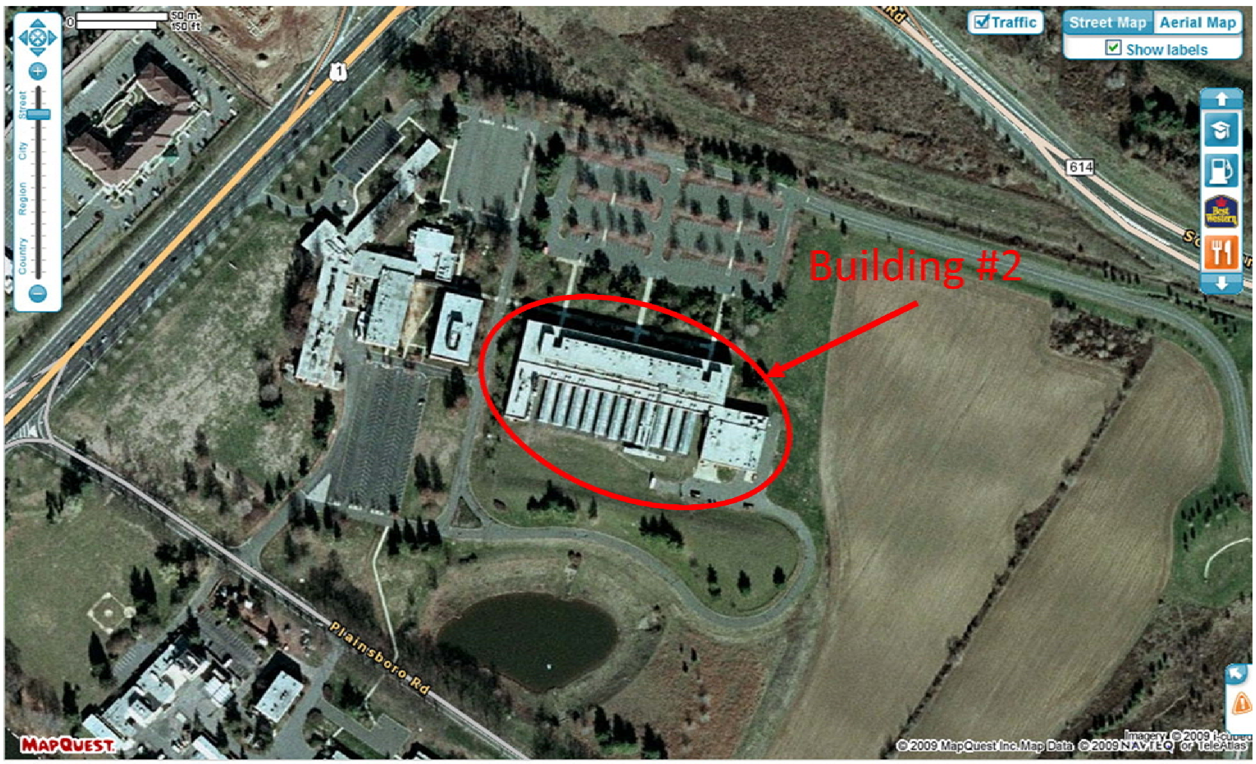


Figure 2 - Arial View of Site before Construction

According to the Geological Map of New Jersey the native soil of the area is a surface layer of sandy silts and silky sands with a bedrock of sandstone and shale bedrock that has a depth ranging from anywhere for 5 to 50 feet in the area. On this site it was found that the bedrock was at a depths ranging from 6 to 18 feet. It should also be noted that groundwater on the site was encountered around a depths of 15 to 19 feet.

Building Systems and Construction Summary

Foundation:

The foundation of the building on all stages outside of the renovation to building #2 will consist of using cast in place concrete. After the footing is excavated, cast in place concrete will be use to create the footings and the foundation walls. The foundations will be done in four phases with the Central Utility Plant being first, Diagnostics & Testing Building second, Bed Tower West third and last Bed Tower East. All four phases fallow the same procedure of footing excavation, prep and pour footings, prep and pour foundation walls, survey anchor bolts, and last cure foundation walls.

Structure:

The construction of the structural steel framing is to be type 2, simple framing with composite steel decking for slabs. Most structural steel is to be connected with high-strength bolts, nuts, and washers and a shear connection. Most of the columns are to be W12x79 and W14 with no typical length. For the beams and girders there is no typical size except that most of the beams are W24 or W21 and the girders are W16 or W12. Cast in Place Concrete is going to be used for the footings, foundation walls, slabs on grade, and suspended slabs. The footing is to be a shallow foundation with soil bearing pressure being 8,000 psi or 4,000 psi. Slab on grade should have a depth of either 5" or 12" over 6" crushed stone. Forms for the concrete should be exterior-grade plywood panels. For the bed tower there are two cranes erecting the structural steel. The first one is a Manitowoc 999 (200 ton) and the second one is a truck type crane (140 ton).

Finish:

The finishing of the building started with mechanical system being installed in the ceiling with sprinkler mains fallowing. After that plumbing, electrical and the sprinkler mains fallowed. The partitions where not completed till after all of the MEP was in place and HVAC inspected, the only exception being the door frames since they were installed after the sprinkler mains.

The low voltage systems would begin most of their work after the partition framing when the cable trays where installed. The work for the finish was phased just as it was for the foundation and structure the only difference is that Building #2 is included because of interior renovation. After substantial completion punch list and commissioning is done on all 5 phases of the building.

Demolition:

There is demolition of two buildings on site, and demolition is required inside Building 2 for interior renovation which will include the removal of MEP, roofing on 1st, 2nd, and roof, and interior. Demolition will require a refrigerant recovery technician to remove refrigerant from site. Demolition is to be done from the top floors down. All materials that are not to be reused or recycled must be hauled off site to an EPA-approved landfill.

Mechanical System:

The mechanical system consist of 17 air handling units, 5 in the basement of west and east M.E.P. room, 2 on the 2ed floor of D and T M.E.P. room, 3 in the penthouse, and 8 on the roof of the tower building. Of the 17 air handling units 11 of them are 100% outside air systems to keep fresh outdoor air circulating into the hospital. The other 6 used a mix of outdoor and indoor air because they are in none critical areas like offices, basements, and ets. Fire suppression system is a standpipe sprinkler with fire hose stations in stairwells of every floor with full cover of floor.

Electrical System:

The electrical system is a dry type transformer with 480/277v, 3-phase, and 4-wire with grounded neutral primary for power for mechanical systems and lighting and a 108/120V, 3-phase, 4-wire with grounded neutral secondary for power and appliances. The building is serviced by 13.kv, 3-phase, 3-wire with grounded neutral and the emergency generator is a diesel engine generator.

Masonry:

Masonry is a basic veneer with ties and anchors used for exterior. The scaffolding is metal pole like scaffolding.

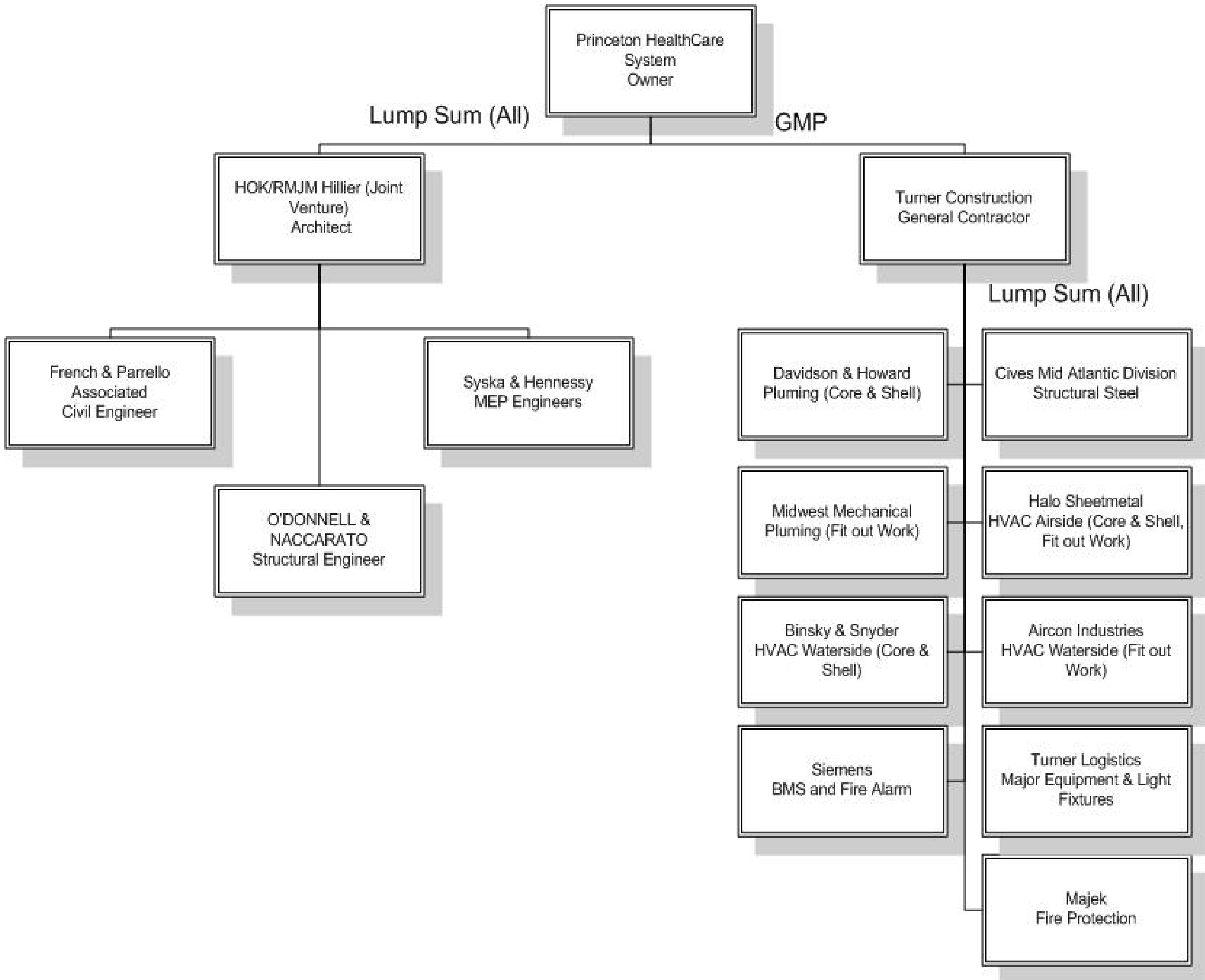
Curtain Wall:

The curtain wall system consists of aluminum windows, metal insulated panels and sunshades, the windows are also insulating glass. The curtain wall is a major component in the south entrance of the new building as you have seen from the cover of the report.

Support of Excavation:

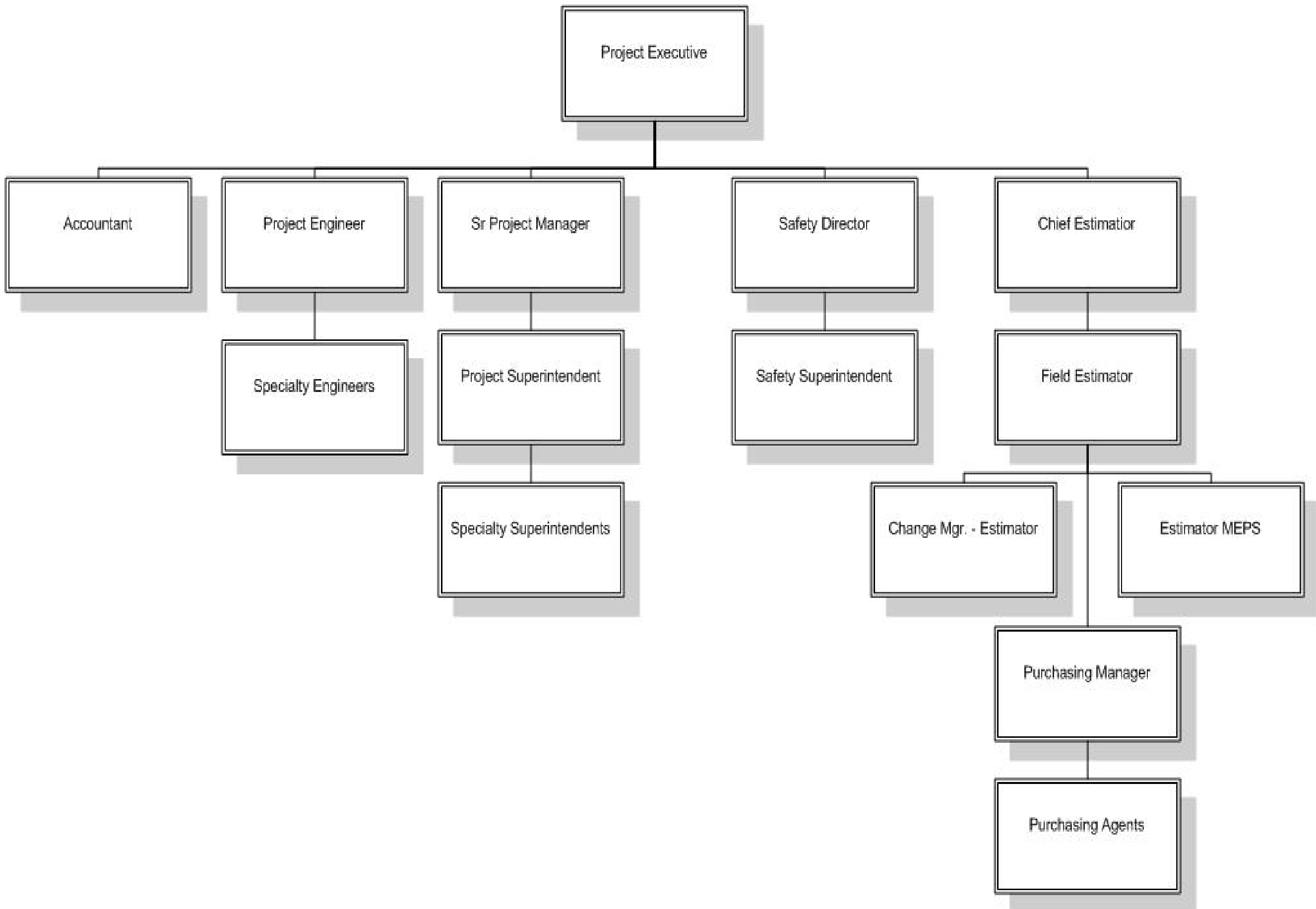
Excavation will be supported with steel piles and wood lagging with nominal rough thickness of 3 inches. Dewatering systems is to be placed on an as need bases to protect excavation and surrounding environment. All of this is temporary and removed from site when finished or not need anymore.

Project Delivery System



The project delivery system for the University Medical Center of Princeton is a traditional design-bid-build method. The owner holds a GMP contract with the Turner who is the General Contractor; because this is a traditional design-bid-build delivery method all of the Subcontractor's contracts are held by the General Contractor. The advantages of using this method is that Princeton HealthCare Systems can have a set price before construction starts and allows the owner to not have to be actively involved in the construction on a day to day bases because the General Contractor is responsible for the work of the Subcontractors. Contractors where selected on a lowest bid and the MEP has been split between core and shell and fit out with the HVAC being broken down even father to sheet metal ductwork and fans from HVAC piping. On the project Turner holds a builder's risk and liability insurance with the Subcontractors holding liability insurance. Turner also has a performance bond and serenity bond.

Staffing Plan



For the staffing plan on the project the Project Executive sees over the whole project but the Sr. Project Manager is on the site at all times. The Project Superintendent on the job looks over trade specific Superintendents, like Structural Superintendent, Interior Superintendent, MEP Superintendent, Mechanical Superintendent, and est. The trade specific Superintendents are only on the site when they are needed. The Project Engineer also has trade specific engineers that are on site as need for their specific trade. The Purchasing Manager has eight Purchasing Agents the work under him to.

Detailed Structural Systems Estimate

The structural system consists of a steel superstructure and a cast in place concrete structure. The takeoff is focused mainly on the bed tower with the total cost steel and concrete coming out to be $9,678,898.46. All of the cost are from RSMeans cost data 2009, and the steel and concrete takeoff where both done by hand. Please view appendix for complete breakdown of the structural systems estimate.

There are a few assumptions for the concrete estimate. The first the aside from the elevated slabs that are place with crane and bucket the rest of the concrete is placed with a direct chute not over 6" deep. There is also different strength of concrete for the footings and walls, slab on grade and slab on metal deck. 3,000 psi is to be used for spread footing, strip footing, retaining walls, and foundation walls. 3,500 psi is to be used for slab on grade and 4,000 psi for slab on metal deck.

General Conditions Estimate

General conditions estimate was done using RSMeans cost data 2009. The general conditions estimate is broken down in to 4 subcategories, personnel, temporary utilities/facilities, insurance and bonds, and general requirements. The total general conditions cost is $26,084,125.50 where personnel cost is $5,305,985.00, temporary utilities/facilities cost is $242,496.00, insurance and bonds is $16,435,200.00, and general requirements is $4,100,444.50. If going by schedule the project is to take 3 years, 36 month, or 148 weeks to complete. With the personnel the project executive is only on the job 75% of the time. Temporary Utilities/Facilities the office trailer is assumed to be 32'x8' and the portable toilets are chemical. The insurance and bonds use the maximum percentage for the job. General requirements there are two cranes a crawler crane (200 ton, 70' boom) and a truck mounted mobile crane (150 ton, 18' radius). The dumpster is 30 C.Y. 10 ton capacity, fence chain rented 6' high, and temporary access roads that are 4" deep. Please view the complete general conditions estimate in appendix for more details.

Analysis I – Efficient Curtain Wall

Background Information

Figure 1.1-South Entrance of University Medical Center of Princeton

The University Medical Center is designed with the front entrance of the building being a giant curtain wall system as you can see in Figure 1. The front entrance face of the building faces south making the curtain wall visible to the maximum amount of sunlight possible. The windows on the curtain will then have a huge affect on the building in terms of heating and cooling loads. The U-value of the window could greatly affect the heating and cooling loads on the building and also affect the energy efficiency on the building. A window with a lower U-value is good for sustaining heat which is important in a hospital during the winter mouth. It is important though that the new window does not change in size due to constructability challenges and possible schedule modifications due to change in window size.

Goals

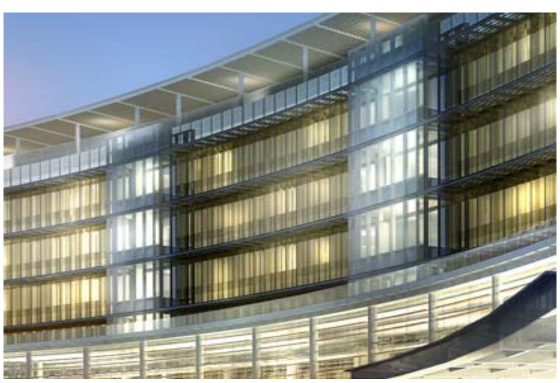


Figure 1.2- Windows on Curtain Wall

The main focus behind this analysis will be to find a different kind of window that has a lower U-value than the one that is already in place. The window will hopefully add more solar heat to the building and also work as a better insulator. It would be good to also find a window that blocks out harmful UV rays, since this is a healthcare facility this could be very important in protecting patience along with better comfort. Another thing that will be very important is finding a new window that does not require any changes to the rest of the building or affect the constructability of schedule of the project besides possibly downsizing the mechanical system. Overall I hope that the new windows will decrease the mechanical load and increase energy savings.

Window Comparisons

The original window that is to be installed is Viracon Solarscreen Radiant Low-E (VRE) Insulating Glass (VRE 1-46). The winter and summer U-Values on this type of window is 0.3 Btu (hr x sqft x ˚F) and 0.27 Btu (hr x sqft x ˚F). The window that I am is a Super-Insulating Serious Windows (SG 7 64/49-100) which has winter and summer U-Values as 0.3 Btu (hr x sqft x ˚F) and 0.27 Btu (hr x sqft x ˚F) respectfully. The chart below gives a comparison of the two products.

Window Comparison		
	Serious Windows (SG 7 64/49-100)	Viracon (VRE 1-46)
U-Value		
Winter	0.15	0.3
Summer	0.16	0.27
Shading Coefficient	0.56	0.33
Relative Heat Gain	115	69
SHG (Solar Heat Gain)	0.49	0.28
LSG	1.31	1.53
Transmittance		
Visible	64%	43%
Solar	36%	23%
UV	1%	16%
Reflectance		
Visible Light - Exterior	13%	34%
Visible Light - Interior	14%	15%
Solar Energy	23%	40%

Table 1.1 - Window Comparison

U-Value – Measure of the rate of non-solar heat loss or gain through the window. The lower the U-value the better the window is at resisting heat flow and is a better insulator. The lower U-value is better for in the cooler climates.

Shading Coefficient – Measure of the windows ability to transmit solar heat. The lower the shading coefficient means that less solar heat it transmits.

Relative Heat Gain - Measurement of heat gain through a window.

Solar Heat Gain – Measurement of how well the window will block heat from the sun. The higher SHG is better for northern climates due to better heating in the winter.

LSG (Light to Solar Gain) – This is the measurement of solar hear gain over visible transmittance. The higher the LSG is the better it is for warmer climates.

Transmittance – The measurement of the amount of light that transferees through the window.

Reflectance - The ratio of reflected to incident radiant energy.

As you can now see from the chart above is that the Serious Glass (SG 7 64/49-100) windows are far more efficient in heat gain and insulating for this building in New Jersey where there a cold winters. Since this is a hospital is very important that patience rooms stay warm during the winter mouth and the Serious Windows (SG 7 64/49-100) windows can help lower heating cost without affecting the temperatures of rooms. The Serious Windows (SG 7 64/49-100) is also a common 1" double pane glass package just like the Viracon (VRE 1-46) glass which means that there will be affect to the constructability or schedule of the project. Another thing that the Serious Windows benefits at is that it is better a blocking away harmful UV rays from the sun. Serious Windows block up to 99.5% of UV rays that come from the sun that could be harmful to the patients. The better U-value from Serious Windows is not the only benefit from using Serious Windows. According to Serious Windows web site, Serious Windows has energy savings of up to 32%. Serious Windows also have a payback of the upfront cost in as little as up to 1-2 years and an average 30 years savings of up to $17 million. There are potential for LEED points with Serious Windows.

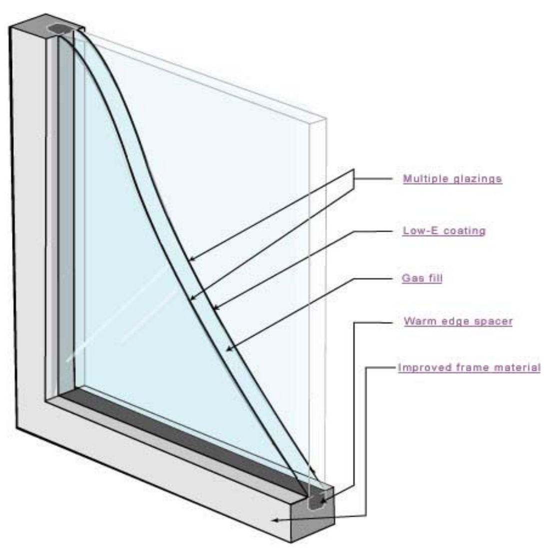


Figure 1.3 - Double Pane Window

Mechanical Loads

The change in the U-value will change the total load on the building. Calculations are done on a single patient room that is about 13 feet by 22 feet. The windows in the room are to be 4' x 6' along the curtain wall. The change in the load in a patient's room will be done by finding the difference in the load due to the change in the window during the winter design conditions and summer design conditions. The summer design condition for New Jersey is to be 92°F and the winter design condition for the winter in New Jersey is 10°F. Room temperature is to be around 70°F and the area of the windows is 24 feet squared with 3 windows per room.

Figure 1.4 - Patients Room

The equation that is to be used to calculate the loads is below.

$$Q = U\,(A)\,(T_{out} - T_{in})$$

Winter Loads

Viracon

0.3(72) (10 – 70) = 1296 BTU per Hour

Serious Windows

0.15(72) (10 – 70) = 648 BTU per Hour

Total Winter Load Saving

1296 – 648 = 648 BTU per Hour

Summer Loads

Viracon

0.27(72) (92 – 70) = 427.68 BTU per Hour

Serious Windows

0.16(72) (92 – 70) = 253.44 BTU per Hour

Total Summer Load Saving

427.68 – 253.44 = 175.24 BTU per Hour

From these calculations you can see that the Serious Windows is far better at insulating heat and cooling loads as the cooling load and heating load where decreased by almost 50% if Serious Windows (SG 7 64/49-100) is used as opposed to Viracon (VRE 1-46).

Cost Savings

Since the windows are roughly the same price (around ≈$8.00 per square foot for both Viracon and Serious Windows) and there is no change in constructability and schedule. The saving from this product will come from the savings in the mechanical system and energy cost. Due to the change in the loads from the change in the systems the mechanical systems could be downsized by 50%.

SeriousWindows™
SAVES MORE ENERGY THAN ANY OTHER WINDOW. PERIOD.

With the cost of the mechanical equipment right now being around $19 million dollars with the Viracon (VRE 1-46). The cost savings from using Serious Windows (SG 7 64/49-100) could be almost around 10 million due to the decrease in the load. The better insulation from the Serious Windows well definitely decreases the size of the mechanical system causing there to be great mechanical and electrical savings.

Recommendation

Serious Windows is definitely the way to go on this project. The U-value decrease definitely is a cost savings idea on the mechanical system also on energy savings. The insulation of the Serious Windows definitely makes Serious Windows more attractive than Viracon. The Serious Windows package is also good in providing UV protection which is very important in a hospital. Since there is no change to the schedule or the constructability of the building it is a good choice to possible use Serious Windows on the Curtain Wall and also maybe in the entire building.

Analysis II – Greywater System

Background Information

There are a few sustainable design ideas that the design team for the University Medical Center of Princeton Replacement Hospital did not take into consideration for this project. On area of sustainable design that the design team did not look into outside of energy and material savings is greywater treatment system. Greywater treatment systems are becoming very popular and are a good way to recycle water. What greywater treatment systems will do is take the used water from kitchen, bath, and laundry and recycle it for landscape irrigation or even HVAC systems.

Figure 2.1 - Landscape Irrigation

Since this is a health care facility it is wise that this water only be used for irrigation of the landscape on site or HVAC system. Using the greywater from the kitchen is also a better and safer alternative then using water from patience sinks, showers, and laundry do to the potential of contamination of human waste. Something to keep in mind with greywater is that it should not be used for as drinking water due to health hazard, especially in a healthcare facility.

It is already known that a greywater system will not have an effect on the schedule or constructability of the project since it will have no bearing on the critical path of the schedule. The only cost analysis on the greywater system will be how much it cost up front and what it saves in terms of sewage cost and some water usage.

Goals

The main focuses behind this analysis is to better understand the benefits of a greywater treatment system and to implement a low cost water treatment system that will be used to irrigate selected areas of the landscape. The desire most of all is to find a way to recycle some of the water that is used in the building (mainly the kitchen) to be reused for plant water or HVAC system use. One thing that will need to be found is a good area for plant irrigation and there is hope that and greywater treatment system will help cut down on sewage expenses and some watering expenses on landscaping.

What is Greywater?

Greywater is waste water that comes from the uses of laundry, dishwashing, sinks, and bathing. Greywater is different from blackwater in the since that blackwater comes mainly from the toilet. The real difference though between the two is that blackwater takes longer for pollutants to decay, making it harder to purify the water. Most of the time greywater and blackwater are combined at the sewer where they are treated under the same system. As you can see on the chart below there is a breakdown of what sources supply greywater and the percentage of containments are in each greywater and blackwater (Potassium, Nitrogen and Carbon Dioxide). The high traces for Nitrogen that are found in blackwater is what makes it harder to treat do the more time it takes to decompose Nitrogen from the soil.

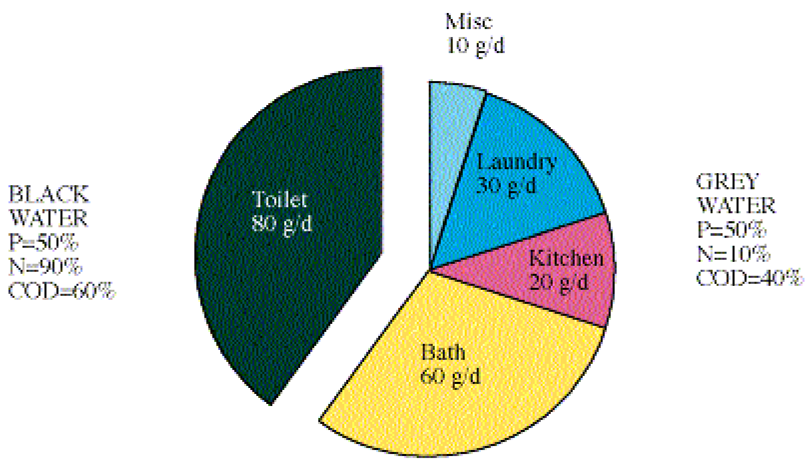


Figure 2.2 - Greywater & Blackwater

An efficient way of dispose of greywater is to use it to irrigate plans. The contents from the greywater can be use as nutrients for plants.

Greywater System Used and Placement

Greywater from the kitchen will be the focus for the system, due to the chances of limited contamination of blackwater to the water coming from the kitchen. Greywater can be contaminated in the laundry and bath by body waste that will make the water more like blackwater. Below is a drawing of a typical greywater system that will be put in place.

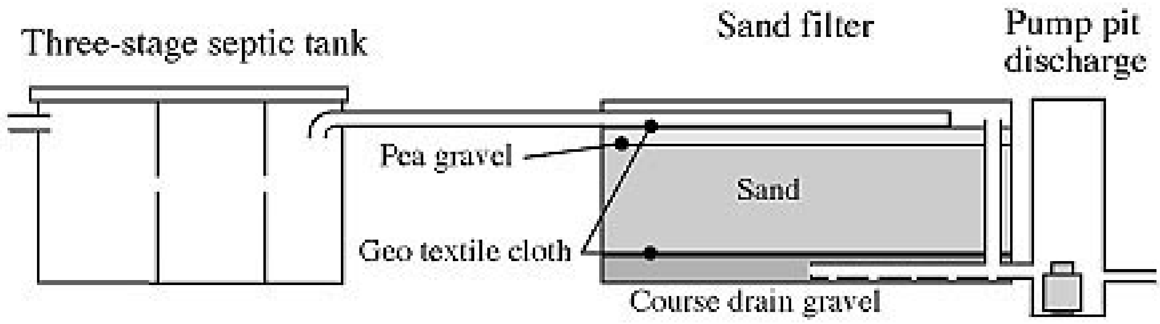


Figure 2.3 - Greywater System

The system above is an anaerobic to aerobic pre – treatment system. This system is best used for kitchen water because it's best for breaking down cooking greases and food residue that is mixed in with the water. This system is broken up into three parts, three part septic tank/grease trap, sandfilter, and pump pit. The three part septic tank/grease trap separates the sludge and grease with the water leaving the septic tank to be anaerobic (minerals in the water are broken down with no oxygen). The greywater will then enter into the sandfilter where the greywater is then turned into aerobic conditions (minerals in the water are broken down with oxygen). The last phase is the pump will pump the water to a planter bed for near potable treatment.

One of the few problems with implementing a greywater treatment system is that even though a majority of the system is underground (septic tank/grease trap, sandfilter, and pump pit) the planter bed for the treatment must be above ground. Below is a drawing of the possible areas that could be used for the treatment system.

Figure 2.4 - Areas for Greywater Treatment System

These three spots would be best in my opinion for the location for the greywater treatment system because the systems would be away from the hospital. Which is best for keeping contaminates from getting into the hospital and from containments from the hospital entering getting into the system. It should also be noted that even though the septic tank/grease trap, sandfilter, and pump pit are underground there must still be access to them which would make these areas perfect for it.

Greywater System Cost

With the implementing of a greywater system there is no savings with the direct cost, but the system should be able to pay itself off over time. The greywater system that would be put in place is to cost approximately $4,232.00 that covers the cost of the materials and the installation of the greywater system. The only thing that this does not cover is the cost of the maintenance of the system. According to a study done by EPA (Environmental Protection Agency) on water use in health care facilities it states that the average kitchen area for a hospital uses on average about 478 gallons of water a day. This is only about 9% of water used in a health care facility.

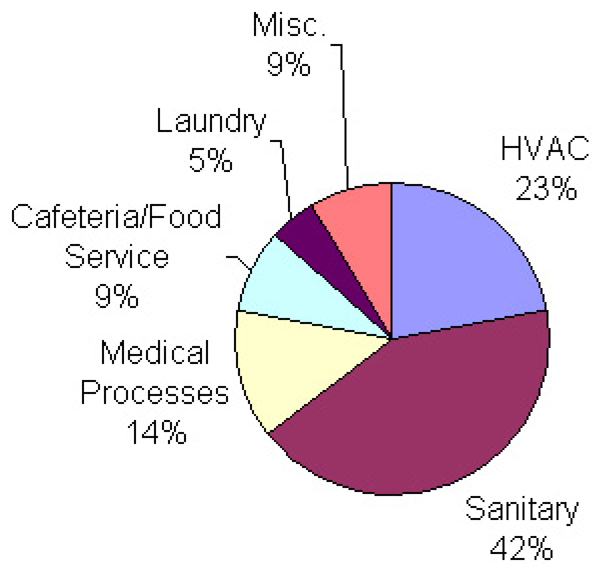


Figure 2.5 - Water Use in Hospitals

The average cost of water in New Jersey is $0.02 a gallon and the swear cost in New Jersey is to be $2.18 for every 1,000 gallon. Using this I can find how long it will take for the system to pay itself off.

$$\frac{478\ gallon}{1\ day} \times \frac{\$\ 2.18}{1{,}000\ gallon} = \$1.04\ a\ day\ for\ sewage$$

$$\frac{478\ gallon}{1\ day} \times \frac{\$\ 0.02}{1\ gallon} = \$9.56\ a\ day\ for\ tap\ water$$

$$\$1.04 + \ \$9.56\ = \$10.60\ a\ day\ for\ overall\ water\ cost$$

$$\frac{\$4{,}232\ for\ greywater\ system}{\$10.60\ water\ cost\ a\ day} = 399\ days \approx 13.5\ month$$

The system will then pay itself off in 13.5 month, which could be very good for cost savings down the line.

Recommendations

I personally feel that a greywater system is a very good idea for this project. The system pays for itself in little over a year and is a very good sustainable idea. The use of the system is good for landscape irrigation and HVAC cooling. The only negative thing about the system is the initial upfront cost of greywater treatment system. Overall the positives of implementing a greywater system ultimately outweigh the negatives of the system.

Analysis III – Precast Foundation Wall System

Background Information


Figure 3.6 - Pre Cast Foundation Wall Being

The foundation walls are a critical part to the overall construction of the building due to the fact that the construction of the foundation walls lay on the critical path of the schedule. A change in the construction of the foundation walls could impact the construction schedule either positively or negatively. That why it's very reasonable to look at pre-cast foundation wall system for the potential of schedule acceleration on a project, because like I always say time is money. Not only can pre cast foundation walls be looked at as a means of schedule acceleration, it can be a way to reduce construction waste on site from formwork due to being manufactured off site.

Goals

The focus behind this analysis is to look at the cost comparisons for the use of a pre cast foundation wall system compared to a cast in place foundation wall system. Cost analysis will be done to look at the comparison of materials used, labor, and equipment. The possibility of schedule acceleration due to the construction of a precast foundation wall system to a cast in place concrete foundation wall will also need to be analyzed. The advantages and disadvantages of using pre cast foundation walls will be looked at along with the sustainable advantages.

Type of Precast Foundation Wall

The pre cast foundation wall that I am planning on implementing into this project is the Superior Wall Xi Foundation System. The Xi foundation system is one of the best pre cast foundation systems on the market today. Superior Walls are mainly used for home residential but could also be use for commercial purposes. The concrete that is used in Superior Walls can reach strength of up to 5000 psi and are also protecting against water penetration. Superior Walls also have the ability to be insulated up to R-50 and meet the Energy Conservation Code Requirements. The insulation that is in a Superior Wall is 2-1/2" Dow® extruded polystyrene insulation, 1" foam insulation on bond beams and 1" foam insulated concrete studs. In the appendix there is a broacher of the Superior Walls Xi Foundation System that is being proposed to install instead of a cast in place foundation wall system. Constructability will not be a problem with Superior Walls since all wall panels will be manufacture to owners specifications.

<u>Cost Analysis on Construction</u>

The cost are different in the uses of cast in place concrete foundation walls and precast foundation wall systems. The first cost that was looked at was at how much the current system that is being put in place cost (cast in place concrete foundation wall). The cost of concrete, placement, formwork, and rebar where calculated. All of the data for these estimates came from RSMeans.

Cast in Place Wall									
	Quantity	Units	Materials Cost	Materials Total	Labor Cost	Labor Total	Equipment Cost	Equipment Total	Total
3000 psi Concrete	2,600	C.Y.	$101.00	$262,600.00	$0.00	$0.00	$0.00	$0.00	$262,600.00
Placement Direct Chute	2,600	C.Y.	$15.85	$41,210.00	$0.52	$1,352.00	$16.37	$42,562.00	$85,124.00
Formwork	81,880	S.F.	$1.49	$122,001.20	$6.50	$532,220.00	$7.99	$654,221.20	$1,308,442.40
Rebar	356,040	Lb.	$0.42	$149,536.80	$0.25	$89,010.00	$0.00	$0.00	$238,546.80
Total				$575,348.00		$622,582.00		$696,783.20	$1,894,713.20

Table 3.2 - Cast in Place Foundation Wall Estimate

The total for a cast in place foundation wall is $1,894,713.20. It should also be taken from this estimate that there is 81,880 square feet of formwork that is going to be construction waste when the project is finished. The next chart shows that cost of the pre cast system that I am proposing to put in place.

Pre - Cast Wall									
	Quantity	Units	Materials Cost	Materials Total	Labor Cost	Labor Total	Equipment Cost	Equipment Total	Total
Pre - Cast Wall	70,200	S.F	$32.40	$2,274,480.00	$2.36	$165,672.00	$1.43	$100,386.00	$2,540,538.00

Table 3.7 - Pre Cast Foundation Wall Estimate

You can see from the blue boxes both in Table 1 and Table 2 that the cost for the pre-cast walls is more than the cast in place walls by $645,825.20 with the cost of the pre cast wall to be $2,540,538.00. The reason for this mainly is because when looking at the materials cost for the pre-cast wall that is the total cost for the manufacturing of the walls before they are shipped to the job site. General conditions will have to be looked at next to do to the possibility that the schedule will change.

<u>Cost Analysis with General Conditions</u>

If the walls are changed from cast in place concrete wall foundation system to a pre-cast wall foundation system the change will affect the schedule. It should already be known that the pre-cast wall will take less time than a cast in place foundation wall system because the pre-cast foundation walls do not need time to cure and reach maximum strength. Since the pre-cast foundation wall systems do not take as long as cast in place foundation systems the general conditions will be affect along with the schedule being accelerated. One of the benefits along with schedule acceleration is that there will be savings on the general conditions.

Figure 8.2 - Placement of Pre-cast Foundation Wall

According to the schedule the cast in place foundation walls are to take a total of 107 days to complete. The pre-cast foundation walls that are being proposed only take 50 days with a rate of 1400 square feet of pre-cast foundation walls being installed per day and a total of approximately 70,220 square feet of pre – cast foundation walls. The savings on time then by using pre-cast foundation walls is 57 days or approximately eight weeks. Below are two general conditions estimates showing the difference in general conditions cost with cast in place foundation walls and pre-cast foundation walls (A full general conditions estimate is in appendix ?, this is just an estimate with the numbers that changed.

Brief General Conditions Estimate with Cast in Place Concrete Foundation Walls						
Personnel			Number of Staff	Weeks of Job	Cost per Week	Total Cost
	Projec Excutive		1	111	$2,175.00	$241,425.00
	Sr. Project Manager		1	148	$2,175.00	$321,900.00
	Project Engineer		1	148	$1,350.00	$199,800.00
	Project Superintendent		1	148	$2,025.00	$299,700.00
	Accountant		1	148	$380.00	$56,240.00
	Assistant Engineers		6	148	$1,165.00	$1,034,520.00
	Assistant Superintendents		12	148	$1,775.00	$3,152,400.00
					Total Personnel Cost	$5,305,985.00
Temporary Utilities/Facilities			Amount	Units	Cost per Unit	Total Cost
	Trailers		1	Ea.	$200.00	$7,200.00
	Office Equipment		1	Month	$155.00	$5,580.00
	Office Supplies		1	Month	$85.00	$3,060.00
	Telephone		1	Month	$80.00	$2,880.00
	Light & HVAC		1	Month	$150.00	$5,400.00
	Portable Toilets		6	Ea.	$171.00	$36,936.00
	Storage boxes		1	Ea.	$5,040.00	$181,440.00
					Total Cost	$242,496.00
					Overall Total	$5,548,481.00

Table 3.3 - Cast in Place General Conditions Estimate

Brief General Conditions Estimate with Pre - Cast Concrete Foundation Walls						
Personnel			Number of Staff	Weeks of Job	Cost per Week	Total Cost
	Projec Excutive		1	103	$2,175.00	$224,025.00
	Sr. Project Manager		1	140	$2,175.00	$304,500.00
	Project Engineer		1	140	$1,350.00	$189,000.00
	Project Superintendent		1	140	$2,025.00	$283,500.00
	Accountant		1	140	$380.00	$53,200.00
	Assistant Engineers		6	140	$1,165.00	$978,600.00
	Assistant Superintendents		12	140	$1,775.00	$2,982,000.00
					Total Personnel Cost	$5,014,825.00
Temporary Utilities/Facilities			Amount	Units	Cost per Unit	Total Cost
	Trailers		1	Ea.	$200.00	$7,200.00
	Office Equipment		1	Month	$155.00	$5,270.00
	Office Supplies		1	Month	$85.00	$2,890.00
	Telephone		1	Month	$80.00	$2,720.00
	Light & HVAC		1	Month	$150.00	$5,100.00
	Portable Toilets		6	Ea.	$171.00	$36,936.00
	Storage boxes		1	Ea.	$5,040.00	$181,440.00
					Total Cost	$241,556.00
					Overall Total	$5,256,381.00

Figure 3.4 - Pre-cast General Conditions Estimate

The major difference in the two charts is that the amount of weeks of work for the personnel was decreased by eight weeks and all of the temporary utilities and facilities that are charged by the month are charged for 34 month instead of the 36 if a cast in place foundation wall is used. The difference in the price of the two is that the cast in place general conditions estimate is $5,548,481.00 where as the general conditions estimate for the pre-cast foundation wall system is $5,256,381.00.

$5,548,481.00 - $5,256,381.00 = $292,100.00

The savings then on the general conditions for the pre-cast foundation system then is $292,110.00 and 57 days /8 month.

Overall Cost Comparison

To find the overall increase in cost in using a pre-cast foundation wall system I have to subtract the savings from the general conditions estimate and then find the difference between the pre-cast and cast in place foundation walls. The cost of the pre-cast foundation wall system is $2,540,538.00, cast in place foundation wall system is $1,894,713.20, and the general conditions savings is $292,110.00.

($2,540,538.00 – $292,110.00) - $1,894,713.20 = $353,715.80

So the total added cost for a pre-cast foundation wall system is approximately $353,715.80. Now taking a look at the advantage and disadvantages of a pre – cast foundation wall system could help decide if the extra cost is worth it.

Advantages/Disadvantages

There are advantages and disadvantages of using a pre-cast foundation wall system. The list below will separate the advantage from the disadvantages of using pre –cast foundation wall systems.

Advantages:

-Takes less time to installs pre-cat foundation wall systems

-Schedule acceleration

-Better quality due to being manufactured off site

-Less construction waste

-More energy efficient

Disadvantages:

-Cost as opposed to cast-in place foundation wall system

-Size of panels limitations due to shipping

-More coordination on site

Recommendation

Pre-cast foundation wall systems are not a bad idea. The price difference is not that bad on the two systems. The pre-cast foundation wall system does offer the possibility of cost savings on energy with better insulating, but that fact that the basement is only going to be used for the mechanical and electrical rooms it might not be effective enough. There is the benefit in minimizing construction waste that makes the pre-cast foundation wall more favorable. What it comes down to tough is that it’s up to the owner’s preference and also up to the construction team as to which system they are more comfortable installing.

Analysis IV – Green Roof

Background Information

Green roofs are a growing thread in the construction industry today. With the large amount of space that is on the roof of University Medical Center of Princeton there is potential for a green roof to be very good sustainable design for the building. Green roofs are in a nutshell can be described as a garden on the roof or other words a roof covered with vegetation. Green roofs are known also to minimize storm water runoff which goes along with the idea of the greywater system of recycling water for good use and reduce the heat island effect.

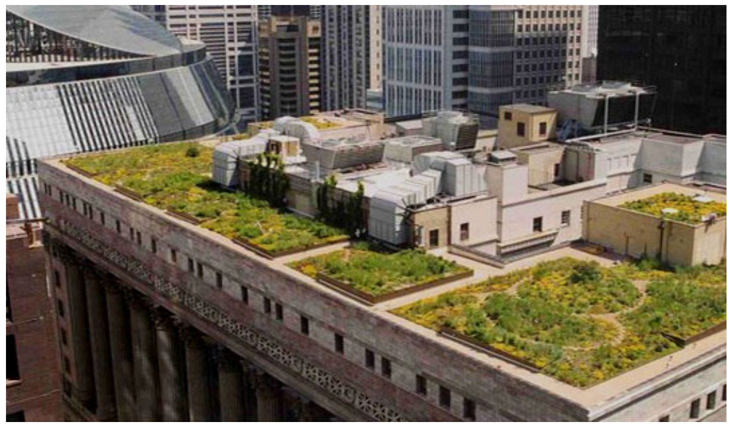


Figure 4.1 – Green Roof on Top of Chicago City Hall

In respect to the constructability and schedule of the project, the implementation of a green roof will have no impact on either. The only restrained that could possibly be on the schedule would be that the green roof needs to be installed during the summer month in northern climates like in New Jersey.

Goals

It will be important when looking at a green roof to understand how it works and to also look at the upfront cost of the green roof. It is very important when looking at implementing a green roof that the structural system of a typical bay consisting of girders, beams, and columns will be able to hold up the green roof. It is expected that the green roof will be beneficial in the collection of storm water and reducing storm water runoff. It is also expected that there will be a high upfront cost but the overall benefits of the green roofs will outweigh the initial cost of the system.

Cost and Components of Green Roof

Green roofs can be very expensive depending on the type of green roof system that is being installed. The green roof that I am planning on installing on this building is a Green Grid G3 4-inch module that cost around $14 dollars per square foot. With the roof are being approximately 18,500 square feet the total cost of the green roof would be as shown below is $259,000.00.

18,500 square feet x $14.00 per square foot = $259,000.00

A green roof works almost like your garden. First thing you do when you are planting a garden is lay down some weed block fabric then you have top soil and plants. I works the same way with a green roof, after the roof is constructed with the roof deck going on first and then the protection board and waterproof membrane (important so that there is no leaky roof). After the waterproof membrane is laid down the insulation, drainage/storage layer, and filter fabric are laid down. These three things are important for two reasons, first these layers are used to store storm water and second they protect the waterproof membrane from the potential of roots digging into the membrane. The last thing to go on the green roof then is the growing medium and plants.

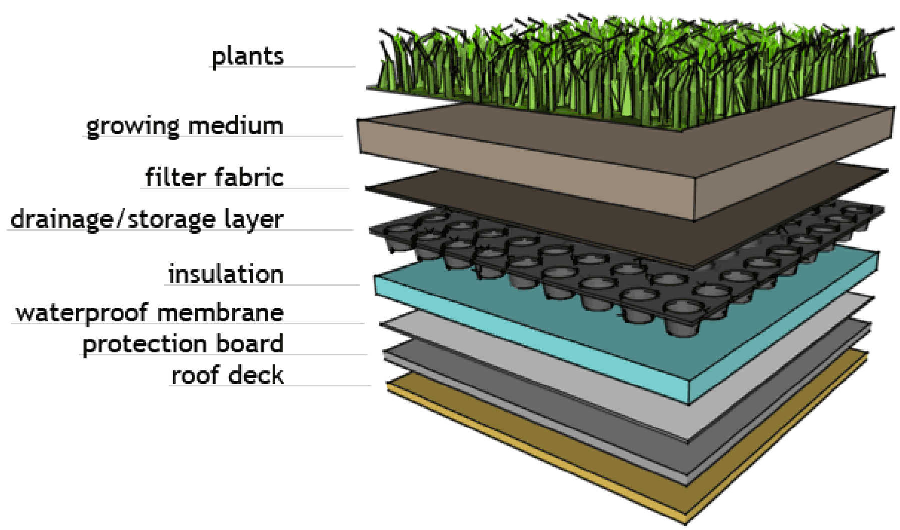


Figure 4.2-Componets of a Green Roof

Structural Analysis

The important thing with implementing a green roof system is making sure that the structural steel will be able to support the weight of the green roof. The green roof that I am looking at implementing is a Greengrid G3 4-inch module which weights approximately 21 pounds per square foot wet load. The 21 pound per square foot green roof will be added to the dead load of the structural roof calculation to get a new load distribution. Calculation was done on a typical bay to test and see if the superstructure would be able to support the added dead load on the roof.

A typical bay in the superstructure is to be W18x35 for the girders, W21x68 for the beams, and W14x90 for the columns. The weight of the roof was found by using the live load and dead load reductions using the fallowing equation

$$W_{roof} = 1.2\,(Dead\ Load) + 1.6\,(Live\ Load)$$

This then gave me a uniformly distributed load along the steel girder. The max moment and point load are found and then compared with the allowable max moment and point load of a W18x35 girder to assure that the load would pass. The equations for the max moment and point load are listed below.

$$M = \frac{wl^2}{8}\ and\ V = \frac{wl}{2}$$

M and V are the moment and point load (force) and the w is the weight of the roof and l is the length of the girder from fixed end to fix end. The max moment came out to 212.2 kips/ft and the point load came out to be 22.9 kips which make is pass since the design max moment is 249 kips/ft and the max design point load is 159 kips. The point loads on the girders are then transferred to the beams. With the point loads the max moment and point load on the beams are then calculated using the equation below.

$$M = P\,(a)\ and\ V = P$$

P is the point load and (a) is the distance of the point load to the fixed end of the beam. Using the calculations above the moment came out to be 251.9 kips/ft and the point load came out to be the same as the girders 22.9 kips. Using the steel manual as before with the girders it is proven that the beams will pass the max moment and point load which are 600 kips/ft and 273 kips. The last thing that needs s to be checked is the columns. Using the equation below the columns will be checked for axial compression

$$M = P\ (e)$$

The (e) is the distance of the load to the center of the column. As expected the column passed the test with a calculated moment of 13.36 kips/ft and the max design load being 876 kips/ft.

In the appendix all the hand calculations for the girders, beams, and columns can be found along with the free body diagrams of the girders, beams and columns.

Stormwater Collection

One of the major benefits of the green roof is the collection of stormwater runoff. I have found that the average rainfall per month in New Jersey is around 3.84 in per month. This meaning that in one square foot there is an average of 2.4 gallon of water on the roof per month if one cubic foot equals 7.48 gallons. This also means that with the roof being approximately 18,500 square feet the total stormwater runoff is about 44,280 gallons of water per month.

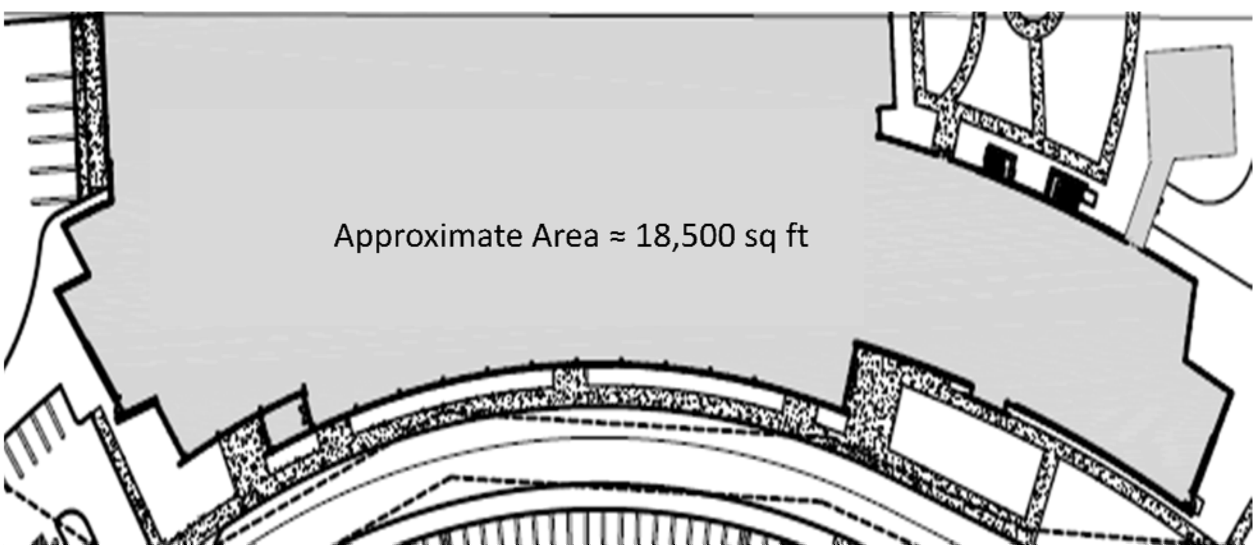


Figure 4.3-Footprint and Roof Area

Below are two charts the show how much water the 4 inch green roof modules can retain.

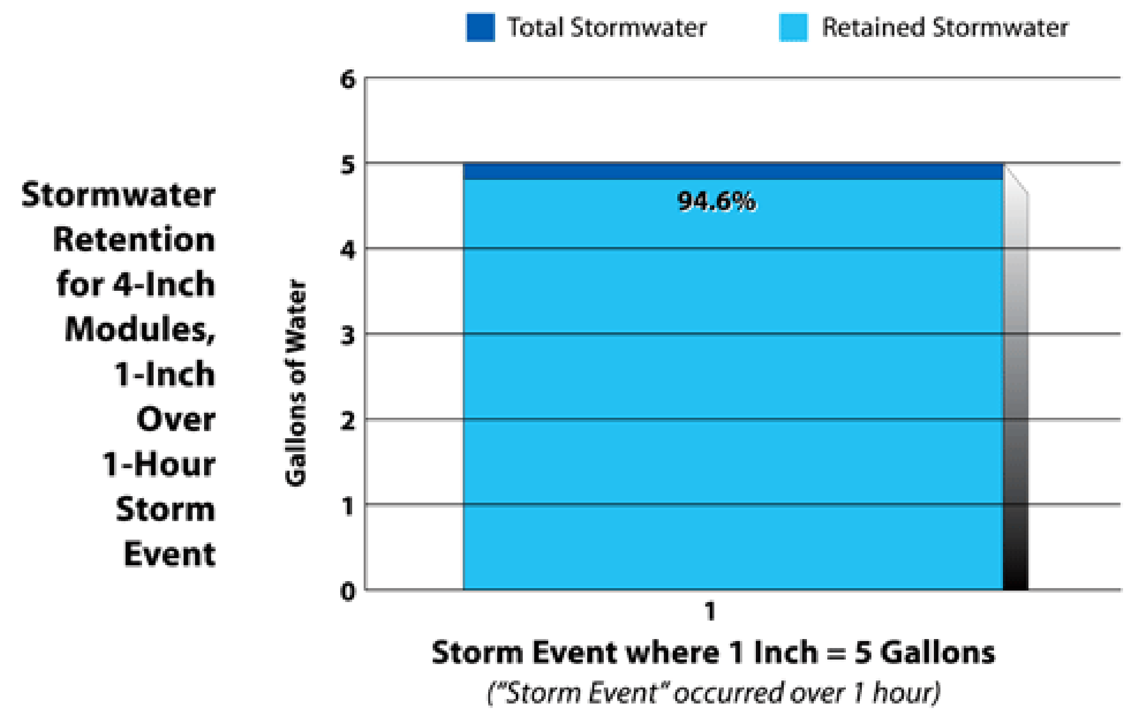


Figure 4.4-Stormwater Retention

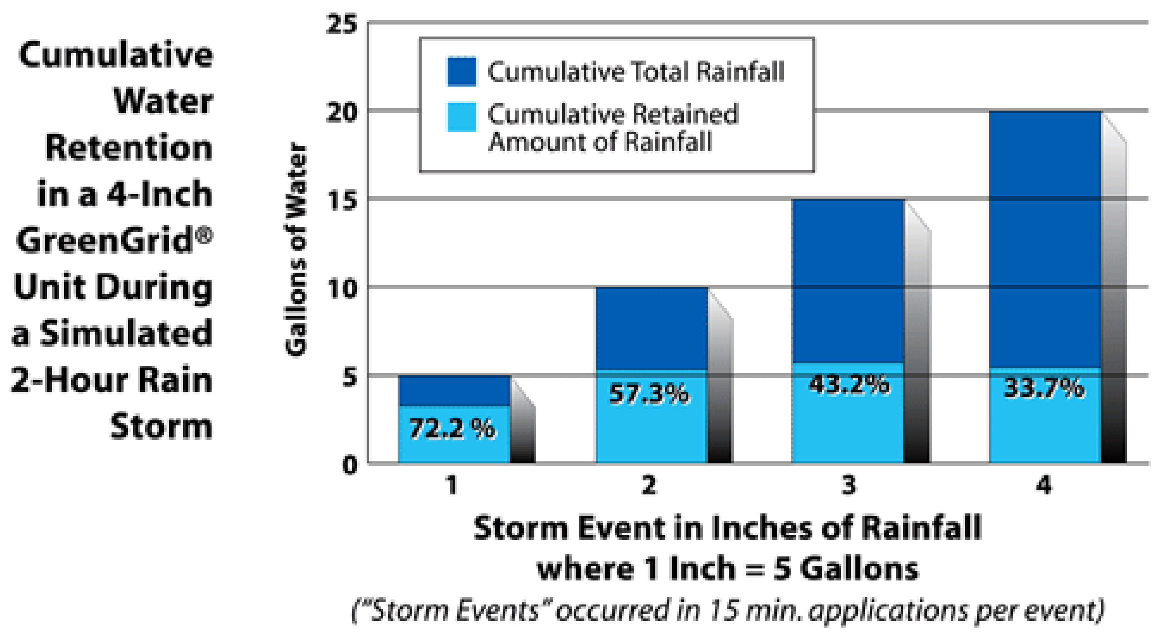


Figure 4.5-Cumulative Water Retention

As you can see for the charts above the green roof is very effective in collecting and reducing stormwater runoff. As you can see the average rainfall for New Jersey would net in no stormwater runoff, but in the case of a rainstorm that is over one inch of rainfall there will be stormwater runoff. The benefit though of this system though is that there will be hardly any stormwater runoff if the rainfall is less than one inch making it very efficient.

Benefits of Green Roof

Outside of just the stormwater runoff collection there are many other benefits of using a green roof system. One of the biggest effects from using a green roof system is that a green roof system minimizes the effect of urban heat-island effect. Urban heat island effect is when the sun is shining down on the roof of a building and the roads they absorb an incredible amount of heat, which is then radiated back up into the atmosphere. What the green roof does is the plants on the roof transpire which ends up cooling the atmosphere. This is why cities are always so much hotter in the summer then rural areas where there is a lot of grass and trees.

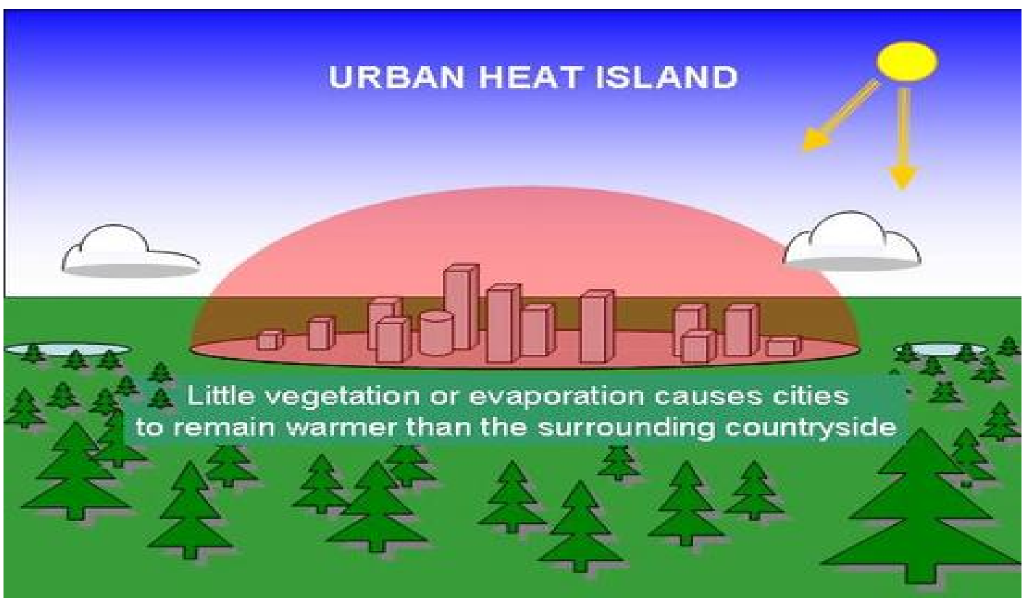


Figure 4.6-Urban Heat Island Effect

Another thing that a green roof does is help insulate the building. Just like the change in the windows did in the earlier analysis, the implementation of a green roof will help insulate and reduce the cooling and heating load of the building by around 25%. A green roof could possible held reduce the size of the mechanical system and also save money on the amount of energy needed to heat and cool the building.

Recommendation

Even with the added up front cost of a green roof, I feel that a green roof is a very benefiting design idea. The environmental benefits of a green roof are very favorable due to the benefits of decreasing stormwater runoff and urban heat island effect. The fact that the structural system does not have to change also should play into the benefits that there will be no need to add the cost of a new structural system if a green roof is potentially added.

Appendix

Appendix 1 – Structural Estimate

Structural Systems Estimate										
	Steel									
Columns		Quanity	Units	Materials Cost	Materials Total	Labor Cost	Labor Total	Equipment Cost	Equipment Total	Total
	W12x72	264	L.F.	$82.50	$21,780.00	$2.36	$623.04	$1.69	$446.16	$22,849.20
	W14x82	156	L.F.	$122.00	$19,032.00	$2.48	$386.88	$1.77	$276.12	$19,695.00
	W14x90	1,144	L.F.	$122.00	$139,568.00	$2.48	$2,837.12	$1.77	$2,024.88	$144,430.00
	W145x99	572	L.F.	$122.00	$69,784.00	$2.48	$1,418.56	$1.77	$1,012.44	$72,215.00
	W14x109	416	L.F.	$122.00	$50,752.00	$2.48	$1,031.68	$1.77	$736.32	$52,520.00
	W14X120	156	L.F.	$198.00	$30,888.00	$2.54	$396.24	$1.81	$282.36	$31,566.60
	W14X132	1,456	L.F.	$198.00	$288,288.00	$2.54	$3,698.24	$1.81	$2,635.36	$294,621.60
	W14X136	52	L.F.	$198.00	$10,296.00	$2.54	$132.08	$1.81	$94.12	$10,522.20
	W14X145	1,690	L.F.	$198.00	$334,620.00	$2.54	$4,292.60	$1.81	$3,058.90	$341,971.50
	W14X159	338	L.F.	$198.00	$66,924.00	$2.54	$858.52	$1.81	$611.78	$68,394.30
	W14X176	702	L.F.	$290.00	$203,580.00	$2.67	$1,874.34	$1.91	$1,340.82	$206,795.16
	W14X193	182	L.F.	$290.00	$52,780.00	$2.67	$485.94	$1.91	$347.62	$53,613.56
	W14X211	78	L.F.	$290.00	$22,620.00	$2.67	$208.26	$1.91	$148.98	$22,977.24
	W14X311	754	L.F.	$290.00	$218,660.00	$2.67	$2,013.18	$1.91	$1,440.14	$222,113.32
	W14X347	442	L.F.	$290.00	$128,180.00	$2.67	$1,180.14	$1.91	$844.22	$130,204.36
Beams									Total Columns	$1,694,489.04
	W8X40	434	L.F.	$51.00	$22,134.00	$4.43	$1,922.62	$3.17	$1,375.78	$25,432.40
	W12x19	9,882	L.F.	$26.50	$261,873.00	$2.77	$27,373.14	$1.98	$19,566.36	$308,812.50
	W12X26	270	L.F.	$43.00	$11,610.00	$2.77	$747.90	$1.98	$534.60	$12,892.50
	W12X40	126	L.F.	$43.00	$5,418.00	$2.77	$349.02	$1.98	$249.48	$6,016.50
	W14X22	396	L.F.	$43.00	$17,028.00	$2.46	$974.16	$1.76	$696.96	$18,699.12
	W16X26	23,994	L.F.	$43.00	$1,031,742.00	$2.44	$58,545.36	$1.74	$41,749.56	$1,132,036.92
	W16X31	1,798	L.F.	$51.00	$91,698.00	$2.71	$4,872.58	$1.93	$3,470.14	$100,040.72
	W18X35	2,666	L.F.	$58.00	$154,628.00	$3.67	$9,784.22	$1.95	$5,198.70	$169,610.92
	W18X40	805	L.F.	$66.00	$53,130.00	$3.67	$2,954.35	$1.95	$1,569.75	$57,654.10
	W21X44	8,897	L.F.	$72.50	$645,032.50	$3.32	$29,538.04	$1.76	$15,658.72	$690,229.26
	W21X50	1,302	L.F.	$82.50	$107,415.00	$3.32	$4,322.64	$1.76	$2,291.52	$114,029.16
	W21X55	217	L.F.	$82.50	$17,902.50	$3.32	$720.44	$1.76	$381.92	$19,004.86
	W24X55	8,232	L.F.	$91.00	$749,112.00	$3.18	$26,177.76	$1.69	$13,912.08	$789,201.84
	W24X62	259	L.F.	$102.00	$26,418.00	$3.18	$823.62	$1.69	$437.71	$27,679.33
	W24X68	1,519	L.F.	$112.00	$170,128.00	$3.18	$4,830.42	$1.69	$2,567.11	$177,525.53
	W27X54	252	L.F.	$155.00	$39,060.00	$2.96	$745.92	$1.58	$398.16	$40,204.08
	W27X84	1,302	L.F.	$155.00	$201,810.00	$2.96	$3,853.92	$1.58	$2,057.16	$207,721.08
	W30X99	280	L.F.	$163.00	$45,640.00	$2.94	$823.20	$1.56	$436.80	$46,900.00
Metal Decking									Total Beams	$3,943,690.82
	3" deep 20 gauge	492,000	S.F.	$4.12	$2,027,040.00	$0.43	$211,560.00	$0.04	$19,680.00	$2,258,280.00
									Total Metal Decking	$2,258,280.00
	Concrete									
Foundation										
	Spread Footing	2,980	C.Y.	$101.00	$300,980.00	$13.20	$39,336.00	$0.43	$1,281.40	$341,597.40
	Strip Footing	1,840	C.Y.	$101.00	$185,840.00	$13.20	$24,288.00	$0.43	$791.20	$210,919.20
	Retaining Walls	2,520	C.Y.	$101.00	$254,520.00	$15.85	$39,942.00	$0.52	$1,310.40	$295,772.40
	Foundation Walls	80	C.Y.	$101.00	$8,080.00	$15.85	$1,268.00	$0.52	$41.60	$9,389.60
Floors									Foundation Total	$857,678.60
	Slab on Grade	1,600	C.Y.	$104.00	$166,400.00	$14.40	$23,040.00	$0.47	$752.00	$190,192.00
	Slab on Metel Deck	5,080	C.Y.	$106.00	$538,480.00	$26.00	$132,080.00	$12.60	$64,008.00	$734,568.00
									Floors Total	$924,760.00
									Total Structure	$9,678,898.46

Appendix 2 - General Conditions Estimate

General Conditions Estimate						
Personnel			Number of Staff	Weeks of Job	Cost per Week	Total Cost
	Projec Excutive		1	111	$2,175.00	$241,425.00
	Sr. Project Manager		1	148	$2,175.00	$321,900.00
	Project Engineer		1	148	$1,350.00	$199,800.00
	Project Superintendent		1	148	$2,025.00	$299,700.00
	Accountant		1	148	$380.00	$56,240.00
	Assistant Engineers		6	148	$1,165.00	$1,034,520.00
	Assistant Superintendents		12	148	$1,775.00	$3,152,400.00
					Total Personnel Cost	$5,305,985.00
Temporary Utilities/Facilities			Amount	Units	Cost per Unit	Total Cost
	Trailers		1	Ea.	$200.00	$7,200.00
	Office Equipment		1	Month	$155.00	$5,580.00
	Office Supplies		1	Month	$85.00	$3,060.00
	Telephone		1	Month	$80.00	$2,880.00
	Light & HVAC		1	Month	$150.00	$5,400.00
	Portable Toilets		6	Ea.	$171.00	$36,936.00
	Storage boxes		1	Ea.	$5,040.00	$181,440.00
					Total Cost	$242,496.00
Insurance and Bonds				Contract Amount	% of Contracte	Total Cost
	Insurance			$321,000,000.00	0.62%	$1,990,200.00
	Permits			$321,000,000.00	2.00%	$6,420,000.00
	Bonds			$321,000,000.00	2.50%	$8,025,000.00
					Total Cost	$16,435,200.00
General Requirements			Frenquency	Duration	Cost per Unit	Total Cost
	Crawler Crane		Mouth	8	$21,300.00	$170,400.00
	Mobil Crane		Mouth	9	$19,000.00	$171,000.00
	Material Hoist		Mouth	36	$10,200.00	$367,200.00
	Dumpster		Weeks	148	$1,000.00	$148,000.00
	Signage		S.F.	100	$21.00	$2,100.00
	Final Clean		Job	$321,000,000.00	1.00%	$3,210,000.00
	Temporary Road		S.F.	450	$7.61	$3,424.50
	Temporary Fenceing		L.F.	3,000	$9.44	$28,320.00
					Total Cost	$4,100,444.50
					Total GC Cost	$26,084,125.50

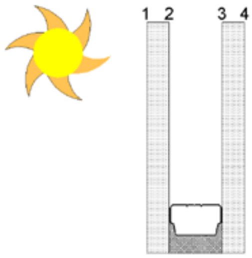
Appendix 3 – Viracon Data Sheet

VIRACON

Solarscreen Radiant Low-E (VRE) Insulating Glass

VRE 1-46

Make-Up



Notes:
1/4" (6mm) clear VRE-46 #2
1/2" (13.2mm) airspace
1/4" (6mm) clear

Performance Data

Metric | English

Product Code	VRE 1-46
Transmittance	
Visible Light	43%
Solar Energy	23%
Ultra-Violet*	16%
Reflectance	
Visible Light-Exterior	34%
Visible Light-Interior	15%
Solar Energy	40%
ASHRAE U-Value	
Winter	0.3 Btu/(hr x sqft x °F)
Summer	0.27 Btu/(hr x sqft x °F)
European U-Value	1.6
Shading Coefficient	0.33
Relative Heat Gain	69 Btu/hr x sqft
Solar Factor (SHGC)	0.28
LSG	1.53

*Ultra-violet defined as 300 to 380 nanometers (nm)

Viracon, Inc. 800 Park Drive -
Owatonna, MN 55060
(800) 533-2080
(507) 451-9555

Appendix 4 - Serious Glass Brochure

Super-insulating SeriousGlass™ benefits:

- Highest energy savings & rapid payback
- Tuned solar heat control
- Superior condensation control
- Maximum daylighting
- Optimal winter insulation
- Highest UV protection
- Simplified HVAC design & loads
- Noise control

SERIOUS MATERIALS COMMERCIAL GLASS

Saves more energy than any other commercial glass. Period.

Drawing upon 28+ years of worldwide leadership at the forefront of super-insulating glass technology, Serious Materials manufactures a comprehensive family of Suspended Coated Film (SCF) architectural glazing. With SeriousGlass, high performance and affordability go hand-in-hand with utmost energy savings and greater indoor comfort.

Virginia Air & Space Museum

SeriousGlass™

SAVES MORE ENERGY THAN ANY OTHER COMMERCIAL GLASS. PERIOD.

SeriousGlass super-insulating glass units, including Suspended Coated Film (SCF) technology, go far beyond the performance benefits of low-e for the same or comparable price. Proven in over thousands of projects nationwide, SeriousGlass results in high energy savings, cost-effective thermal efficiency, and greater indoor comfort. SeriousGlass enables a new world of unprecedented architectural freedom and design possibilities to use more glass across all building types and climate zones.

SeriousGlass Advanced Performance

- Super-insulating performance up to R-20 (U-0.05)
- Highest Light to Solar Gain (LSG) ratios – up to 2.36 – in the industry
- NE-SW Tuning: Maximizes NE thermal performance and natural light; manages SW solar gain
- 99.5%-99.9% UV blockage
- Optimal condensation control
- Highest winter glass temperatures

Serious Technology & Expertise for New Construction & Retrofit Projects

- Compatible with all new or retrofit deep pocket glazing/framing systems including storefront, curtainwall, and commercial window designs
- Fully compatible with tinted, patterned, laminated and ceramic-frit glass
- Silicone sealant option for "flush" glazing
- 3rd party certification (IGCC, IGMA, NAMI, AAMA, NFRC)
- Contributes to LEED credits (potential of up to 19 points)

Super-Insulating SeriousGlass Pays

For the same or less cost as commonly specified performance glazing, SeriousGlass results in higher energy savings and faster payback. Depending on building type and climate zone:

- Highest energy savings up to 32%
- Rapid payback as little as 1-2 years in many cases
- 30-year savings up to $17 million

**According to Architectural Energy Corporation, Parametric Study of the Savings Associated with Selected Serious Materials Glazing Product, October 2009. Standard dual clear glazing as baseline.*

Photos
Top: Eagle County Justice Center
Middle: Friedlander Residence
Bottom left: Homer Atrium
Bottom right: Westside Marketplace

SERIOUS MATERIALS

Super-Insulating SeriousGlass: The World Beyond Low-E & Triple Pane Glass

Serious Materials produces commercial and residential glass that dramatically improves occupant comfort with warm-winter and cool-summer glass and blockage of UV radiation.

Serious Materials emphasizes directional "tuning" to complement the most sophisticated energy efficient architecture, extending natural lighting as well as passive solar heating. SeriousGlass packages protect south and west facing sides of buildings with low solar heat gain and cool summer glass temperatures to increase indoor comfort and reduce HVAC and energy costs. The north-east building façade is tuned to maximize thermal performance and natural light.

All SeriousGlass blocks 99.5% or more of ultraviolet radiation. Since UV energy accounts for approximately two-thirds of fading, the protection provided by SeriousGlass to both furnishings and occupants is often of primary interest to business and home owners.

Serious Materials also manufacturers super-insulating high R-value SeriousWindows™ in a full range of fiberglass frame styles and designs. With high R-values of R-4.0 to R-11, SeriousWindows result in heating and cooling cost savings of up to 40% depending on climate zone. All windows incorporate SeriousGlass packages and are designed for both residential and commercial use.

Commercial Glass Examples

Product	U-Value		R-value	SHGC	Glass Surface Temperature (°F)		Reflectance (%)			Transmittance (%)			Shading Coefficient	Relative Heat Gain	LSG
	Winter	Summer			Winter	Summer	Vis-Out	Vis-In	Solar	Visible	Solar	UV			
Common 1" Glass Packages															
SG 5 56/25-100	0.19	0.20	5.3	0.25	58.8	85.7	13%	16%	37%	56%	21%	< 1%	0.29	60.0	2.24
SG 5 55/34-100	0.19	0.20	5.3	0.34	59.2	94.2	14%	14%	32%	55%	24%	< 1%	0.39	80.3	1.62
SG 5 62/36-100	0.20	0.21	5.0	0.36	58.7	89.1	13%	16%	30%	62%	29%	1%	0.41	84.9	1.73
SG 7 64/49-100	0.15	0.16	6.7	0.49	61.4	99.7	13%	14%	23%	64%	36%	1%	0.56	115	1.31
Common 1-1/2" Glass Packages															
SG 6 61/35-150	0.18	0.18	5.6	0.35	59.7	89.1	22%	20%	35%	61%	28%	1%	0.40	82.0	1.78
SG 7 64/49-150	0.15	0.15	6.7	0.49	61.4	99.7	13%	14%	23%	64%	36%	1%	0.56	115	1.31
SG 7 62/35-150	0.14	0.14	7.1	0.35	61.9	87.7	13%	16%	30%	62%	29%	1%	0.41	82.9	1.75
SG 8 57/24-150	0.13	0.13	7.7	0.24	62.0	82.3	13%	16%	37%	57%	22%	< 1%	0.28	57.4	2.36
SG 8 56/24-150	0.13	0.13	7.7	0.24	62.0	83.7	13%	16%	37%	56%	21%	< 1%	0.28	57.3	2.31
SG 8 55/33-150	0.12	0.12	8.3	0.33	62.6	92.9	14%	14%	32%	55%	24%	< 1%	0.38	78.5	1.64
SG 12 56/31-150*	0.08	0.09	12	0.31	64.9	86.7	16%	19%	34%	56%	25%	< 1%	0.35	71.4	1.84
Specialty 1-1/2" Glass Packages															
SG 7 68/50-150	0.15	0.15	6.7	0.50	61.4	93.9	17%	17%	22%	68%	40%	1%	0.57	117	1.36
SG 7 65/49-150	0.14	0.14	7.1	0.49	61.9	92.0	16%	16%	22%	65%	38%	< 1%	0.56	115	1.33
SG 7 66/53-150	0.14	0.15	7.1	0.53	61.5	95.7	20%	20%	21%	66%	42%	< 1%	0.61	124	1.24
SG 12 58/43-150	0.08	0.09	12	0.43	64.8	96.9	19%	19%	24%	58%	31%	< 1%	0.36	99.4	1.35
SG 12 55/32-150	0.08	0.09	12	0.32	64.8	88.3	16%	19%	31%	55%	25%	< 1%	0.36	73.9	1.74
Specialty 1-3/8" Glass Packages															
SG 14 37/23-138	0.07	0.08	14.3	0.23	65.3	93.4	20%	18%	37%	37%	14%	0%	0.27	54.5	1.62
SG 20 44/29-138	0.05	0.06	20.0	0.29	66.4	94.6	17%	16%	38%	44%	18%	0%	0.33	66.7	1.53

*Packages above are based on 1/4" glass. Other thicknesses available upon request. *Based on 3/16" glass.*

Manheim Township High School,Lancaster County, Pennsylvania
SeriousGlass cut annual energy bills by 40%. Thermal performance allowed the school to install a smaller HVAC system. Payback achieved in 6.5 years.

McDonalds Play Places
SeriousGlass used in 54 structures over 5 years with a 7 month financial payback based on reduced HVAC costs.

GREEN JOBS
GET SERIOUS

Save energy.
Save money.
Create green jobs.
Build green.

For the **same or less cost** as commonly specified performance glazing, SeriousGlass results in **higher energy savings** and **faster payback**.

Example: 20-story office building in Chicago

	Cost Per Square Foot	Annual Savings %	30 Year Savings	Simple Payback
SeriousGlass SG-8L (SG 8 56/24-150)	**$8.00**	**26.5%**	**$15,844,533**	**1.18**
Commonly specified high-performance glazing	$8.00	23.2%	$13,810,646	1.35

**According to Architectural Energy Corporation, Parametric Study of the Savings Associated with Selected Serious Materials Glazing Product, October 2009. Standard dual clear glazing as baseline.*

About Serious Materials

Serious Materials develops and manufactures sustainable green building materials that save energy, save money, improve comfort, and aggressively address climate change. Super-insulating high R-value SeriousWindows™ reduce heating and cooling energy costs by up to 40%. SeriousGlass™ industry-leading insulating commercial glass has been installed in thousands of projects and offers the highest energy savings in the industry. QuietRock® soundproof drywall reduces material use, enhances livability, and supports dense urban construction. EcoRock™ is the only true green alternative to gypsum drywall. Serious Materials' products are manufactured in the company's five factories across North America.

SERIOUS MATERIALS

1250 Elko Drive
Sunnyvale, CA 94089
(800) 797-8159
www.seriousmaterials.com

PN# 102-00016-020810

Appendix 5 – Superior Walls Brochure

THE BEST SOLUTION

X-TRA INSULATION

SUPERIOR WALLS Xi FOUNDATION SYSTEM

DRY

Your permanent barrier against sidewall water penetration

- ❶ Clean Crushed Stone Footing
- ❷ Auxiliary Drain Pipe
- Superior Sealant® Applied in All Joints for Permanent Moisture Barrier

WARM

Warmer in winter, cooler in summer... reduces your home's energy loss

- ❸ 2-1/2" Dow® Extruded Polystyrene Insulation
- ❹ 1" Foam Insulated Concrete Studs
- ❺ 1" Foam Insulation on Bond Beam

SMART

Ready to finish...with pre-engineered access built-in

- ❻ Access Holes for Ease in Wiring and Plumbing
- ❼ Galvanized Steel Stud Facing Ready for Drywall Finishing
- CAD Custom-Designed to Virtually Any Home Style
- Laser-Leveled to be Plumb, Level, Square
- Installs on Your Site in Just Hours for Time and Money Savings
- America's Strongest Foundation Guarantee*

SUPERIOR

*Steel reinforced...and backed by the industry's strongest guarantee**

- 5,000+ PSI Concrete for Superior Strength
- ❽ Horizontal Steel Rebar Inside Top and Bottom Beams
- ❾ Steel Reinforced Top Bond Beam
- ❿ Vertical Steel Rebar (Inside Each Stud)
- ⓫ 1-3/4" Concrete Face Shell
- ⓬ 10-1/4" Overall Wall Thickness
- ⓭ Steel Reinforced Concrete Studs
- ⓮ Steel Reinforced Footer Beam
- ⓯ Concrete Floor

Special Note: *Items #1,2,&15 as well as the joist/flooring system are provided on site per Superior Walls specifications by builder and contractors as an integral part of the Superior Walls foundation system.*

See the limited warranty. Contact your local Superior Walls representative for details.

Superior Walls®

THE FOUNDATION OF EVERY SUPERIOR NEW HOME™

www.superiorwalls.com

Xi™

EXTRA STRENGTH. EXTRA INSULATION.

- Provided with 2-1/2" of insulation = R-12.5
- 5000+ PSI concrete reinforced with rebar and polypropylene fibers
- Precast access holes for wiring and plumbing
- Meets Energy Conservation Code requirements for basements (IECC, IRC Chapter 11)
- Thermally isolated/insulated from exterior
- Insulated corners, studs and bond beam
- Monolithically poured = greater strength
- Galvanized steel stud facing
- May be insulated up to R-50+
- No additional dampproofing required
- Precast openings for windows and doors
- Reduces building time
- Ready in virtually any weather

GUARANTEED 15 YEARS

Superior In Every Way. Guaranteed.*

**See the limited warranty. Contact your local Superior Walls representative for details*

General Specifications

Superior Walls products are insulated precast concrete wall systems that are custom manufactured to each building's specification. The Xi product forms a concrete cavity wall panel with concrete studs at 24 inches on center attached at the top and bottom with bond beams and the entire assembly is faced with an integral concrete face shell. The wall is reinforced with rebar and polypropylene fibers providing additional structural strength. In addition, the concrete studs are cast with holes for wiring and factory galvanized steel on each stud for interior finishing. For more information see www.superiorwalls.com.

Superior Walls panels are available in a variety of standard heights and custom lengths to suit your project. The maximum axial load (uniform house weight) for this product is 5500 pounds per linear foot. Special point loads up to 50,000 pounds can be accommodated.

WARRANTY* ***Superior Walls*** Xi product is warranted for 15 years against defects in workmanship and side wall water penetration.

QUALITY ASSURANCE Each manufacturing plant is regularly inspected by an independent third-party inspection agency to ensure compliance with the Quality Assurance program. In addition, manufacturing and installation personnel are certified by ***Superior Walls of America, Ltd.***

DAMPPROOFING The concrete used in the ***Superior Walls*** wall systems provides protection against freeze/thaw cycles and water vapor transmission. The urethane sealant used between panels provides superior protection against water penetration. Therefore, no additional dampproofing materials are required.

VAPOR BARRIER The closed cell polystyrene material in the Dow STYROFOAM™ Insulation provides a vapor barrier for ***Superior Walls*** panels**.**

FIRE RESISTANCE Dow STYROFOAM™ Insulation exhibits the following surface burning characteristics: flame spread 5 and smoke developed 165.

Superior Walls products do not require the attachment of a 15-minute thermal barrier over the foam plastic as proven by UL 1715 and equivalent UBC 26-3 tests.

Superior Walls products qualify as a two-hour fire separation wall when two layers of 5/8" Type 'X' drywall are applied to the studs.

Superior Walls of America manufacturers are independently owned and operated. Check with your local Superior Walls representative for availability.

Superior Walls®

Superior Walls
937 East Earl Road
New Holland, PA 17557

800-452-9255
www.superiorwalls.com

Appendix 6 – Green Roof LEED Info

Fact Sheet
GreenGrid® and LEED® Certification

LEADERSHIP IN ENERGY AND ENVIRONMENTAL DESIGN

Leadership in Energy and Environmental Design (LEED®) is the green building rating system developed by the United States Green Building Council (USGBC). The intent is to provide a standard certification process that registers buildings constructed with environmental performance, efficiency, and occupant health and well-being as primary goals. Buildings receive points towards varying levels of certification based on the set of categories established by the USGBC.

GREENGRID® GREEN ROOF SYSTEM

The GreenGrid® green roof system is an innovative, modular approach to green roof technology. Green roofs have a number of benefits that have been proven for years in Europe and more recently in North America. For example, the National Research Council Canada found that in buildings less than three stories in height, a green roof can reduce average daily energy demands for cooling by 50% or more compared to a typical flat roof. As a result, reductions in the size of mechanical equipment, such as, air conditioning equipment are possible. Additionally, stormwater runoff can be reduced by up to 95% following a 1-inch rain event, lowering the impact of a building on the municipal storm drainage system and the surrounding watershed. The GreenGrid® system's modular design allows for a lighter green roof, faster installation (increasing cost effectiveness), and easier post-installation repairs (or changes) to roofs compared to traditional built-in-place green roof systems. The modules are made from a minimum of 60% post-industrial recycled plastic (HDPE), some edge treatment options are made from recycled metals or plastic and sawdust, and pavers are made from 100% post-industrial recycled rubber.

GREENGRID® AND LEED CERTIFICATION POINTS

A GreenGrid® green roof can help contribute towards a building's LEED certification in a number of different categories. Although any green roof may assist with certification in some areas, specific features of the GreenGrid® system can further enhance the rating in some categories that would not apply to a traditional green roof. The major categories of the USGBC rating system and potential points achievable with a GreenGrid® green roof include the following:

Sustainable Sites

Stormwater Design: Quantity Control – SS Credit 6.1 – A GreenGrid® roof can prevent a post-development stormwater discharge peak rate associated with the building's footprint from exceeding that of pre-development and reduce stormwater discharge by more than 25% (rate and quantity). Green roofs may also be considered as stormwater treatment through their ability to remove suspended solids and other pollutants. **Potential Points: 1 point**

Heat Island Effect: Roof – SS Credit 7.2 – A GreenGrid® roof can reduce roof temperatures from summertime highs of 150°F to less than 80°F. The USGBC specifies green roofs as a way to meet this objective, when the green roof installation covers at least 50% of the roof surface. **Potential Points: 1 point**

WESTON SOLUTIONS

Fact Sheet

GreenGrid® and LEED® Certification

Water Efficiency

Water Efficient Landscaping – WE Credit 1.1 – GreenGrid® roofs can be designed so that irrigation is not required. Drought-resistant plants can be selected or greywater systems can be directed onto the roof to irrigate. As an added benefit, runoff from the green roof is filtered by the vegetation and soil media, so this water can be used to irrigate other landscaping features without pretreatment. **Potential Points: 1 to 2 points**

Energy and Atmosphere

Optimize Energy Performance – EA Credit 1 – Green roofs have been documented to reduce energy demand by more than 50% annually in certain types of structures. Reduced demand and increased efficiency may also lead to smaller cooling systems and lower capital costs. **Potential Points: 1 to 8 points**, depending on total energy reduction as a percent versus conventional buildings of the same size.

Materials and Resources

Recycled Content – MR Credit 4.1 – The GreenGrid® modules, pavers, and some edge treatment options are made from recycled materials and can be applied toward the goal of 5% to 10% of the total value of project materials originating from recycled material. **Potential Points: 1 to 2 points**, depending on the overall percent of recycled project materials included in the project.

Regional Materials – MR Credit 5.1 – GreenGrid® systems are assembled and pre-planted prior to installation at local nurseries thus the system can contribute toward having 20% to 50% of a building's materials manufactured within a 500-mile radius. Since plants and media are obtained at local nurseries, the GreenGrid® can contribute to the 50% extracted regionally credit. **Potential Points: 1 to 2 points**

Innovation and Design Process

The GreenGrid® system may qualify for innovation and design credits by improving the workplace environment, creating an educational laboratory, or a recreational space. When combined with recycled rubber pavers, decorative edgings, benches, etc., the roof can become a useable space for meetings and relaxation. In addition, green roofs can reduce exterior sound by up to 40%, increasing a building's acoustic performance which is an element not covered by LEED®. **Potential Points: 1 to 2 points**

IN SUMMARY

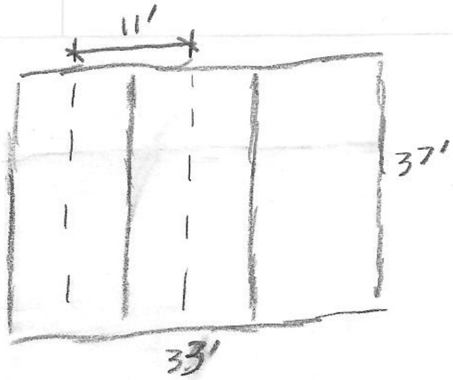
Overall, the GreenGrid® Green Roof system installed on 50% or more of the roof surface virtually guarantees 2 LEED® points and can contribute towards an additional 7+ points towards LEED® certification, almost 25% of the total needed to certify.

For more information on the GreenGrid® green roof system, visit **www.GreenGridRoofs.com**, send us an email at **GreenGridRoofs@WestonSolutions.com**, or call us at **847-918-4000**.

WESTON SOLUTIONS

Appendix 7 – Structural Loads

Structural Breadth Analysis



Girders = W18×35
Beams = W21×68
Columns = W14×90

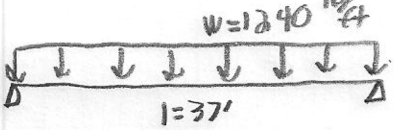
Girders

LL = 30 psf (Snow)

DL = 33 psf + 21 psf (Green Roof)
= 54 psf

$w_{Roof} = 1.2(54) + 1.6(30) = 112.8$ psf

$w = 112.8\text{psf}(11') = 1240.8$ lb/ft



$V = \frac{wl}{2} = \frac{1240(37)}{2} = 22.9$ kips

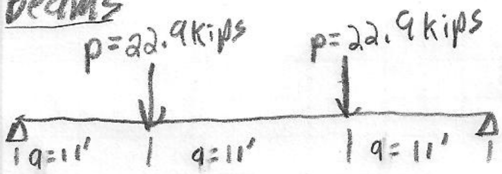
$M = \frac{wl^2}{8} = \frac{1240(37)^2}{8} = 212.2$ kips/ft

W18×35

$\phi_b M_{px} = 249$ kips/ft > 212.2 kips/ft ∴ ok

$\phi_v V_{nx} = 159$ kips > 22.9 kips ∴ ok

Beams



$V = P = 22.9$ kips

$M = P(a) = 22.9\text{kips}(11') = 251.9$ kips/ft

W21×68

$\phi_b M_{px} = 600$ kip/ft > 251.9 kips/ft ∴ ok

$\phi_v V_{nx} = 273$ kip > 22.9 kips ∴ ok

Columns

$P = 22.9\text{kips}$

$e = 7/12$

$M = Pe = 22.9\text{ kips}\,(7/12') = 13.36\text{kips}$

W14×90

$\phi_c P_n = 876 < 13.36 \quad \therefore \text{OK}$