Joe Bonacci | Construction

Charlottesville Community Hospital

Final Report

Spring 2014

Advisor: Robert Leicht

Charlottesville Community Hospital

Charlottesville, VA

Structural System

The Hospital is built predominantly of a cast in place concrete structure, which includes concrete beams, columns, slabs, and shear walls. The foundation incorporates grade beams and 88 total caissons. Steel beams support the Northwest cantilevering corner of the building on floors two-six.

Mechanical System

An air to air mechanical system is implemented with the use of 3 air handling units stationed on the roof. A water to air system is also evident by use of VAVs. These are found in a majority of rooms on every floor. Two chilled water pumps service the buildings VAV system.

Electrical System

The electrical system consists of a three phase 480Y/277V main switch board and has a max load of 4000 amps. In addition, 480Y/277V is the main utility transformer, which has a max load of 2500KVA. For added insurance, a diesel powered emergency generator is provided, with output capacities of 1500KW/1875KVA.

View looking Southeast from 1223 West Main Street, Charlottesville, VA

Building Information

- 200,000 Gross SF
- LEED Silver (pending)
- $141.6 million
- 7 above grade floors

Architecture

The Building's façade includes brick on the East and South faces, and glass on the North and West. The glass faces of the structure are taken into consideration when orienting the interior. Reception areas, play spaces, and general waiting areas are located near these faces to provide nature light, while exam rooms, operating rooms, and nurse stations are located in the center of the building and towards the rear brick walls.

Completion Date:
Summer 2014

Joe Bonacci
Construction

Special Thanks to isec beyond boundaries

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Executive Summary

The following report analyses four areas of interest of the Charlottesville Community Hospital that are intended to be improved upon. This seven story building has a project cost of $141 million and is expected to be completed by June 2014. A high standard exists from owners for quality finish materials and craftsmanship. Throughout the report a strong emphasis is placed on job site safety and site logistics due to congested site restraints and the surrounding urban environment.

Analysis one introduces the idea of using prefabricated brick panels instead of the traditional brick with CMU backup method. The panels would cover 24,417 square feet of the building façade and would take 13 days to erect compared to 240 days for the traditional method. For installation, the tower crane on site would be used to hoist each panel, which would eliminate the need for scaffolding. An additional cost of $207,580 would be added to the project budget if prefabricated panels were used. A mechanical breadth was conducted to determine if the new façade would yield better thermal properties. It was found that both systems produce roughly the same annual BTU consumption rate, with a negligible advantage towards prefabrication.

The second analysis implements roof wind turbines into the structure of the penthouse roof surface. This addition would provide clean renewable energy directly into the building's main distribution panel. The apparatus will face the Southwest where the highest wind speeds impact the building. The total cost of the system is $32,168 and should be installed during the months of February or March of 2014 after the penthouse roof membrane is applied and before substantial completion. The payback period was confirmed through an electrical breadth which reveals a timeframe of 11.5 years.

A third analysis investigates the possibility of using a temporary offsite storage facility to accept material deliveries. The structure would be located walking distance from the hospital where specific daily deliveries would be assembled and transported to the project's loading dock. The purpose of this strategy is to improve upon the logistics of delivery traffic and the material hoist necessity. The structure will cost $360,000 and will be in place for two years from March 2012 to March 2014. With a lead time of four weeks, the erection of the facility will take five days to install. This work will not influence the project schedule since it is located offsite and will be erected by the warehouse distributors.

The final analysis presents a site specific safety plan that focuses on organizing interior construction means and methods. A material layout and staging plan is created to help visualize how material is dispersed throughout the 4th floor of the building. The goal of the analysis is to eliminate construction debris from corridors in order to prevent injuries and decrease time wasted from moving materials more than once. Additionally, material handling methods for items like drywall and metal stud were outlined to avoid injuries during transportation.

Project Introduction

Along with high quality and performance standards and a necessity to match the historical architecture surrounding the project, the Charlottesville Community Hospital project has the primary goal of centralizing pediatric care into one building. In past years, child medical care has been segregated among several areas of the hospital, often resulting in patients being transported from one building to another, depending on their current health needs. This system has also been a burden to traveling parents and hospital visitors, who have needed to travel to multiple buildings for their child's care. With the completion of this hospital, all pediatric services will be located under one roof. Some of these services will include 36 specialty clinics, Pediatric Dentistry, Pediatric Radiology, 12 operating rooms, and a complete outpatient rehabilitation and therapy facility. The building will stand seven stories above ground and cover 200,000 gross square feet. The North end's first floor will serve as a street accessible store front for a future commercial tenant. The main construction challenge is the lack of project space. There is essentially no material laydown space on the project and contractor parking is limited. The proposed hospital is also positioned among other buildings such as a university office building, a restaurant, and a newly built parking garage, as seen on the existing site plan. It is also important to notice how closely the construction is positioned to roads and sidewalks. The sidewalk immediately in front of the project has been closed to provide more room for construction, and another segment has been given overhead protection from potential falling objects. Due to the sidewalk closing, all pedestrian traffic coming from the project side of Main Street and Jefferson Park Ave must cross the street to bypass the construction.

Project Location – Charlottesville, Virginia

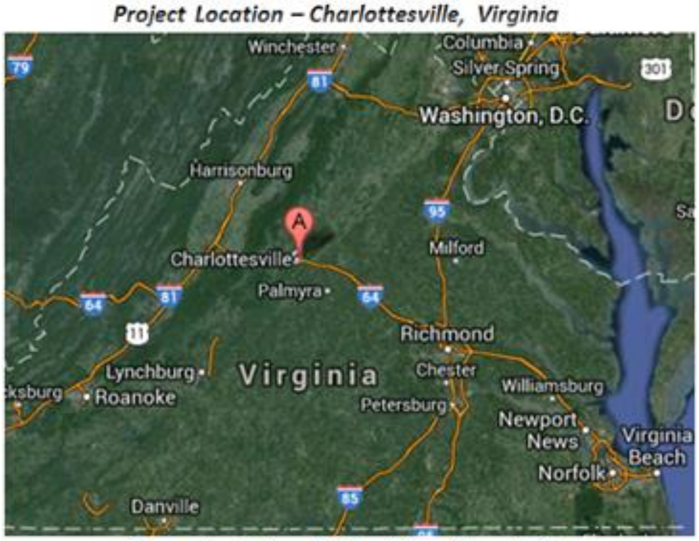


Figure 1; Photo obtained from Google Maps

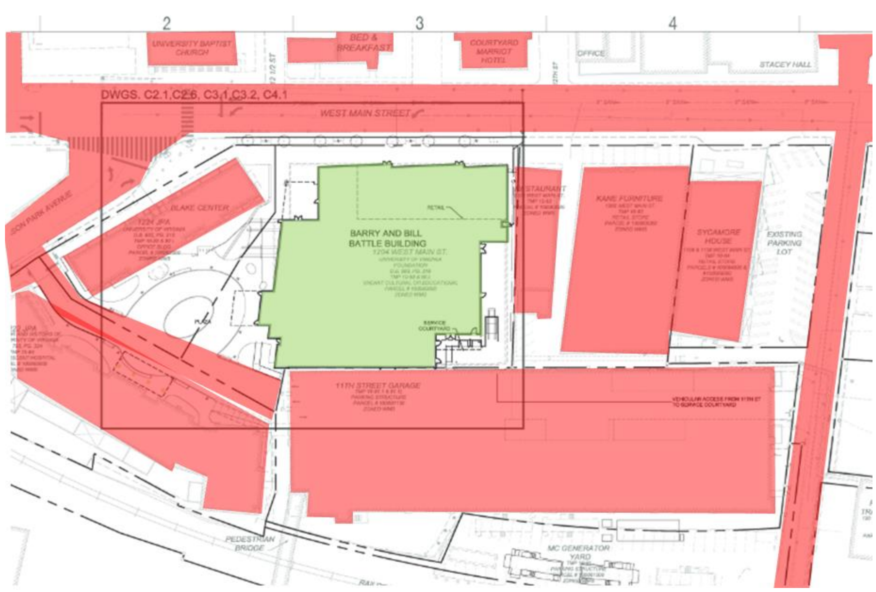


Figure 2; Existing Surrounding Buildings and Roads

Client Information

The town of Charlottesville, Virginia is home to a large community centered around health care and education. Plans for a new children's hospital have been in place since 2005. The three phase project began with the parking garage that currently sits to the hospital's South. This was necessary because previous parking for the area existed on the proposed hospital footprint, and was scheduled to be demolished. After its completion in 2008, several more renovations and utility work were completed in preparation for ground breaking of the Hospital. Historically, the owners have a reputation of building high quality buildings, rarely sacrificing quality when choosing construction materials. Owner inspections are often performed during construction to ensure their specifications are being met. An advantage of the owner's project team is that they have experience in building hospitals such as this one.

* Pristine jobsite working conditions

* Barriers and site protection to hide noise and construction from neighbors

* Identification cards for every employee

* The highest quality craftsmanship
* High end products and materials
* Strict owner inspections

Site Conditions

The site plan below shows the existing conditions of the project site. Utilities such as power, sewer, and water are labeled, as well as essential walk ways and fire hydrants. Other notable features include site entrances and exits, contractor parking, and neighboring buildings. There are four locations into and out of the site. The two southernmost, represented in yellow, have two lanes for access into and out of the project. These locations are predominantly for material deliveries. They are effective in this manner because they are connected to side streets that see limited traffic compared to Main Street on the buildings North face. These processes work efficiently, with entrance and exit only access ways located on the more narrow and congested side of the project. Contractor parking located in green is limited due to the lack of space. General Contractor parking as well as their main office is located two blocks East on Main Street. Another temporary office annex will eventually be located on the third floor of the hospital, which will house contractor's meetings, and other project resources.

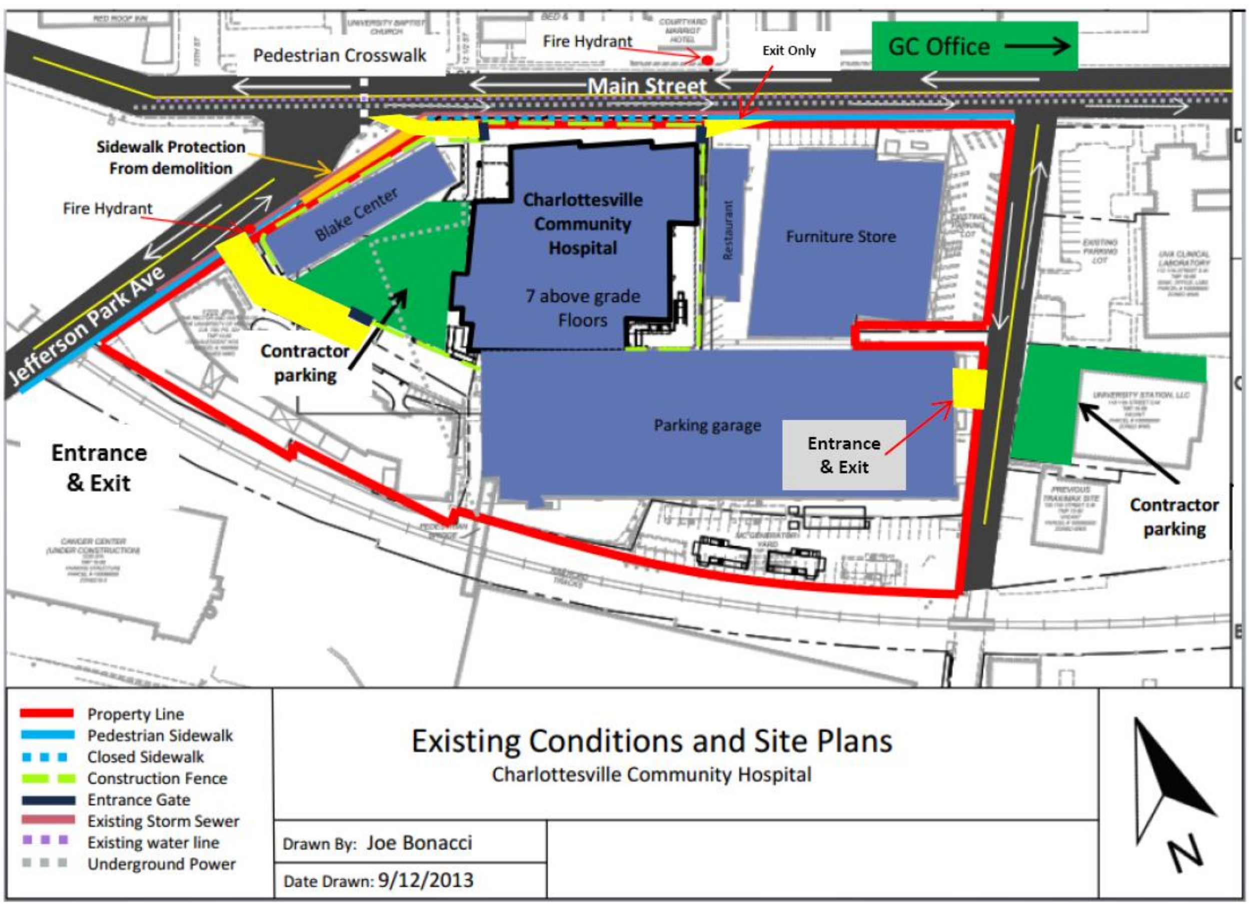


Figure 3; Existing Conditions Site Plan

Currently, tool and equipment staging is set up near part of the contractor parking areas, which is within walking distance to the site. Two dumpsters seen in brown will arrive on site after excavation has begun, and will be used for the remainder of construction. They are located in easily accessible areas so that they can be easily transported to and from the site.

The finish phase site plan in figure 4 introduces the use of loading docks, seen in pink, and a material hoist, seen in orange. These features provide almost all access of interior building materials. The primary function of the loading dock on the northern corner of the building is for trash removal. It is located near a trash dumpster and is regularly manned by at least one member of the general contractor's construction team. The loading dock in the southern corner receives most deliveries, and surrounds the material hoist. All major deliveries use this hoist and loading dock by entering through the east entrance to the parking garage, and traveling through the garage to the material hoist. Portable toilets are located on the ground level along Main Street, as well on the third floor mezzanine roof. These portable toilets on the roof are on an exposed platform that will eventually be the location of a green roof, and it is accessible by a temporary door way from the third floor. This prevents the need for crew members to have to travel from the top floors of the project all the way to the ground floor, which wastes time and causes more foot traffic on site.

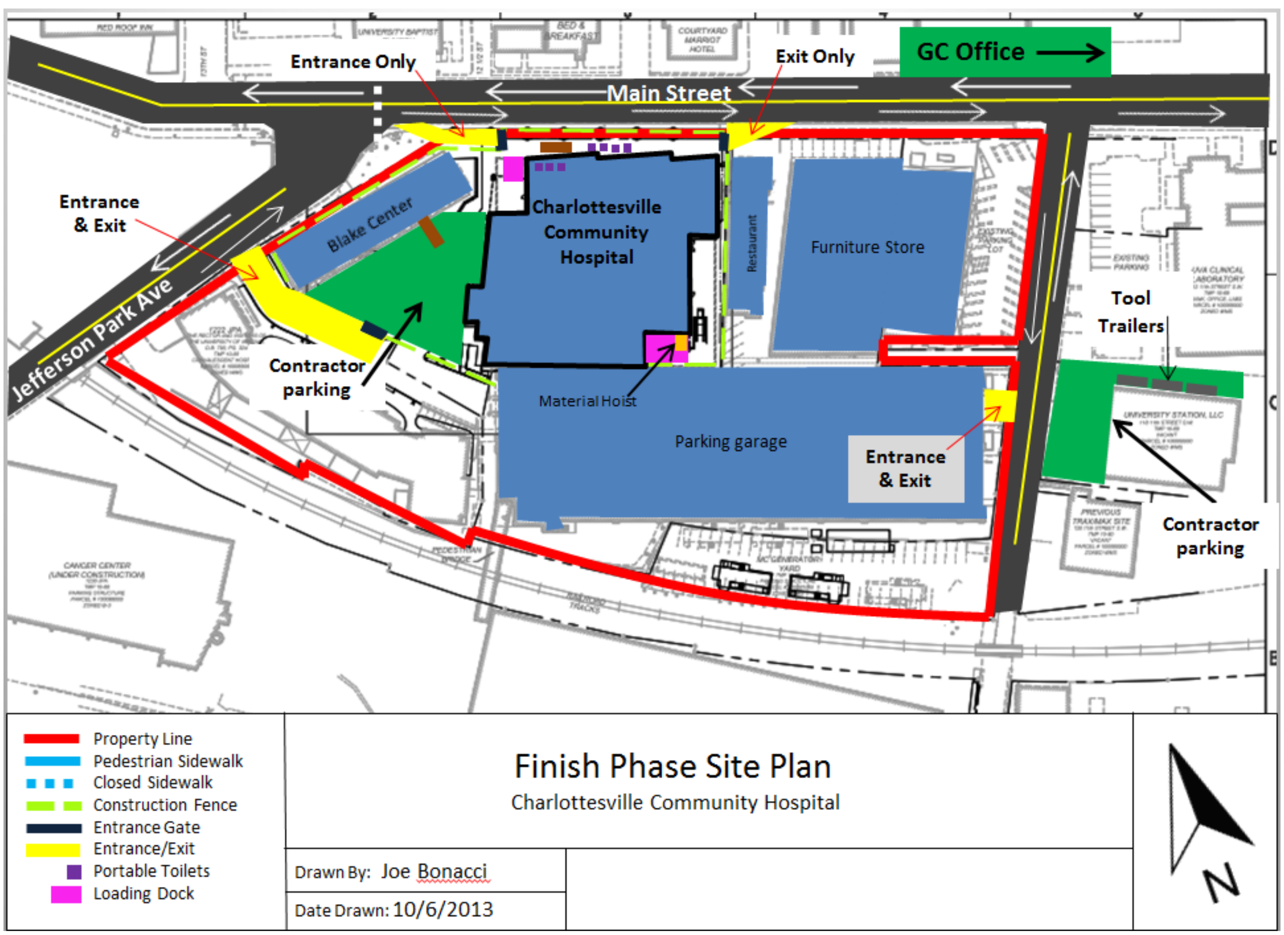


Figure 4; Finish Phase Site Plan

Demolition

Before groundbreaking of the hospital could begin, the demolition of an existing parking lot was completed. This parking lot has recently been replaced by a new parking garage which connects to part of the hospital's South Façade. Other minor demolition such as trees and landscaping were also needed to be removed. Figure 5 shows the project boundary in blue, removable landscape in green, and the footprint of the hospital in red which covers most of the existing parking lot.

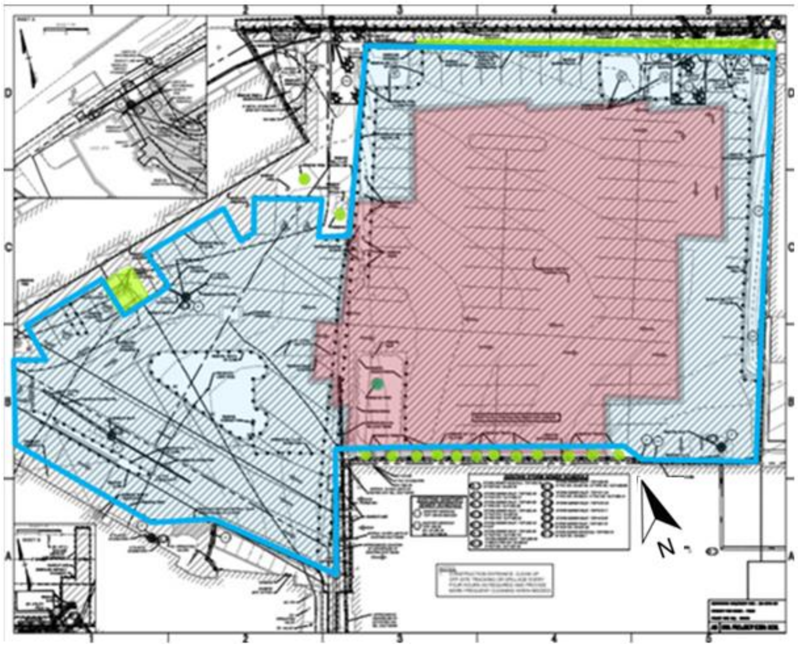


Figure 5

A critical demolition segment of the project scope was to eliminate an existing office building that sits next to the Hospital on its West side. Highlighted in red in figure 6, this building will begin to be demolished on November 12, 2012, which is 18 months after the start of the Hospital's construction. Since the two buildings are oriented so close together, the tear down of the office building will be concealed as much as possible. Starting from the interior, crews will begin demolition of partitions, ceilings, and non-structural components of the floors. Debris is then discarded through windows and emptied into dumpsters. Once the core and shell are ready to be taken down, the building will be surrounded by scaffolding with a tarp applied over top to project against possible falling objects. Demolition will progress from the top down as seen in figures 7 and 8. The completion of the demolition is scheduled to finish during the same time as overall project turnover.

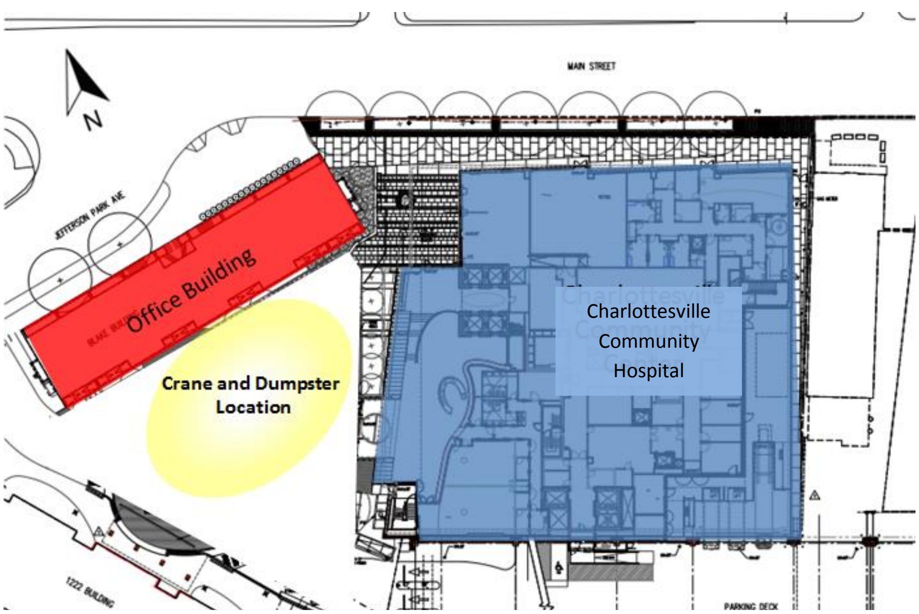


Figure 6

Figure 7

Figure 8

General Contractor's Staffing Plan

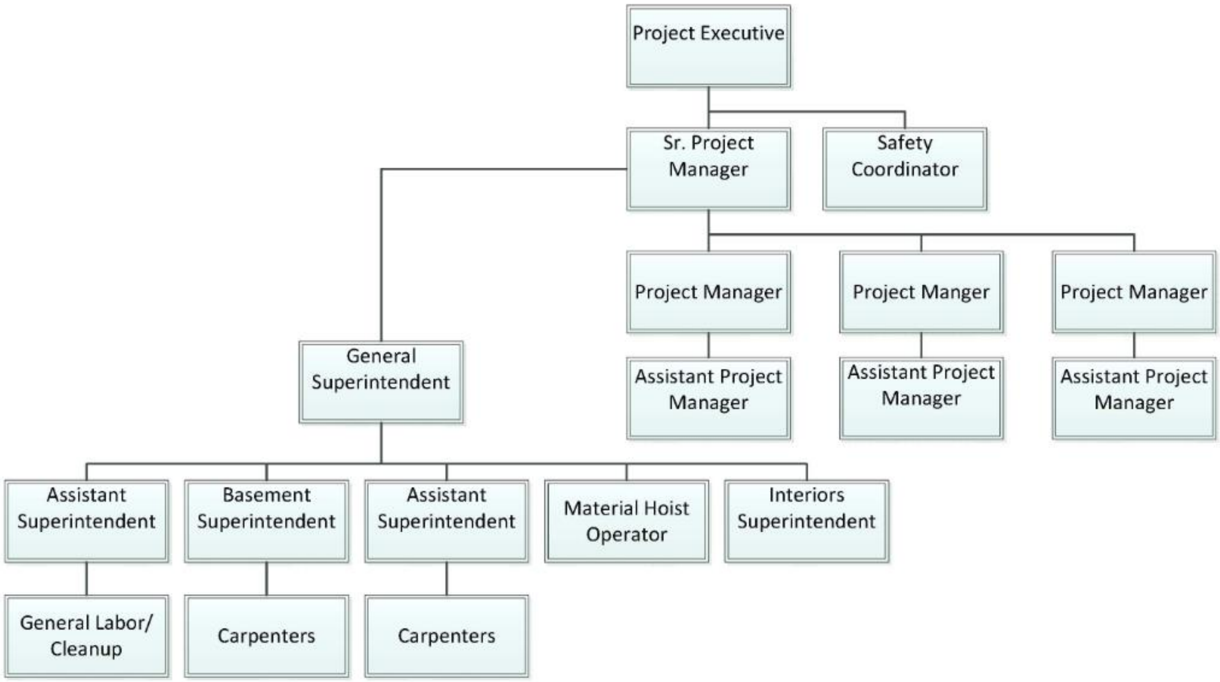


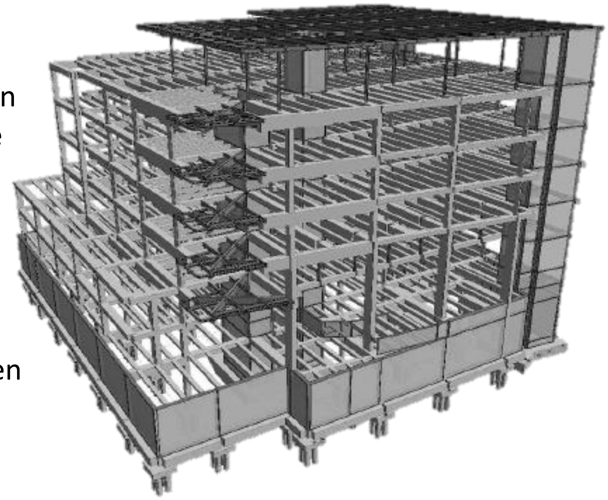
Figure 9

The Senior Project Manager for the General Contractor's team is the main on-site contact with the owner. They are ultimately responsible for the quality and completion of finished product. Three project managers help coordinate with superintendents, change orders, and subcontractor relations. Their time is split between the construction site and the General Contractor's office which is labeled in figure 4. The field side of management is divided by divisions and floors in order to provide a more focused approach. A general superintendent oversees all construction, they are often needed to make final construction decisions in the field, and they are the main contact to all project managers. An interiors superintendent manages the finish work of floors one to six. This involves coordination with interior trades such as drywall and paint, finished flooring, ceiling grid, and casework. Since the basement is unique and not as repetitions as the above floors, a basement superintendent is in charge of its quality and completion. Due to tight site space, there is one material hoist, which is responsible for transporting heavy tools and materials to each floor. The operator communicates with assistant superintendents throughout the day via radio to coordinate deliveries and other material relocation. Lastly, general labor and carpenters are used when needed throughout the building for tasks such as walking ramps and guardrails, temporary partitions, and site clean-up.

Building Systems

Structural

The Hospital is built predominantly of a cast in place concrete structure, which includes concrete beams, columns, slabs, and shear walls. Each floor's slab in 5" thick and the foundation incorporates grade beams and 88 total caissons. Two W40x277 Steel beams support the Northwest cantilevering corner of the building on floors two-six. They are also aided by seven W14x30 steel beams.



Mechanical

Three air handling units located on the roof make up the entire building's air to air system. AHU one serves all operating rooms and distributes 30,000 CFM of supply air. AHU two supplies 73,000 CFM, and AHU three supplies 96,000 CFM. A variable air volume system is also prevalent in the building, which acts as the building's water to air system.

Electrical

The electrical system consists of a three phase 480Y/277V main switch board. It is comprised of 4 wires plus one ground wire, and has a max load of 4000 amps. Also, 480Y/277V is the main utility transformer which has a max load of 2500KVA. All hospitals are at great risk of losing power, since many hospital machines and care devices run off of electricity. For added insurance, a diesel powered emergency generator is provided, with output capacities of 1500KW/1875KVA.

Architecture

Interior architectural features included in the hospital are an illuminated partition system and play spaces located at the Northwest corner of each floor. These spaces are visible from Main Street and are a colorful attraction for both building occupants and spectators. A feature wall made of similar panels was designed for the main entrance of the first floor. An exterior face brick with CMU backup serves as a façade for the East and South elevations, while the North and West elevations are predominantly made of a 1" thick glass curtain wall system.

Proposal Information

The following four analyses describe problematic features of the Charlottesville Community Hospital, as well as potential improvements to its design and function.

The first topic represented in the report is that of prefabricated brick panels located throughout the building facade. This façade system is composed of either hollow or solid bricks that are assembled in an offsite facility, and then delivered to the site in the appropriate dimensions. Because they are prefabricated offsite, the risk of a construction related injury is decreased. Also, this solution eliminates the need for brick pallets and mortar supplies on the jobsite which are the main causes of congestion. The brick panels would be installed via crane, which eliminates the need for scaffolding. Without the stationary scaffolding wrapping the East and South facades, all egress points would be accessible and the risk of an injury from falling objects would be decreased.

A second analysis consists of the installation of wind turbines on the penthouse roof. An alternate source of renewable energy such as this is not prevalent in the scope of the new hospital. Wind turbines will be mounted near the edge of the roof where they are designed to capture the updraft wind that travels up along the building's façade. If successful, this strategy will contribute to an electrical cost reimbursement to the owner. Also, the project team's goal achieve a LEED Gold Certification may become more achievable by this renewable energy source. The effects of this cost savings will be studied in an electrical breadth to determine the turbines effectiveness.

The third analysis involves the implementation of an on-site storage facility for construction materials. This would present a solution to the concerns such as limited site laydown space and delivery congestion. The temporary loading docks and material hoist would see less daily traffic, which leave more room for car traffic throughout the parking garage, and tradesmen traveling from floor to floor. Material delays would be minimal with the new minor delivery restrictions because of the added staging space. An allotted area of space would need to be allotted for each contractor, with preference to those with large building materials like ductwork, and drywall. A member from the project team would be in charge of overseeing the operations of this facility. Their duties would include managing the storage space, accepting deliveries, and creating specific deliveries to go on-site. These special site deliveries would include materials from multiple trades, depending on what is needed for that day.

Lastly, a safety protocol for the distribution of materials such as ductwork, drywall, and metal stud will specifically be researched as to the best way to transport and store them inside. A plan for specific locations of materials like these to be stored will also be designed. These areas will be a combination of unfinished rooms and general spaces throughout each floor. A floor plan will be devised to show exactly where to put materials as they enter the building. These locations may need to be changed as construction progresses, but they will be planned for. The goal is to provide tradesmen with an organized way of moving materials around without wasting time or getting injured.

[Analysis 1] Prefabricated Brick Panels

Problem Identification

The East and South Façade of the hospital are predominantly composed of red brick masonry. The installation of the brick requires the masons to use scaffolding on the South wall, and a hydraulic scaffolding mast climber on the East wall. The scaffold creates both a safety hazard and an inconvenience for workers traveling alongside the building. There is always the threat of falling objects from construction occurring above ground floor workers. Also, brick material and mortar mixing stations occupy much of the already limited site space. Often times, building entrances would need to be closed off due to the progress of the masons, resulting in tradesmen needing to find alternate egress points. Since the space for material staging was limited, brick was delivered to the job site often and sometimes with short notice. The traditional concrete block and brick exterior wall assembly seen in figure 10 is used throughout the structure. This section labels each wall component and clarifies each pieces width.

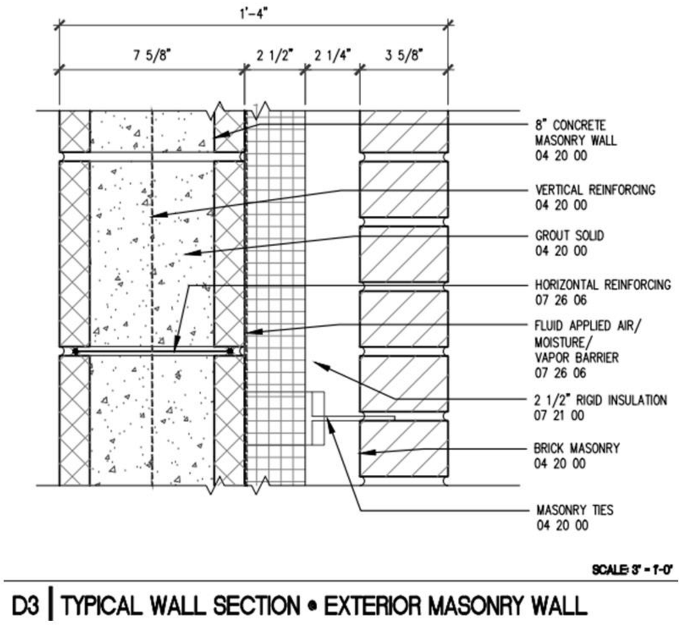


Figure 10

Figure 11 shows the primary location for the scaffolding systems and brick laydown areas in blue. The space is surrounded by existing structures seen in red and is accessible from the first level of the parking garage and a narrow ally alongside the project that leads to the main road. This space is the primary location for material deliveries and is home to the project's loading lock and material hoist which is seen in figure 4. When masonry work interferes with this area, access to the loading dock and immediate material laydown space is limited. Site safety and an efficient façade installation are the primary concerns for this analysis.

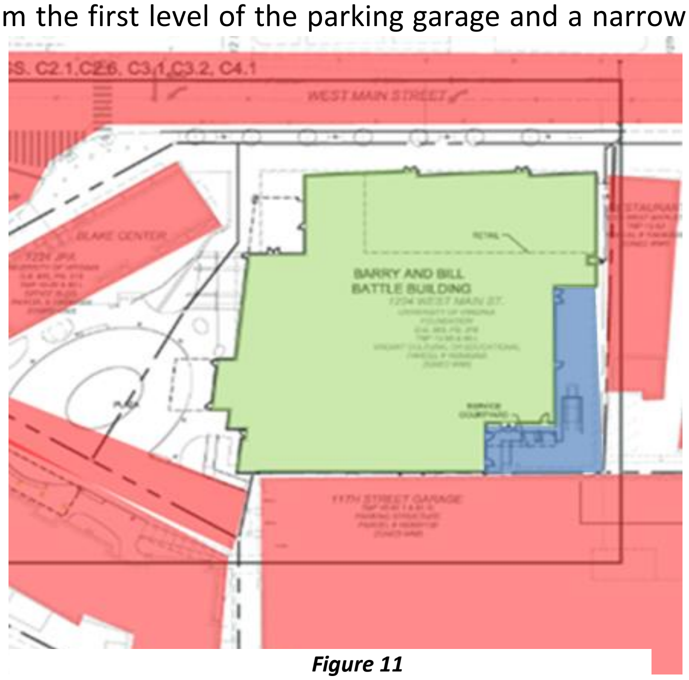


Figure 11

Background Research

Two of the building's five main construction entrances are located near the brick construction. They provide access to the rear of the building when most deliveries are conducted. When they are closed off, the most direct route for traffic to reach the back of the building is to exit from the North side of the building and walk along the East wall, past the scaffolding. Additionally, the installation of the brick facades takes about five combined months to complete. The smaller South Façade takes about one and a half months to complete and is begun after the completion of the East façade, which takes about 3 and a half months. The idea for improving upon the buildings brick façade is driven by unsafe site conditions, congested pathways, and a lengthy schedule.

Potential Solutions

The proposed solution to these issues is to introduce prefabricated brick panels. This façade system is composed of either hollow or solid bricks that are assembled in an offsite facility, and then delivered to the site in the appropriate dimensions. Because they are prefabricated offsite, the risk of a construction related injury is decreased. Also, this solution eliminates the need for brick pallets and mortar supplies on the jobsite which are the main causes of congestion. The brick panels would be installed via crane, which eliminates the need for scaffolding. Without the stationary scaffolding wrapping the East and South facades, all egress points would be accessible and the risk of an injury from falling objects would be decreased.

Requirements for Achieving Analysis

- Contact with *Brick Industry Association* and *Nitterhouse Concrete Products* will be necessary to determine the size, type, and thickness of the prefabricated wall.
- The total R-value for the assembly will need to be found to make a future comparison to current brick construction for an energy comparison.
- Establish location for temporary crane for panel installation. Determine if current tower crane can be useful.
- RS means will provide cost information for current structure and the panel cost will come from the panel provider in order to complete a cost comparison.
- Rate of panel erection and traditional brick laying will be compared to determine if there is potential for a schedule reduction.

THE BRICK INDUSTRY ASSOCIATION

NITTERHOUSE CONCRETE PRODUCTS

Introduction to Prefabricated Panels

After several decades of prefabricated brick masonry being experimented with, it has become more popular today in construction due to the acceptance of its rational design. Also, research into new and improved bricks and mortar has helped the prefabrication process progress. The advantages of this type of prefabrication over traditional masonry construction stand out to building owners and contractors. Most importantly is the efficiency in which the façade can be erected. There is no longer a need for scaffolding and masonry units on site which usually takes up a large amount of ground space. This construction method also allows for the fabrication of complex shapes, angles, and arches which are necessary for windows and other façade protrusions. The panels can be manufactured year round in a warehouse which eliminates construction delays due to weather. Furthermore, they can be ordered well ahead of installation time and be ready for the site when needed. Lastly, the erection process which will be further explained, takes a considerably less amount of time than traditional bricklaying.

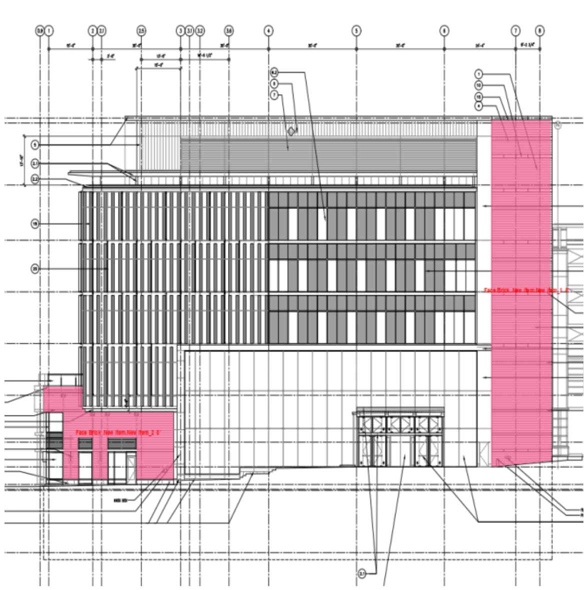
The benefits of prefabrication were further discussed at this year's Architectural Engineering PACE round table event. Here, Penn State's Ray Sowers and John Messner led conversations on the practicality, applications, and safety of prefabrication for trades. The safer job conditions allowed by shifting on-site work into a warehouse, is the motivating factor for this analysis.

Information on Material

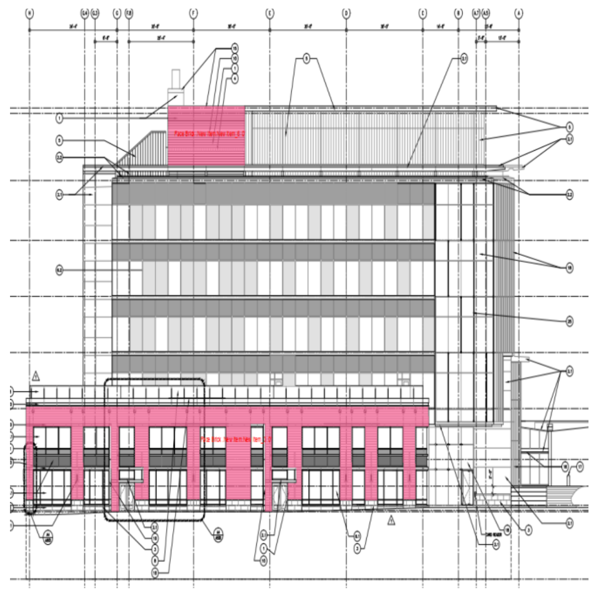
The prefabricated panels to be used on the East and South façade will be six inches thick in total. One of the two components that make up the panel is precast concrete. It will have a width of about 5 3/8" and face the interior of the building. It is common for the concrete to serve as the finished wall for some types of buildings, but for a hospital, the interior facing concrete will be covered with metal studs, insulation, and drywall. The other component is 5/8" thin brick which serves as the exterior face. Thin brick is a type of veneer similar to tradition bricks except for its thickness and it is made of shale and clay. The R-value of the concrete/thin brick panel will be 0.55.

Most precast panels are produced to a maximum of 12 feet in width for shipping purposes. They can be laid on a flatbed trailer during transportation without permitting. The process is scheduled for the trucks to be brought directly from the plant to the crane for installation. The lead-time for such panels is approximately five to six months from award of the project to the delivery start. Therefore, they will be ordered on December 5, 2011, which is about six months prior to the scheduled start of the East wall CMU installation. The total cost of the panels including fabrication, delivery, and installation is about $35 per square foot. This cost may be inflated depending on the amount of repetition in panels. A further cost analysis will be conducted to determine the expense of this new system and how it compares to the existing wall assembly.

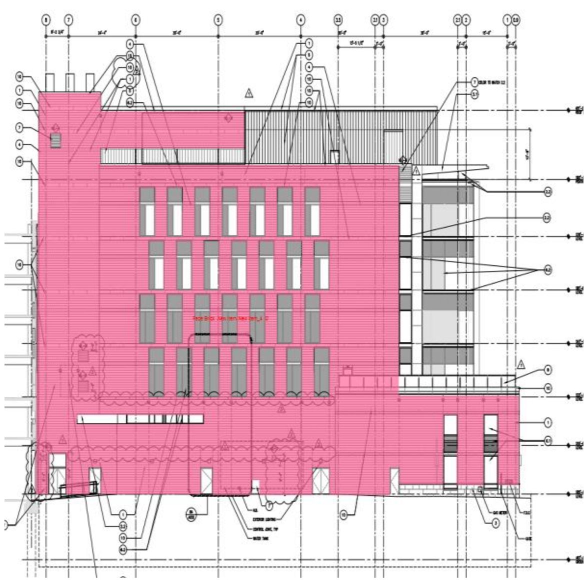
West Facade



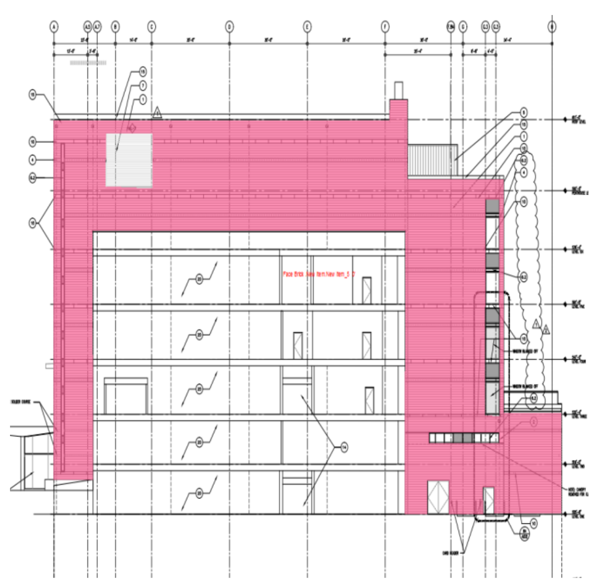
North Facade



East Facade



South Facade



The pink color in each elevation represents the location of all brick veneer with CMU backup. This is also the location where prefabricated panels will be installed. The East wall clearly contains the majority of the material and is the main location of concern for site clutter and safety.

Installation

The process of installing prefabricated brick panels begins with a delivery truck arriving to a specific location on site. The panels will be picked up from the flat-bed truck and instantly attached to the building with all attachment points for cables accounted for by the fabrication team. Each panel will be lifted into place by the project's Linden 8000 tower crane which has a load capacity of 39,680 pounds. The heaviest panel that will be used on the building will weigh 13,500 pounds, so the crane will have adequate strength. A reference of the crane specifications as well as a calculation of panel weight is included in figures 1 and 2 of the appendix. Panel installation will progress from one wall to another with a total of five workers performing to job. A crane operator, two panel installers, and two ground workers will complete the operation sequence. Depending on the workers' pace, 15 to 20 panels can be installed in one day. For the panel installation of this hospital, it will be assumed that 17 panels are installed a day because of their varying sizes. Although panel sizes will vary depending on their location, it will be assumed that each panel takes the same amount of time to be installed.

The order of installation will reflect the original order set on the project schedule, with each wall beginning after the previous wall has already finished. The East façade will be the first to receive prefabricated panels. This façade contains the greatest amount of work with 11,240 square feet of brick. It will be comprised of 80 individual panels, which will take approximately 5 days to erect. The South façade will follow which contains 8,267 square feet of brick. This will require 58 individual panels to be installed which will take approximately 4 days. The North and West facades have a considerable amount of less brick that South and East. Beginning with the North wall, 26 panels will be installed taking 2 days to complete. The West wall will also use 2 days to install its 21 panels and will conclude the building's brick façade. To find the entire duration of installation, each façade's install time will be rounded to a full day. With an assumed rate of 17 panels installed per day, and a grand total of 185 panels, the duration for construction of the prefabricated panels will be 13 days. While panel sizes may vary depending on their location, there will be 24 repetitious panels located on the East façade between the vertical windows. Figure 13 shows these particular panels in blue.

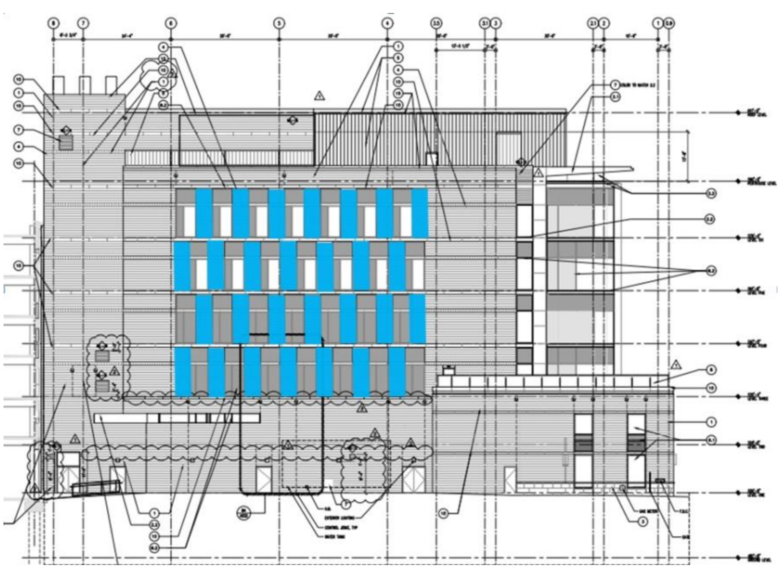


Figure 13

Connection Details

Figure 14 shows a detail of the current exterior façade and how it anchors itself to the floor slab. The brick and insulation seen in red and blue respectively are carried by a steel angle that is connected to the slab. These two materials along with the CMU seen in green will be replaced with a single prefabricated brick and concrete panel. Details of the proposed panel connections are seen in figures 15 and 16. Here, the panels are stacked on top of each other so there is no gravity load applied to the building structure. Steel anchors that are pre-installed into the panels connect to the top and bottom of the slab allowing lateral loads to be distributed to the slab and columns.

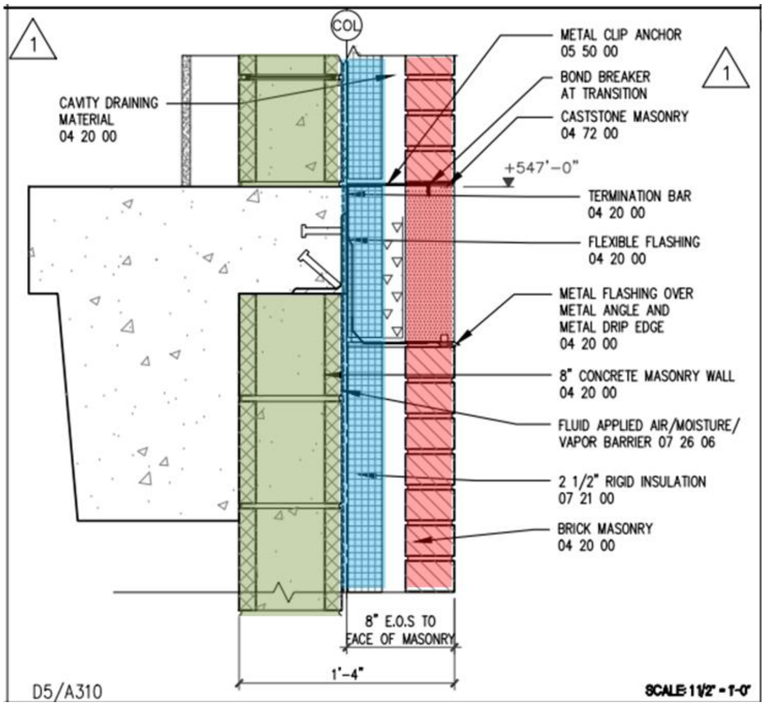


Figure 14

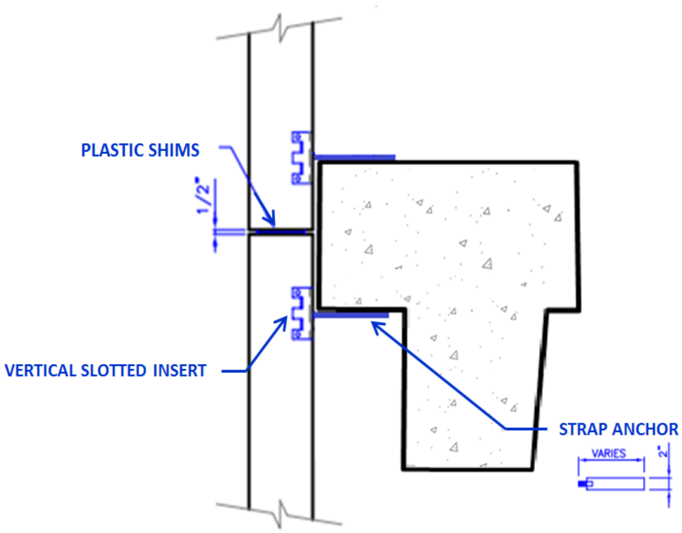


Figure 15

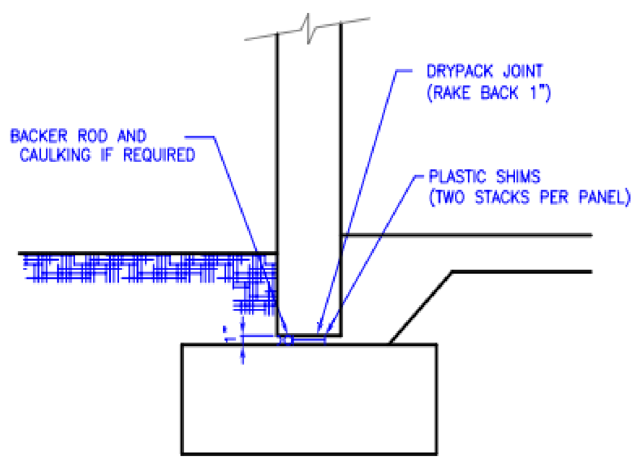


Figure 16

Due to the availability of the tower crane and lack of need for scaffolding, there will not be any lost time due to repositioning of the crane, or moving necessary scaffolding. The most important coordination issue in regards to panel installation is the accessibility of delivery trucks. Figure 17 shows a current site plan and the building footprint as well as the location of the delivery trucks for each elevation.

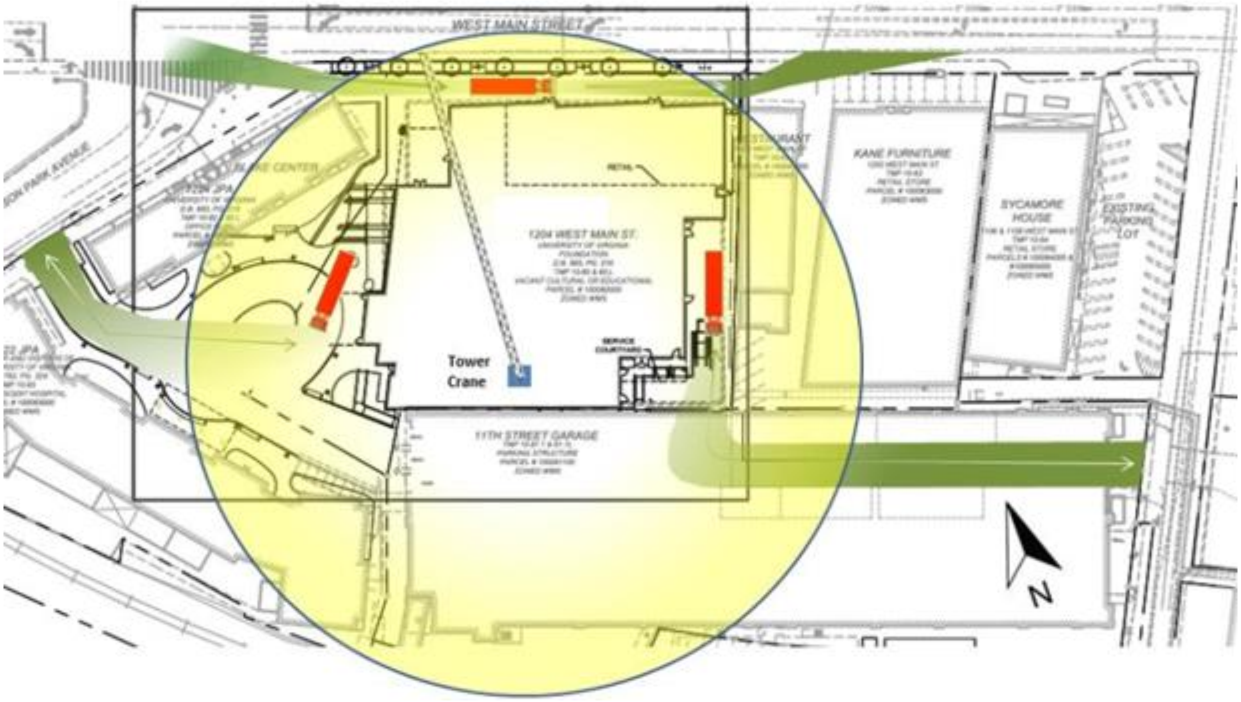


Figure 17

The figure above depicts the delivery operation for the prefabricated panels. The delivery trucks seen in red, travel into and out of the site via the paths seen in green. The Northern most truck will supply panels for the storefront façade. It will be able to enter the site from the West on Main Street and park in front the structure with ample room for ground crews and other workers to travel around the operation. The East façade panels will enter the site through the existing parking garage from the East. The parking garage entrance is 15 feet high and will provide enough room for the delivery truck to back into the appropriate space as depicted above. The third and final truck location to the west will have the most ease in entering and exiting the site and it will provide panels for both the West and South Facades. The current tower crane that is on site will be used to hoist each panel. Its arm radius is depicted by the yellow circle and will be able to reach all delivery locations. A photo of the actual tower crane arm is seen in figure 18. The photo is taken from the Northeast corner of the project, with the crane arm extending over the proposed North truck location.

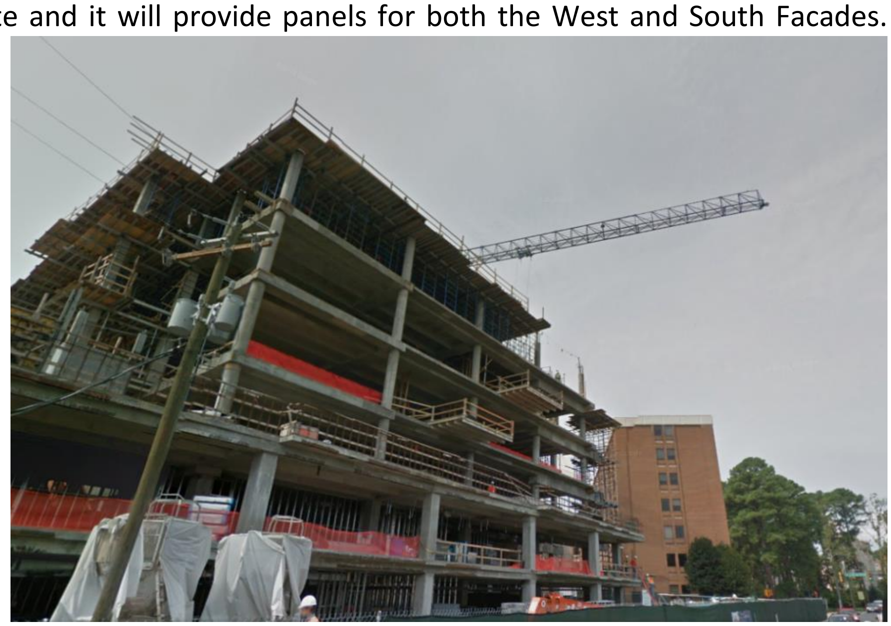


Figure 18

Cost Analysis

One of the research goals of this analysis was to determine if prefabricated brick panels would be more cost effective than traditional concrete block and face brick construction. Costs for the prefabricated panels were obtained from Nitterhouse Concrete Products. A cost of $35 per square foot will be used to determine a total cost of the panels. This assumed value may vary from the actual cost due to the lack of repetition in panel installation. In addition to the concrete panels, a metal stud, insulation, and drywall assembly will need to be implemented on the interior of the building. This practice is necessary in order for the building envelope to maintain an appropriate R-value. With the added building components come additional costs. The cost comparison seen in table 1 shows a breakdown of both methods' material, and which method is most economical. The dollar value associated with each building material is for one square foot of material. The installation and delivery costs of the materials are accounted for in the rates below.

Traditional Method							
	SF	**Face Brick**	**8" CMU**	**2.5" Insulation**	**Vapor Barrier**	**Drywall**	**Total Cost**
East	11240	$18.45	$9.95	$1.12	$0.12	$0.94	$353,610.52
South	8267	$18.45	$9.95	$1.12	$0.12	$0.94	$252,308.96
North	2285	$18.45	$9.95	$1.12	$0.12	$0.94	$69,738.32
West	2625	$18.45	$9.95	$1.12	$0.12	$0.94	$80,115.12
							$755,772.92

Table 1

Prefabricated Brick Panels				
	SF	**Concrete + Thinbrick Panel**	**Drywall & Insulation**	**Total Cost**
East	11240	$35.00	$6.02	$461,064.80
South	8267	$35.00	$6.02	$339,112.34
North	2285	$35.00	$6.02	$93,730.70
West	2625	$35.00	$6.02	$107,677.50
				$1,001,585.34

Table 2

The prefabricated panel method is calculated to cost 25% more than the traditional brick method. The advantages of the cost increase may include cheaper general conditions costs to the general contractor.

Schedule Impact

The modification in façade construction impacts the project schedule both directly and long term. The table below shows the total amount of days that the site will be free of masonry construction and equipment. The original duration for each façade indicates the amount of time in which it was responsible for site scaffolding and other obstructions. Zero days are recorded for the South CMU installation because it is completed during the same time as the East wall CMU. A total amount of 227 days of exterior wall construction were saved by using a prefabricated wall system. This eliminates safety concerns due to ground congestion and falling objects from scaffolding.

Façade	**Original Duration of CMU Installation** (days)	**Original Duration of Brick Installation** (days)	**Total** (Days)	**Duration of Prefab Panel Installation** (days)	**Time Saved** (days)
East	75	40	115	5	110
South	0	39	39	4	35
North	10	30	40	2	38
West	31	15	46	2	44
			240		**227**

Table 3

General Conditions Savings

With the elimination of scaffolding for the South, North, and West facades, and a hydraulic mast climber for the East, general conditions costs will be reduced. In total, $38,232 would be saved. Other mentionable general conditions costs that would be saved include water for mortar mixing, and miscellaneous site clean-up from masonry work.

General Conditions Savings				
	Cost	**C.S.F.**	**Months**	**Total**
Scaffolding	$38.50	131.77	7	$35,512.02
Mast Climber	$680.00		4	$2,720.00
				$38,232.02

Table 4

[Mechanical Breadth] Energy Comparison

With the implementation of a new precast wall panel system, new energy consumption values were investigated with the help of TRACE Energy Modeling software. This program is used to compare two types of building envelops in order to determine their mechanical properties and economic significance. In this Breadth, energy costs were not accounted for. Only an annual energy value in BTU's was found for each type of wall construction. The information entered into the program included the building dimensions, percentage of glass per wall, and the U-values associated with both wall types. A list of the R-values used for the alternative prefabricated wall system is seen in figure 2 of the appendix. The U-value used for the existing wall system was 0.06011, which was predetermined in the program's list of wall assemblies. The table below indicates that both alternatives account for very similar amounts of yearly energy usage. Although the prefabricated panels present a slightly lower BTU consumption, the results do not indicate it as a clear advantage.

Building Energy Consumption

Project Name: Charlottesville Community Hospital | **Date:** February 16 , 2014

City: Charlottesville, Virginia | **Weather Data**: Richmond, Virginia

Note: The percentage displayed for the "Proposed/ Base %" column of the base case is actually the percentage of the total energy consumption.

* Denotes the base base alternative for the ECB Study

		* Alt-1 Traditional Assembly			Alt-2 Prefabricated Panels		
		Energy 10^6 BTU/yr	Proposed/ Base %	Peak kBtuh	Energy 10^6 BTU/yr	Proposed/ Base %	Peak kBtuh
Space Heating	Electricity	34.8	1	9	35.5	102	9
	Gas	3006.3	79	1435	2992.6	100	1441
Space Cooling	Electricity	277	7	528	270.4	98	508
Heat Rejection	Electricity	33	1	57	32.4	98	54
Fans - Conditioned	Electricity	430.5	11	49	413.9	96	47
Total Building Consumption		**3781.7**			**3744.8**		

		* Alt-1 Traditional Assembly	Alt-2 Prefabricated Panels
Total	Number of hours heating load not met	0	0
	Number of hours cooling load not met	0	0

	* Alt-1 Traditional Assembly	Alt-2 Prefabricated Panels
	Energy 10^6 BTU/yr	Energy 10^6 BTU/yr
Electricity	775.3	752.2
Gas	3006.3	2992.6
Total	**3782**	**3745**

Table 5

Final Results

The table below highlights the three main analysis topics that were investigated. The cells in green indicate the more advantageous option. The cost for prefabrication has been adjusted to represent the cost savings from the decreased general conditions. It should also be noted that the 227 day decrease in brick and CMU construction does not reflect an overall project schedule savings. It is simply displaying the amount of time in which scaffolding and mortar mixing supplies will not obstruct the project grounds and various access ways into the building. Lastly, the building energy consumption from both methods was found to be almost identical. Even though there is a slight advantage of using prefabrication, the results do not indicate that there will be a significant energy bill savings, or that the mechanical system could be altered. In conclusion, the results of the analysis prove that job site conditions may be safer with the implementation of prefabricated panels. However, the increased cost and irrelevant energy consumption difference may hinder the owner from going with prefabrication.

Analysis 1 - Prefabricated Brick Panels Results			
Method	**Total Cost**	**Duration** (Days)	**Energy Consumption** (BTUx10^6)/yr
Traditional Brick	$755,772.92	240	3781.7
Prefabrication	$963,353.33	13	3744.8

Table 6

References

1.) Prefabricated Brick Masonry. (2001). Technical Notes on Brick Construction. The Brick Industry Association. http://www.gobrick.com/Technical-Notes

2.) Technical Info. (2006). Nitterhouse Concrete Products. http://nitterhouse.com/technical-info/detail-drawings/panel-connections/

[Analysis 2] Rooftop Wind Turbines

Problem Identification

To power the new hospital takes a great deal of electrical demand. The goal of this analysis is to lower the energy costs of the building by means of renewable energy. This type of renewable power is not common on this project, and the facility could greatly benefit from the modification. Although a LEED Silver certification is required, the project team has a goal of Gold. Additional LEED points will be needed to attain this goal.

Background Research

To begin the search for renewable energy potential, the exterior of the structure was investigated. It was first determined that the penthouse roof is a well suited site for renewable energy. Its surface spans approximately 5000 square feet and is flat with minimal rooftop obstructions seen in figure 19. Additionally, research into local wind reports and building orientation will need to be performed to determine if wind power would be viable. It was determined that the town of Charlottesville has an average wind speed rate that is well above the average for the rest of Virginia as well as the average for the United States. Also, the hospital will be roughly the tallest building in the immediate area, so wind speeds should be at their peak.

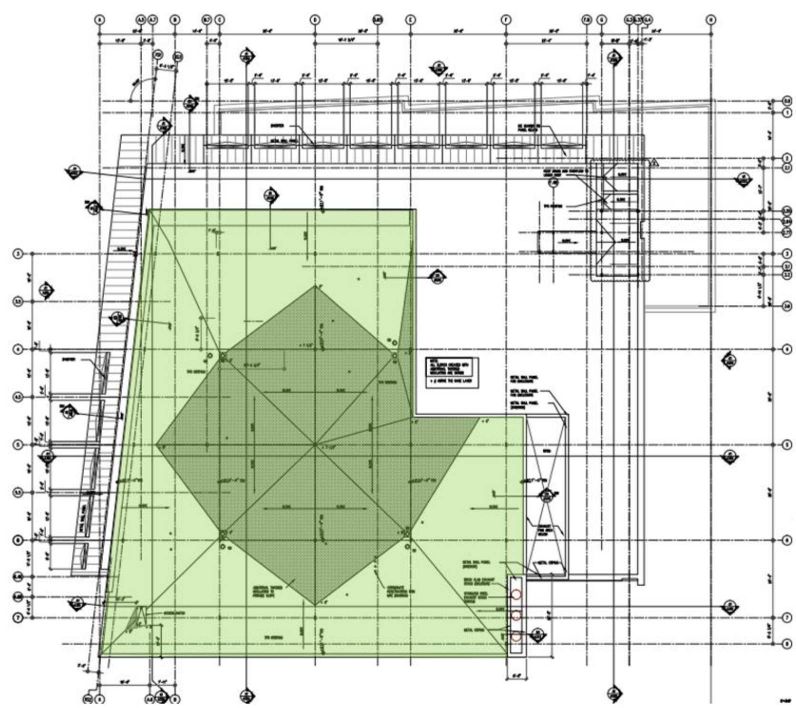


Figure 19

Potential Solutions

The installation of wind turbines will be implemented on the penthouse roof facing the most effective direction. They will be mounted near the edge of the roof where they are designed to capture the updraft wind that travels up along the building's façade. This strategy would contribute to electrical cost savings for building owners by directly feeding alternating current into the building main distribution panel. Another important purpose of the addition is to provide an architecturally pleasing design that promotes sustainability for building admirers and occupants.

Requirements for Achieving Analysis

- Research the historical wind rose for Charlottesville, Virginia to determine the effectiveness of wind turbines and their appropriate building orientation.
- Determine the type of surface the turbines will be mounted to and establish constructability requirements and concerns.
- Contact *Building Turbines Inc.* to determine installations methods, equipment used for installation, and how to calculate the number of turbines needed.
- A calculation of the potential power the turbines can generate will be done to see the financial benefits to the Hospital.
- Determine an appropriate place in the schedule for installation and the time it takes to install turbines to see if there are any scheduling concerns.

buildingturbines™

Introduction to Wind turbines

The specific type of wind turbine that is proposed for this analysis is manufactured by Building Turbines Inc., located in Austin Texas. They have patented a low profile wind turbine product that produces clean on-site renewable energy with low maintenance needs. The turbines are designed to sit on the rooftops of commercial buildings, where they catch the updraft wind that travels up the façade of the building; more commonly known as a parapet vortex. Their design incorporates a horizontal axis which is centered over the vortex in order to capture the maximum electrical power generation capability from the wind. The photo below shows a real application of the turbines situated on a commercial rooftop. The structure of the apparatus is made of lightweight square steel tubing. When operating, very little noise and vibration is created, which is often a concern of roof top wind turbines. A stainless steel axle rod runs down the middle of the turbine, which come in 27 foot assemblies. Power originates from the turbines permanent magnet generator that generates electricity when the turbine spins. The power is routed from the alternator to the inverter where it can be inverted into AC power. The alternating current is then consumed by the buildings main AC panel, which directly offsets power that would have been purchased from the electrical grid.

Figure 20

Turbines measure approximately 10' tall by 27.5' long, with each individual panel measuring about 6' across. Due to the panel's relatively light weight of 1400 pounds, a more focused approach to electrical power and design will be considered rather than a structural analysis. It will be assumed that the roof structure will be adequate enough to support the additional weight. As for the amount of turbines, as many assemblies that are desired may be used together depending on space provided and owner preference. Furthermore, the design is modular in nature so new turbines or system components may be added in the future if desired. For this analysis, it will be assumed that one assembly of four wind panels will be used on the hospital's penthouse roof.

For a building integrated wind turbine to become certified, it needs to be approved by the Small Wind Certification Council. They are an independent accredited certification group who certify wind turbines that meet or exceed the requirements of specified standards. There are currently only eight types of turbines that are certified. While the turbine used for this analysis is not certified by the council yet, it is still legally allowed to be installed on commercial rooftops. A disadvantage of this is that no confident power ratings and sound levels exist.

Benefits of Wind Technology

- Wind power is a premier renewable energy source with zero emissions.
- Power generated from wind can alleviate the electrical load taken from the grid.
- Wind energy helps to promote energy independence from fuel sources such as fossil fuels and foreign oil.
- Allows community to realize the responsibility we have to the environment as a society.
- Electricity can be generated even at low wind speeds of 8 MPH
- Federal and state rebates exist to reduce capital costs to owners for sustainable building advancements.
- Power can be created night and day, regardless of weather, sunlight, or time of year.
- Wind energy can be integrated with solar power on the same building in a "shared system"

Figure 21

Local Wind Research

The diagrams in figure 22 provide wind information for Charlottesville, Virginia. The blue diagram at left is a wind rose which shows the frequency of winds from all directions. In the red diagram at right the bar length shows the average speed of winds when they come from certain directions. The darker colors in the graphs are proportional to the yearly averages. The percentage in the middle indicates how often the winds are less than 5 knots. The information depicted above represents the month of March, which historically has the strongest winds. It also shows that in this month, the greatest amount of wind comes from the Southwest, as seen in blue. However, the greatest wind speeds come from the west, as seen in red.


360
330
30
300
60
270
90
240
120
210
150
180
10%
5%
45%
calm
Frequency by Direction
15kts
10kts
45%
calm
Average Speed by Direction
57%
calm
Frequency by Direction
57%
calm
Average Speed by Direction

Figure 22

Turbine Location

The wind information provides an explanation of how to orientate the turbines on the building. They will sit on top of the west façade, favoring the southwest corner. This will both increase wind generation effectiveness as well as minimize the view of the turbines from pedestrians on Main Street. In this location, the turbine's base sits at 106 feet and they will rotate and be effective in winds as low as 5 mph.

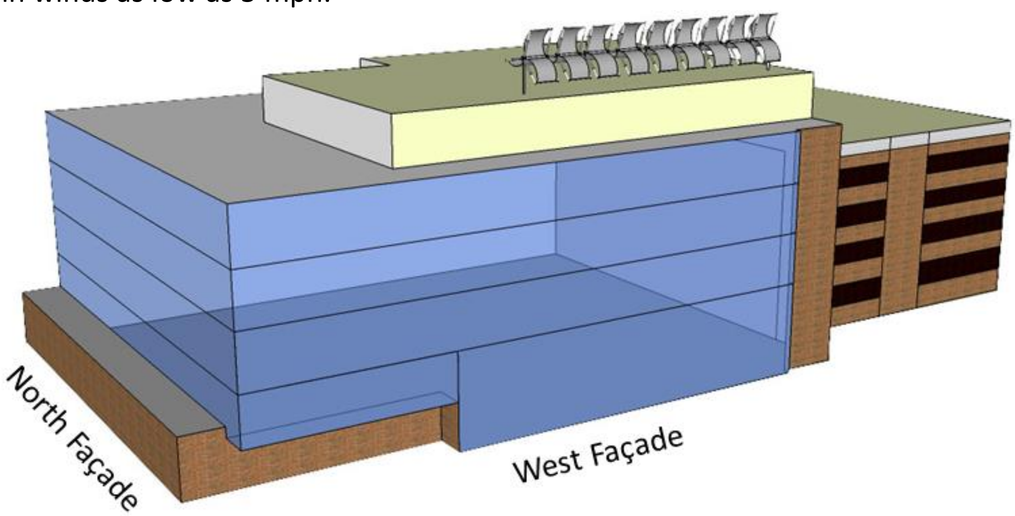


Figure 23

Constructability

One assembly of wind turbines will be used on the roof top of the hospital. This consists of four rotating blades, a generator, an inverter, and the required wiring. The turbines themselves along with the steel tubing frame and generator can be installed in two days with a crew of three men. An additional three to four days may be needed to install structural supporting members that are necessary to hold the extra weight. It is assumed in this analysis that no additional structural support will be needed. The turbines are installed on site at roof level and are delivered to the roof in pieces. It will be assumed that all material is brought to the roof by hand through the building since most material is lightweight metal tubing. A section of the platform in which the turbines will be attached to is seen in figure 24. A TPO roof membrane with rigid insulation sits on top of 1.5" roof deck.

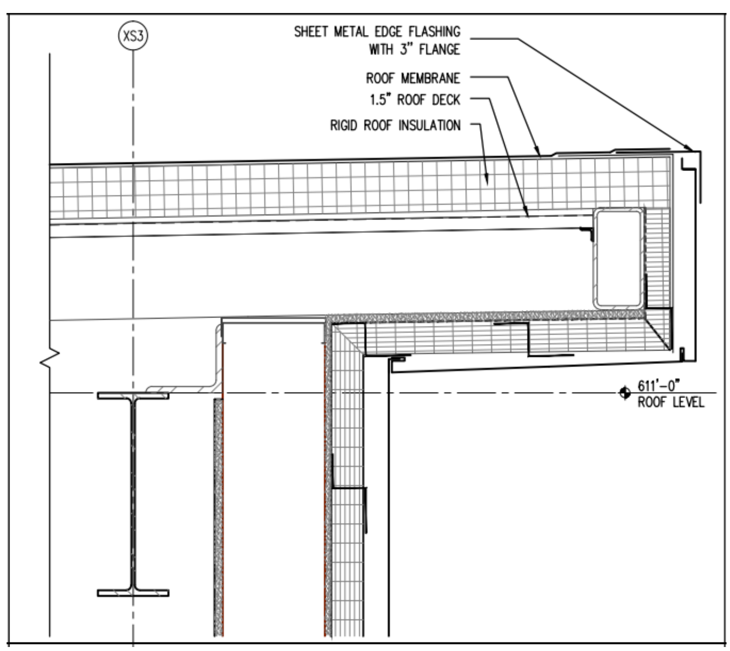


Figure 24

Cost and Schedule Impact

The table below shows all of the variables that are incorporated into the proposed wind turbine addition. Prices were found from Building Turbines Inc. and RS Means 2014. Since the turbines are not a critical path item there is no defined location in the project schedule for them. They must be installed after the penthouse roof is completed, which is scheduled for April 5, 2013. It would be most advantageous for the turbines to be installed after major construction has been completed so that there is minimal conflict among other trades. With a total duration of two days, they can be installed anytime from February 1st to April 1st, before project turnover.

Cost Analysis of Turbines				
Item	**Units**	**Qty**	**Cost**	**Total**
Turbines	Each	1	$25,000.00	$25,000.00
Installation	Hr	8	$150.00	$1,200.00
DC to AC Inverter	Each	1	$3,350.00	$3,350.00
#9 wire	CLF	0.48	$110.00	$52.80
#13 wire	CLF	9.16	$48.00	$439.68
1/2" Conduit	CLF	253	$8.40	$2,125.20
				$32,167.68

Table 7

- **Calculations found on page 60 of appendix**

[Electrical Breadth] Clean Electricity Production

Introduction

The purpose of this breadth is to determine the electrical cost savings to the building owners and find a rough payback period for the turbines. A cost for the required wiring and conduit will be added to the cost analysis of the turbines themselves. The line diagrams below shows the major components of the system from the turbines to the main distribution panel. The specific turbines used in this analysis are relatively new to the building integrated wind industry and do not yet have detailed specifications on total electrical output and voltage. Therefore, the specifications of a similar sized building turbine, which is also designed to be used on the edge of rooftops, will be used for calculation. Total output wattage of 4kw and output voltage of 250V will be used for the turbine, while a 48V, 5kw inverter will be used to transform direct current into alternating Current. These outputs are similar to the certified turbine ratings from the Small Wind Certification Council. A circuit breaker will be installed between the turbine and inverter in order to act as a safety devise. Similarly, a disconnect will be installed between the inverter and MDP so that future maintenance can be performed on the system.

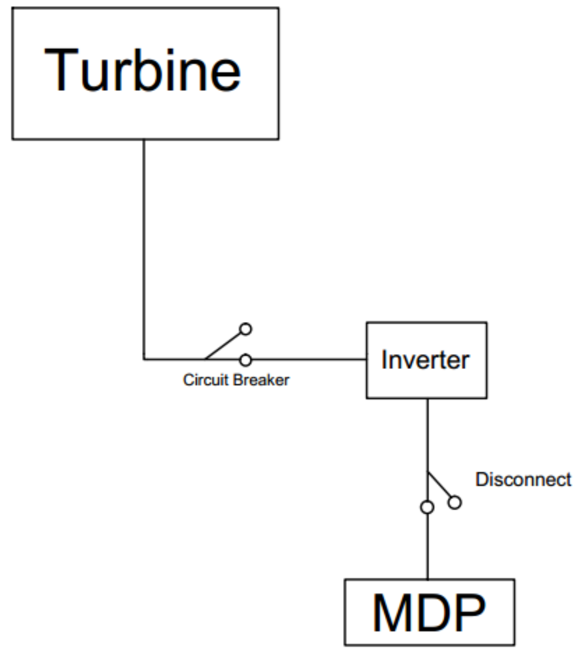


Figure 25

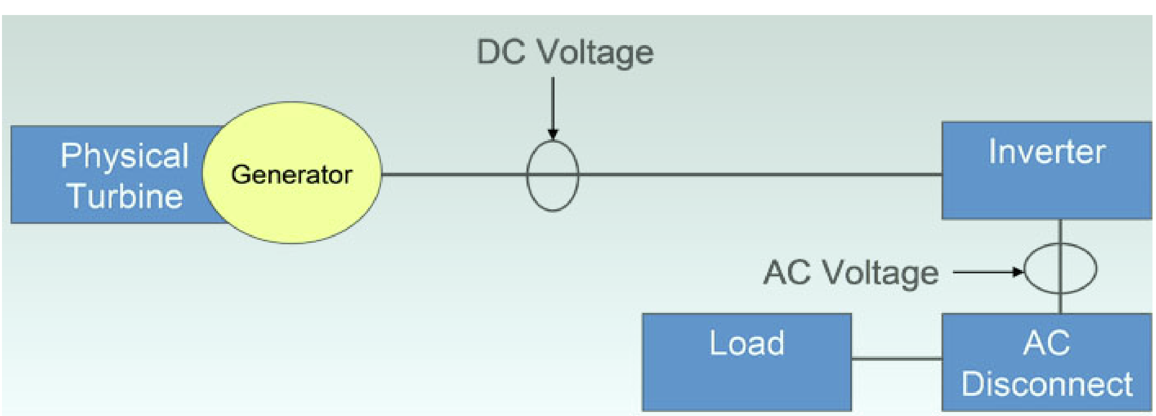


Figure 26

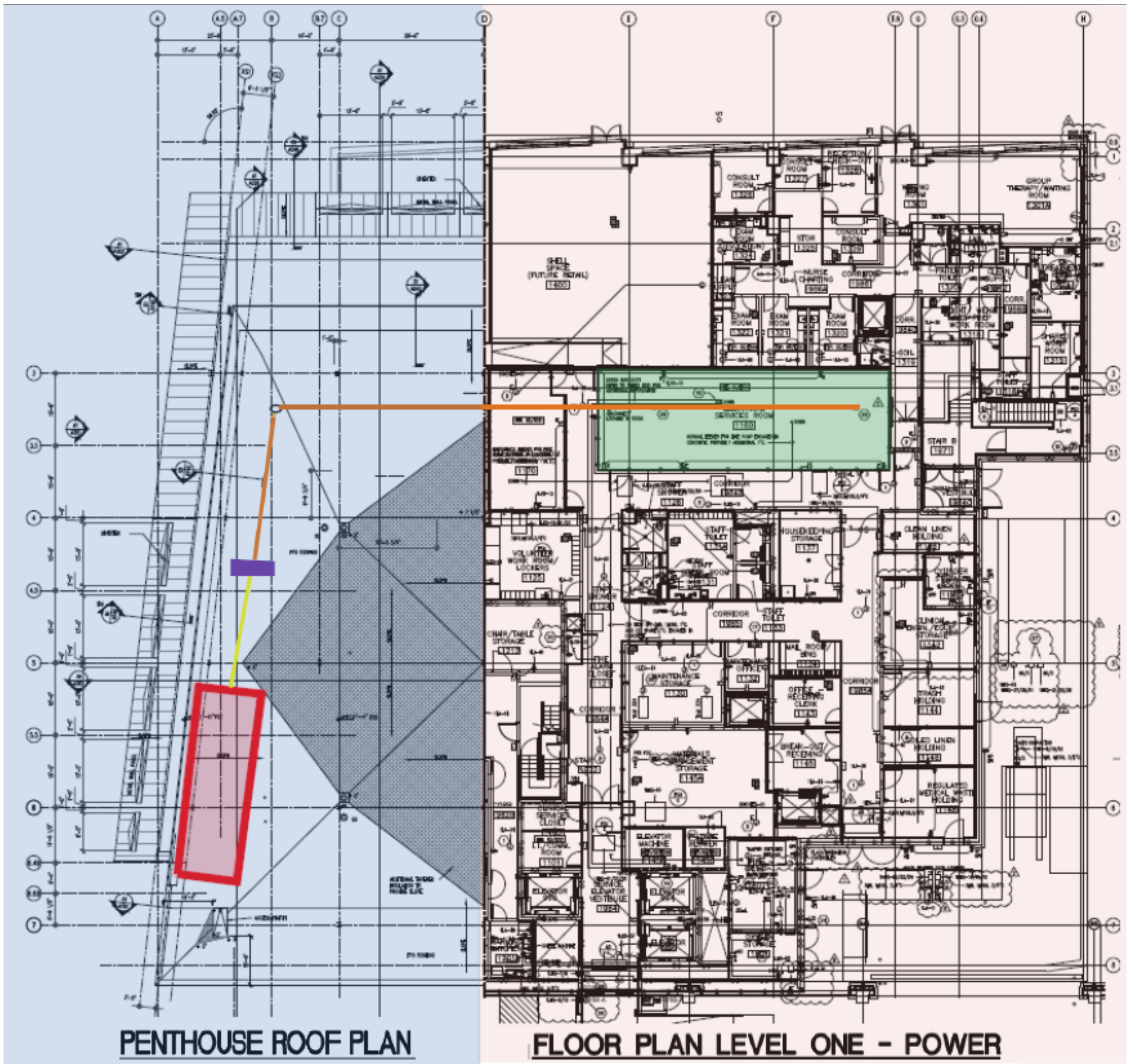


Figure 27

The depiction above illustrates how AC current is delivered to the main distribution panel from the rooftop to the first floor. On the left, the penthouse floor plan shows the turbines in red along with the inverter in purple. The inverter is located a distance away from the turbines incase additional turbines are desired by the owner in the future. DC current carrying conductors connected to the turbines are seen in yellow, and travel 28 feet to the inverter. The orange line represents the AC feeder that is being linked to the MDP located in the first floor electrical room seen in green. To get there, the conductors must travel vertically through the structure for a length of 106 feet and then horizontally through the first floor ceiling plenum for an additional 123 feet.

Payback Period

4kw Turbine * 24hrs/day * $0.0804/kWh = $7.72/day

$7.72/day * 365 days = $2817.8/year

To determine a payback period of the turbine system, an annual cost of electricity that can be produced by the turbines was found to be $2817.80. Included in the calculation is the current electricity cost for commercial buildings in Virginia, provided by the U.S. Energy Information administration. Realistically, the turbines may not operate for 24 hours a day, every day of the year, due to changing weather patterns. Therefore the resulting cost is an absolute maximum possible outcome, which would probably decrease in a real application. With a total system cost of $32,167.68, it would take about 11.5 years to break even with electricity cost savings.

Results

Adding the proposed wind turbine system to the building will add $32,168 to the project budget. Although the calculated payback period was found to be only 11.5 years, the true results of the turbines will most likely decrease due to wind variability. To truly make the wind turbines an effective addition, more advantages than just electrical cost savings will need to be explored. Two areas of interest may be the promotion of sustainability and the architectural influence of the turbines. Showing the community that the hospital cares for the environment and clean energy production can be a good way to gain support for other hospital functions. Also, monitors of the turbines electricity production results can be set up in the lobbies for the public to view and understand. Architecturally, the turbine's panels can be designed for any color or pattern that the owner desires. They may even be able to match the colorful play spaces located at the Northwest corner of each floor that will be visible from Main Street.

References

1.) Renewable Rooftop Wind Power. (2013). Building Turbines. http://www.buildingturbines.com/

2.) KCHO: Charlottesville-Albemarle. (2011). Wind History. http://windhistory.com/station.html?KCHO

[Research Topic] Building Integrated Wind

Wind power is a completely established branch on the electricity market which is growing rapidly. Its implementation is based off the fact that wind is a free, clean, and inexhaustible energy source. Especially today, when petroleum is no longer cheap and plentiful, it is important to develop more new and effective sources of energy. When considering the use of wind turbines, there are criteria that must be considered. The cost efficiency of the amount of energy that can be produced, the impact on the environment, and the impact on the electric usage are all factors to think about. Other motivators for the advancement of wind power are the abundant political support for and public interest in renewable energy. Annual installed wind energy has been and continues to be on the size since the 1990's. Figure 28 shows a graphical representation of the growing rate of installed turbine capacity. Although popularity is growing rapidly, wind power for buildings is not as prevalent as photovoltaic or solar thermal collection devices. The science behind its technology is being further developed and there are still hurdles to overcome in design. From a planning perspective, there are challenges such as noise, vibration, shadows, access for installation and maintenance, and electrical interference. Also, when designing a turbine system, wind speed is a critical component of performance which may vary depending on weather and the time of year. The renewable energy systems industry promotes the idea of a wind-solar hybrid system which simply combines both renewable energy techniques. Wind and solar power can produce similar energy, but may have different attributes. While solar power is quiet and light weight, wind is more efficient and relatively less expensive. Wind power can also work night and day and under cloudy skies, while solar systems rely on sunshine for power generation.

Figure 28

In recent years, the idea of wind turbines being installed on top of homes, school, hospitals and other commercial buildings has become more of a reality. There is a large increase in the interest of Building Integrated Wind Energy Conversion Systems (BIWESCS) for electricity generation due to its various economic and environmental advantages, government incentives, and public awareness. Turbines can be installed strategically throughout a building to specifically augment the air flow. They have been placed in front of air outlets, solar chimneys, and even places between two tall towers, where wind can be naturally channeled.

BIWECS Advantages

- No overhead lines or underground cables required
- Losses are reduced since there is no transportation of power required
- Less storage required
- Maintenance is generally easier with rooftop access

Turbine Types

Residential Building Wind Turbines

A large increase in residential wind turbines have been evident lately largely due to government initiatives. In some instances, the power generated can be connected to the grid and sold back to the utility company. This has encouraged many homeowners to apply a wind turbine on to the roof or yard of their homes. With no required battery and low maintenance costs, it is very easy for a homeowner to save on their electricity bill.

Figure 29

Figure 30

Commercial Building Wind Turbines

An attractive quality of a building turbine on the roof of a buisness is that it shows the effort put into clean energy practices and can serve as a great marketing piece. Also, many small commercial buildings.

Figure 31

Figure 32

High Rise Building Wind Turbines

There are few models currently available of high rise building with building integrated wind, although much research is being conducted into the concept. One example is seen at the Bahrain World Trade Center Building seen in figure 34. Here three wind turbines are situated between two 50 story buildings. The building's walls are angled in such a way as to keep the wind channeled and consistent for all three propellers. In figure, a 42-story apartment building in London will feature three turbines nine meters in diameter that are designed to generate power for the buildings lighting systems.

Figure 33

Figure 34

Wind at Buildings

Wind flow across a building is dependent on many variables and can be studied to strategically place a wind turbine on a roof top. Two areas to focus on include the stagnation point and the separation boundary layer. The stagnation point refers to an area on a building where air flow is at its highest pressure. This point is represented by the black dot in figure 35. Here, wind is either directed upward or downward depending on the orientation of other surrounding buildings. Table 8 shows a ratio of stagnation point heights for buildings with varying dimensions. The reference column lists the names of those whose research the dimensions are based off. Generally, a value of 0.85 is assumed for calculation.

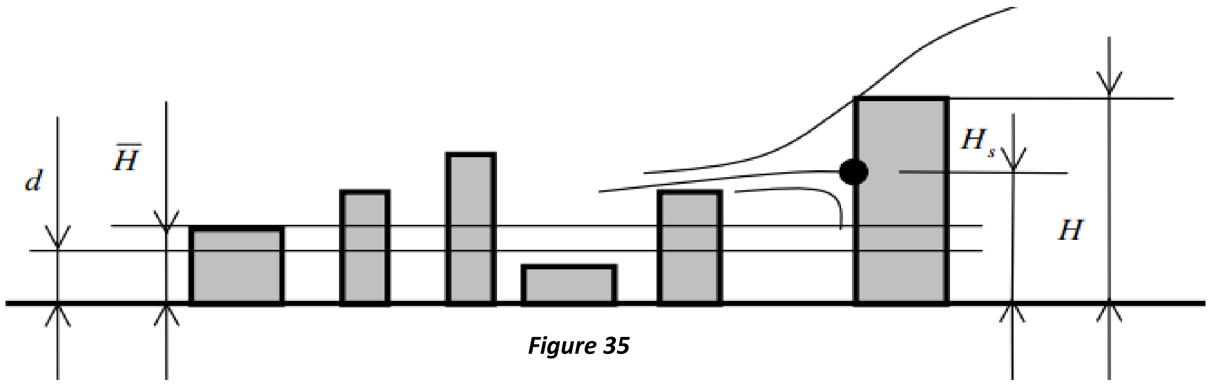


Figure 35

The separation boundary layer is an area above the roof top of a building where the air stream of the wind current meets opposing wind forces in the vortex. This area is seen in figure 36 and is the reason why wind turbines are effective on the edge of rooftops. Because of the separation at the upwind roof edge, the velocity vector outside the recirculation region is not parallel to the roof. The angle between roof and velocity vector outside the recirculation region is called the skew angle to distinguish it from the yaw angle in the horizontal plane. The skew angle varies with the following variables.

Reference	Building Size Depth : Width : Height	$\frac{H_{s,o}}{H}$
Sharan	1:1:2	0.85
	1:1:3	0.85
Baines	1:1:1	0.8
	1:1:8	0.9
Jensen	1:2:1.1	0.8

Table 8

- Position of the roof
- Roughness of the upwind area
- Sizes of the building
- Upwind edge rounding
- Yaw of the free stream wind to the building

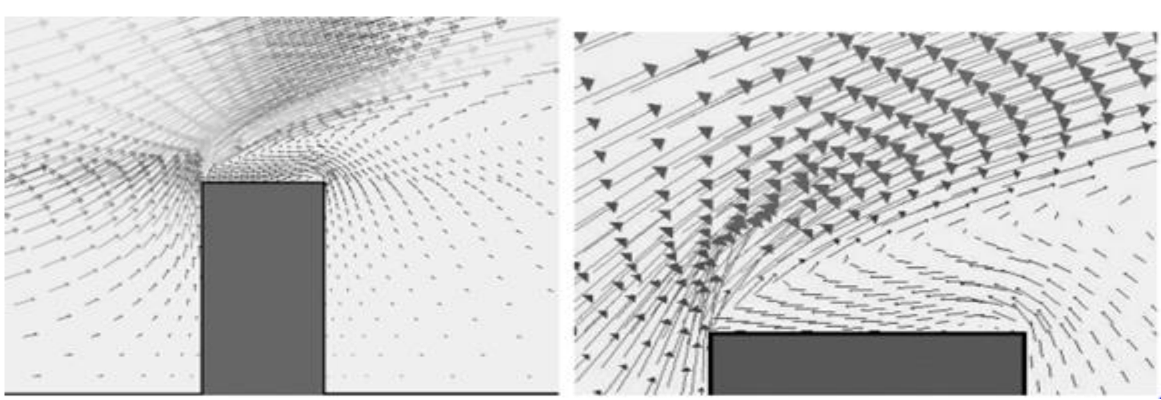


Figure 36

Context for Building-Integrated Wind

There is a strong appeal of integrating wind turbines into our buildings. Rooftops provide great free real estate and higher wind speeds for turbines. The wind power industry has gone through a steady evolution since the 1970's when interest in generating electricity from the wind was relatively new. By the 1980's wind farms were introduced on windy ridges where maintenance was more efficient and power could easily be fed into the utility grid. Today, a newer positive shift of wind power interest comes in the form of integrating wind power directly into buildings. Generating electricity on site reduces the need for transmission. This in turn reduces transmission losses as well as the materials needed for wiring and poles.

Building integrated turbines have plenty of criticisms between their performance and practicality standards. Much of this comes from relatively inexperienced turbine manufactures and the lack of detailed case studies. A common concern for installing wind turbines on buildings is that blades might fly off and injure people or property. Wind turbines have been recorded in the past for occasionally losing a blade. However, these accidents occurred in a field or on a ridge where serious damage was unlikely. Even if the building owner is willing to accept the risk of having turbines on a roof, their insurance company may not be. Another concern is the trouble of obtaining actual measured performance data from manufactures. Most of them claim to not have such data or are unwilling to share it due to the actual electricity production being worse than expected.

The greatest folly associated with building integrated wind systems is their ratio of cost effeteness to electricity production. Rooftop wind turbines operate on too small of a scale to make a significant impact on their building. A major contributor to this inefficiency is turbulent wind flow at rooftops. For a wind turbine to work successfully, it requires a steady stream of air flow to continually strike the blades. At roof tops, turbulence comes from the irregular shapes of buildings, trees, and other unnatural features. A more effective application of wind power comes from wind farms placed in windy parts of the country and oceans. Here, the turbines are exposed to a more laminar flow of wind with minimal turbulence, resulting in a more favorable ratio of cost to electricity production.

To aid in the potential for successful building turbines, it is very important to implement architecture and public awareness to sustainability into the design. While electrical cost savings may not be significant, the idea of creating an architectural feature that promotes green building is helpful. The only precaution of this method is making sure the turbines are always operational. The wrong messages of wind power can be portrayed if the public sees the turbines are not moving during the day. In conclusion, wind power is an effective energy source that is dramatically growing in both technology and popularity. Currently, the best practice for wind turbines exists in large scale rural areas where wind is more streamlined, rather than small scale rooftop applications. Wind is a clean renewable energy source of the future that should continue to be explored.

References

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[Analysis 3] Material Storage/Delivery Hub

Problem Identification

The first of four technical analysis topics to be discussed is the creation of material storage units and a potential delivery hub for all contractors. The idea stems from the main problematic theme of limited site space for material staging. Also encouraging these new units are the congested loading docks and parking garage driving lanes that suffer from large deliveries. Another concern for management is the tight material ordering windows that contractors have. Since contractors can only bring their material into the building when it is ready to be installed, they must either have their own warehouse for staging or have the material delivered at the perfect time. With such demands, the project team is at a greater risk for construction delays due to material not being delivered on time. Additionally, owners are now paying warehouse storage fees for materials that contractors need to have released. These off-site storage facilities are also an inconvenience for the contractors who have to spend time traveling from them back to the job-site.

Background Research

To determine if this analysis was possible, a physical site for the storage facility would have to be proposed. Even though the job-site boundary does not have room, there is a vacant lot located across the street to the East. It is an undeveloped space with part of it used for contractor parking. Another idea considered was the possibility of trades using the facility to pre-assemble or produce buildings parts, instead of doing so in the field. The size, construction type, and materials used for the units will also be considered.

Potential Solutions

The implementation of these on-site storage units would present a solution to the concerns listed above. The temporary loading docks and material hoist would see less daily traffic, which leave more room for car traffic throughout the parking garage, and tradesmen traveling from floor to floor. Material delays would be minimal with the new minor delivery restrictions because of the added staging space. Of course, an allotted area of space would need to be allotted for each contractor, with preference to those with large building materials like ductwork, and drywall. A member from the project team would be in charge of overseeing the operations of this facility. Their duties would include managing the storage space, accepting deliveries, and creating specific deliveries to go on-site. These special site deliveries would include materials from multiple trades, depending on what is needed for that day.

Requirements for Achieving Analysis

- Define the location and orientation of the facility in order to integrate it with the property boundaries and delivery access.
- Determine from Southland Industries the benefits of using a storage facility and what challenges come with scheduling deliveries.
- Research a type of temporary warehouse structure to determine its cost and erection means.

Site Logistics

The proposed lot for the material staging site is located to the East of the hospital across from the entrance to the parking garage as seen in figure 37. In this location, access to both the temporary warehouse and the construction site are easily accessible through the parking garage, which is currently the main source of project deliveries. This location consists of miscellaneous construction materials and contractor parking space which is rarely filled to capacity. With a smooth terrain and easy access from Main Street, this location would well suit a temporary structure. The property is owned by the town of Charlottesville and is zoned as Mixed Use. The dimensions of the lot are 70'x140' which will provide enough room for a temporary structure and sufficient contractor parking.

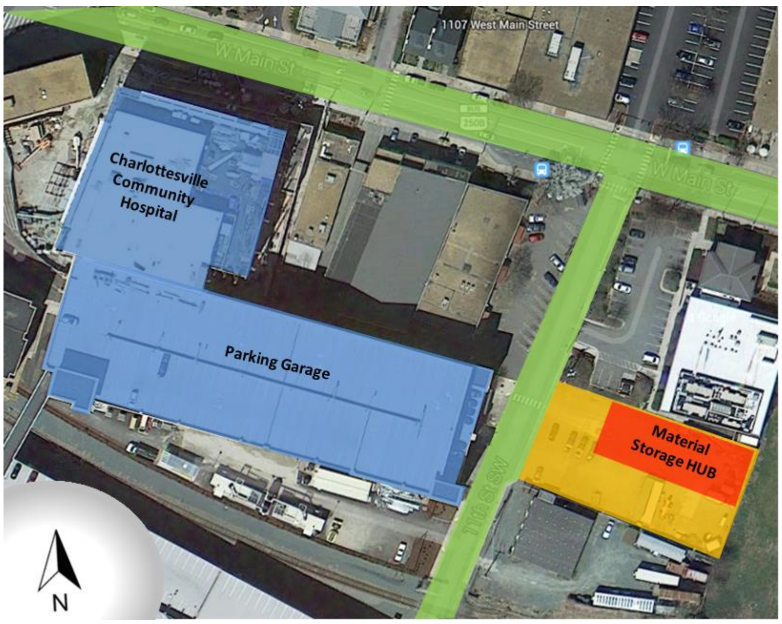

Figure 37

- The buildable footprint is seen in orange with a rough estimate of the size of the structure in red.
- Sufficient space for installation of the warehouse is available.
- In green is depicted the roads in which deliveries are able to reach the warehouse.

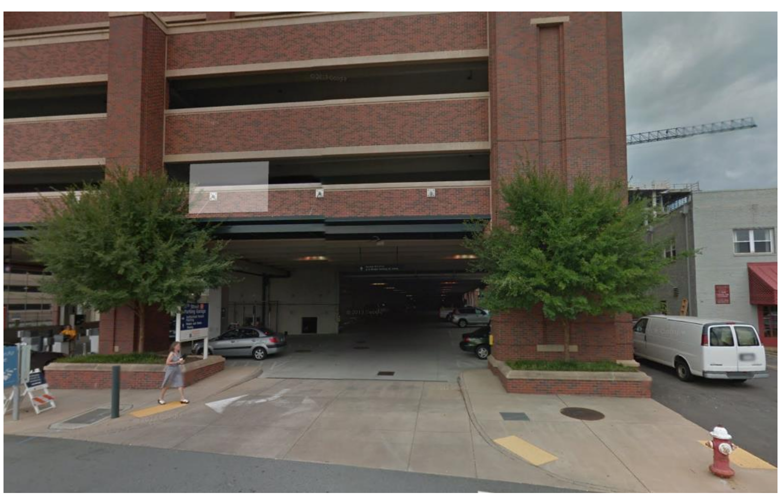

Figure 38

- The parking garage entrance is 15' high, which is tall enough to fit a tractor trailer.
- Lanes are wide enough for cars to access the garage while an unload is occurring at the loading dock.

Building Structure

When determining the needed size of the facility, the types of materials, delivery methods, and necessary contractor parking spaces were considered. The structure would need to be designed tall enough to support a loading dock to accept deliveries from tall trucks that back into the open bay. Also, it would be beneficial for the structure to be setback from the road with enough space for trucks to back into the bay and not obstruct traffic. Although there are no designated parking spots for contractors and there is often extra parking space, an adequate amount of spots will need to remain. Figures 39 and 40 show the orientation of the storage warehouse with parking spaces included.

Figure 39

- Clear access to rolling doors from Side Street.
- Two man doors are located on the right side of the structure.

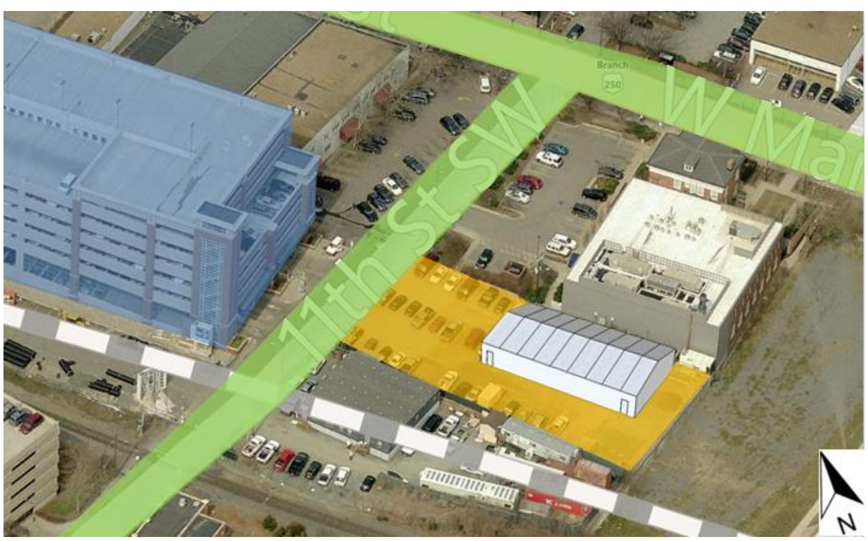

Figure 40

- Installation of structure will take 4-5 days.
- A small boom forklift and 4 men are required for installation
- The remaining space in orange may be used for contractor parking.

HTS-Industrial Building Specialists design, manufacture, and install temporary buildings such as the one needed for this analysis. Located in Florida, they deliver the appropriate building components in pieces via 40 foot containers, with a lead time of about 4 weeks. The structure can be designed for any size, with any arrangement of openings. For this application, a Thermo-Insulated Modular Building will be chosen in order to reduce heating and cooling costs, and to protect stored materials that may be susceptible to unregulated temperature. The building will have an eave height of 13’8” with a perimeter of 40’ by 82’. It will occupy about 34% of the ground space provided for the structure, with the remaining 66% open for contractor parking and delivery access.

Case Study

HTS has provided long term warehouses such as this for all sorts of clients throughout the country. A similar application to the proposed warehouse was executed for a corrugated packaging company who required an extension to their existing building in order to store packaging material. It was decided that the modular temporary warehouse must eliminate internal condensation and be able to maintain a consistent internal temperature. HTS proposed, manufactured and installed their L-series thermo roof buildings, which is the same type of structure proposed for this analysis. The temporary building also featured insulated wall panels for added thermal improvement. This temporary structure was supplied for a fixed term of 36 months, but the client has recently negotiated to extend the term indefinitely because of its successes. Below in figure 41 is a photo of the client’s temporary warehouse.

Figure 41

Working Operation

Southland industries houses a fabrication shop which also serves as a temporary storage facility for product that will soon be delivered to a construction site. A copy of the questions and answers from an interview with southland's Jim Haller are located on page 54 of the appendix. Their insight is reflected in the paragraphs below.

With building materials readily available near the project site, the general contractor's superintendents will have the ability to acquire the products they need when they need them. In order for the operation to run effectively, it would be reasonable for a one week look-ahead to be created which outlines what materials are needed per delivery. A delivery may consist of multiple building components with the intention of immediately constructing a specific area. Otherwise, deliveries may consist of only a few trades' items which are needed for installation. Communication between the superintendent and warehouse manager will indicate the type of delivery from the storage warehouse to the project. This information may be best shared during the weekly contractor's meeting. A responsibility of the superintendent on site is to prepare the material hoist and loading dock for incoming material. This includes blocking off specific times for a delivery truck to use this area.

The warehouse allows contractors to order their required materials and have them delivered to the site immediately, assuming space is still available. This is advantageous to the contractors in that they can receive payment for their materials which have arrived on-site, which can increase their cash flow. Also, the lead times for materials will have less significance since there is a greater timeframe for when they can be delivered. Trades will need to communicate with the warehouse manager to schedule their deliveries, so not to conflict with other trades who may be delivering to the site on the same day. A small forklift will be needed for the transportation of larger materials into and out of trucks and around the facility. Contractors will have the ability to buy certain products in bulk at one time, which could save on the cost per item and future delivery fees. These items may include drywall, metal framing, insulation and conduit, which can be easily stored for longer durations.

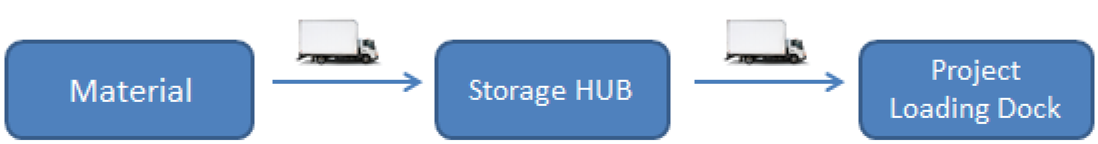

Figure 42

Cost Analysis

Table 9 below shows the breakdown of all costs associated with the addition of the storage warehouse. The warehouse is planned to be in use for 24 months, from March, 2012 to March 2014. Besides the structure shipping and installation costs are included, which were provided by HTS. A copy of the warehouse quotes which include necessary building components, product and shipping costs, is located on page 55 of the appendix. General Conditions costs will increase due to added temporary utilities, material transportation to site, and a warehouse manager. It was assumed that temporary heat and temporary cooling will each operate for five months out of the year. Performance data for the specific type of air conditioner, as well as a calculation of its annual costs is found on page 53 of the appendix. Pricing for general conditions items were recorded from RS Means.

Cost Analysis of Temporary Warehouse

	Item		Cost
Structure	Product		$52,260.00
	Installation		$7,380.00
	Freight		$5,800.00
			$65,440.00

		C.S.F.	Weeks	Rate	Cost
General Conditions	Temp. Heat	32.8	43	$36.00	$50,774.40
	Temp. Lighting	32.8		$21.50	$705.20
	Temp. Power	32.8	103	$0.43	$1,452.71
	Temp. Cooling		43		$3,012.40
	Transport Truck		103	$30.00	$3,090.00
	Forklift		103	$30.00	$3,090.00
	Warehouse Manager		103	$2,250.00	$231,750.00
	General Laborer		103	$2,050.00	$211,150.00
					$505,024.71

Table 9

Conclusions

A temporary material storage facility that will be used to ease delivery methods will exist for a period of 24 months and will require an additional $570,000 to the project cost. This warehouse may increase construction productivity by reducing the demand for the material hoist and minimizing congestion from material staging in corridors and lobbies throughout the building. With the offsite location of the facility and an installation time of about 5 days, the project schedule will not be influenced by this addition. It is suggested that the facility be erected in March 2012 in order to be ready to begin receiving deliveries such as sheet metal duct and mechanical piping. Disassembly may commence by March 2014 when the majority of interior construction is scheduled to be completed.

[Analysis 4] Site Specific Safety Plan

Problem Identification

The premise for this analysis is to make efforts to eliminate construction related risks inside the building. To do so, items such as material staging and organization will be implemented. Currently, the interior spaces such as the corridors and foyer areas are being used to store materials, which are areas often traveled by workers. An issue arises when work needs to be done in these particular areas. Efforts are then made to move materials to other locations, which involves time and safety concerns if the correct moving equipment is not available. Also, trades often do not know where exactly their material is located on a particular floor. This is due to the rapid rate at which material is imported from the material hoist and quickly staged.

Background Research

One critical construction industry topic discussed at the 22nd annual PACE Roundtable event was the idea of preventing safety related issues though design. This involves the preplanning of safety procedures that are appropriate for a specific jobsite. It was noticed that there are a few rooms on each floor of the hospital that are not completed during the same time frame as others. These rooms may need special equipment that is scheduled to arrive at a later date, or they are simply not of high priority to complete. Another applicable feature of the hospital to this research is that floors three to six have very similar floor plans, so a similar safety protocol for material distribution can be used throughout most of the building. Furthermore, workers would recognize and understand these methods as they progressed to different areas of work.

Potential Solutions

Construction materials such as ductwork, drywall, and metal stud will specifically be researched as to the best way to transport and store them inside. A plan for specific locations of materials like these to be stored will also be designed. These areas will be a combination of unfinished rooms and general spaces throughout each floor. A floor plan will be devised to show exactly where to put materials as they enter the building. These locations may need to be changed as construction progresses, but they will be planned for.

Requirements for Achieving Analysis

- Indicate which rooms can be used to stage materials and which cannot.
- Designate a leader and manager of the safety plan to ensure its effectiveness.
- Define requirements for how material is to be staged, laid down, and transported around the floor.
- Research safe material handling and general interior construction guidelines.

Introduction

The purpose of this safety plan is to organize a method for handling and staging the larger construction materials used for interior construction. The plan is designed to be implemented after most interior partitions are installed for a particular floor. Safety procedures for the distribution of material will be highlighted in a model showing the areas of laydown and the progression and different types of staging. The fourth floor will be used as an example for the safety model since its floor plan is closely related to each other floor. Communication between the general contractor and trades will be filtered through a safety coordinator, who will have the primary responsibility of overseeing the workings of the safety plan.

Scope and Requirements

This safety plan is designed specifically for the interior construction of the Charlottesville Community Hospital. It is meant to assist the contractor and all interior subcontractors in the areas of communication, production, and safety. It is expected of everyone involved to follow the guidelines of the program and accept modifications that may be made during contractors meetings. All tradesmen are responsible for reporting accidents or job related injuries that occur onsite to the necessary person in charge. The safety coordinator is in charge of documenting all types of accidents, and making modifications to the safety plan if necessary. They are also expected to assess possible risks and bring them to light. These would include the location of extension cords, adequate lighting for workers, job site clutter, etc. It is important for the general contractor to make all trades aware of the staging and handling plan before construction begins in order to avoid confusion.

Construction Housekeeping

Site cleanup is an integral step to jobsite safety and is a requirement of OSHA. Continuous efforts to keep a tidy jobsite improves moral, encourages good work habits, saves time, and promotes safety. Below is a list of tips for keeping an organized work area.

- Separate scrap from usable material, and store the scrap pieces in a tidy pile.
- Clean up as you go, waiting until the end of the week allows the hazards to pile up.
- Assign chores each day. Give different people jobs like disposing of litter, organizing tools, disposing of flammable rags, etc.
- Send extraneous supplies back to the supply yard ASAP.
- Keep all work areas and passageways clear of scraps, protruding nails, wires, buckets, extension cords, tools, and other hazards.
- If you see a hazard, clean it or alert a supervisor of the hazard. Don't wait until someone gets hurt.

In studies of labor productivity on construction sites, Dr. Randolph Thomas of Penn State University has identified project housekeeping as a direct factor in determining labor productivity. When the site is cluttered or disorganized, workers have to work around the obstacles and waste time searching for missing components. Another important element is to have clear expectations of workers and enforce necessary rules to portray a clear message.

Material Handling/Site Layout Control

Construction field operations can be very inefficient in terms of where and how materials get stored and handled. This can be due to the uncertainty during pre-planning or the lack of control in the filed as material is being installed and delivered. Common questions that are often asked by contractors are; "Where are the materials we need and when will they get here?", or "Who needs these materials, when are they needed, and where?" A layout planning and control system will be devised to address these questions. Since not all situations can be anticipated during advanced planning, the design team will tend to create layout plans that show only larger and more static resources such as staging and laydown areas, egress ways, and equipment that will remain in place for major phases of construction. This plan will be distributed to all interior trades so that a common system can be established. A hardship of modeling the flow of construction operations is that they are highly dynamic and may change as work progresses. A space-time characterization of construction materials and equipment can be seen in figure 43. This graph was presented by Dr. Pierrette Zouein of The University of Michigan in 1995. It depicts the desired flow between different on and off-site locations. Each circle describes a function that may occur at any given area on site, depending on how long materials tend to be in that area and on the conversion process that takes place at that location. In the case of this hospital project, "off-site storage" would refer to the Material Storage Hub from analysis three. Once the material is transferred to the site, it is placed in a laydown or staging area. Laydown areas will refer to rooms in which material can be stored for a short duration. Here, workers will retrieve their daily materials and may need to visit these areas more than once a day. Staging areas will refer to rooms where material can be stored in bulk for long durations. These areas will serve as the location for material to go as soon as it enters the floor from the material hoist. This approach to interior construction organization is meant to be recognized by all trades. It will be implemented mostly by the safety coordinator, with extra help and supervision from the general contractor's interior superintendents.

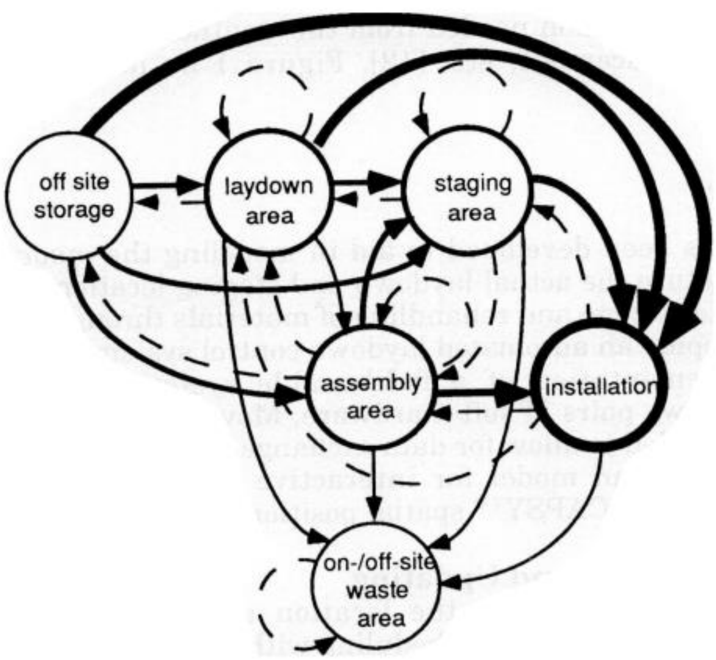

Figure 43

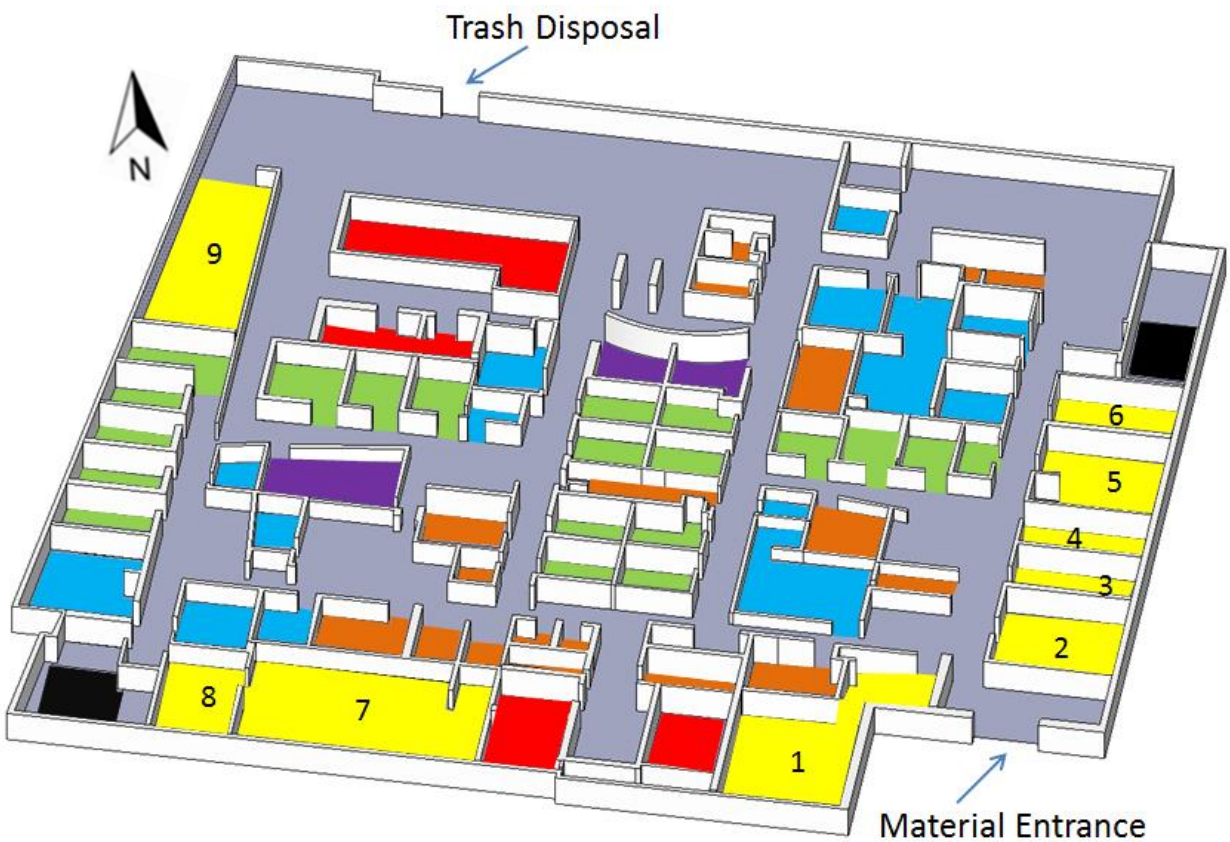

Figure 44: 4th Floor Staging Plan

The figure above is a depiction of the various material staging and laydown areas located on the hospital's 4th floor. This floor was chosen because it most closely represents all floors with its layout. The material entrance is located at the material hoist location, which consists of a temporary opening in the exterior wall that will be sealed up after the hoist is removed. A trash shoot is located at the north end of the project and is labeled as "Trash Disposal". Here, material waste is discarded into dumpsters on the ground. A description of all colors can be seen in figure 45. The rooms highlighted in green are exam rooms and will be the first to be finished by trades like drywall, paint, ceiling, and flooring. Therefore, these rooms will not be acceptable for material laydown or staging. Rooms highlighted in yellow will be finished later on in the schedule and will serve as the best staging areas since they are larger and are located closest to the material hoist. They are labeled from 1 to 9 to help make clearer where material should be placed and taken from. Room 9 is the largest and is located at the opposite side of the floor. This would be an effected location for locating a smaller amount of each material so that workers would not have to travel all the way back to rooms 1 to 8 if they were working in the Northwest

Color	Priority	Description
Green	1st	No Laydown or staging
Blue	2nd	Laydown only, no staging
Orange	3rd	Staging and Laydown
Yellow	4th	Staging Only
Purple	5th	Assembly Area
Red	6th	Elevator Shafts

Figure 45

quadrant of the floor. The rooms in purple labeled assembly areas will be used for which ever trades need space to prefabricate building components. This space can be used for carpenters, plumbers, sprinkler installers, etc. As material enter the floor, its first home will be any of rooms 1 to 6 as long as space is still available. The purpose of this material sequencing plan is to clear the corridors of debris and define specific locations for storing material. Any trade may use the described plan for their material, but the most applicable materials are drywall, metal framing, and duct.

Safe Material Handling

Working with drywall and metal stud in the construction field usually involves working at a fast pace. When crews are working new construction, time is money, and sometimes we overlook the safety aspect of it. It is important to take the time for safety when lifting, cutting, screwing, and taping. Below is a list of some important safety tips and guidelines associated with moving larger types of material.

- Clear your pathway of obstacles before starting.
- Set up loads close to waist height. Keep the load as close to the body as possible while lifting, carrying, and putting the load down. Avoid reaching over obstacles. Always make two person lifts the standard procedure
- Stack gypsum wall panel products flat instead of on edge or end.
- Avoid heavy lifting while bending that puts intense stress on your back. Spinal discs, nerves, and muscles can be damaged.
- Avoid reaching overhead and holding drywall in place, causing joint, muscles of the neck, shoulder, back, and hand injuries.
- Minimize the need for lifting. Have materials delivered as close as possible to where they will be used.
- Wear cut resistant gloves when cutting, carrying, and installing metal stud.
- Work with other subcontractors on the jobsite with safety items such as housekeeping, walkways, and work space

Conclusions

Interior construction of the hospital comprises about 32% of the total construction time of the project. With such a large effort placed on safe work environments, this method of prevention through design will help promote better order with distributing materials and cohesiveness among interior trades. The 4th floor staging plan serves as a model for how material should enter and exit the building. The same type of plan is meant to be implemented on other floors. When installation is in progress, workers should be mindful of the distances they need to carry material, as well as the proper transportation methods.

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[Appendix]

Heaviest Prefabricated Panel

Dimensions: 15’ x 12’ x 0.5’
Volume: 90 cu.ft. Concrete

Weight of concrete: 150 lb/cu.ft.

Panel Weight: **13,500 lbs**

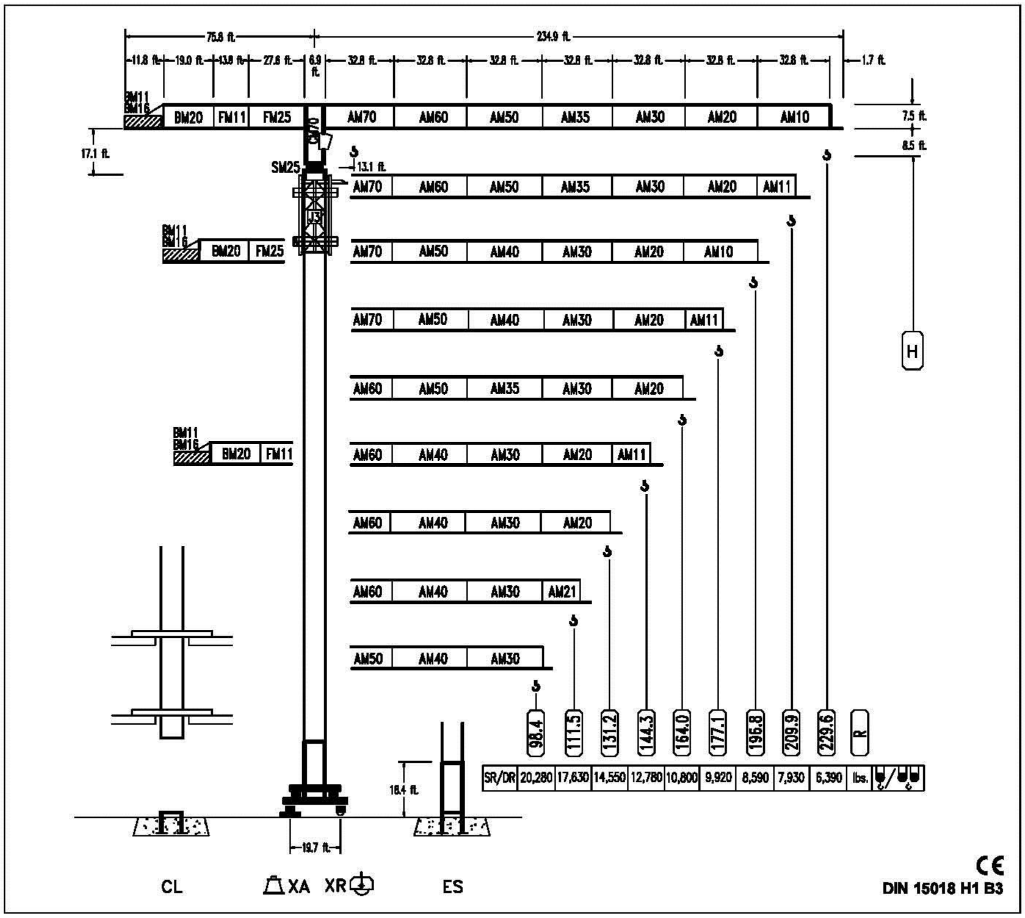
Figure 1

	R-Values Used for Energy Model		
	Material	**Thickness**	**R-Value**
Traditional	~	~	16.64
Prefab Panels	Concrete	5 3/8"	0.45
	Thin Brick	5/8"	0.1
	Drywall	5/8"	0.56
	Insulation	3 1/2"	11

Figure 2

COMANSA

LINDEN 8000 **LC-8652** **39,680 lbs.**



R		R(Cmax)	Cmax	65.6	82.0	98.4	111.5	131.2	144.3	164.0	177.1	196.8	209.9	229.6	ft. / lbs.
229.6	SR/DR	53.8 ft.	39,680	31,430	24,220	19,480	16,750	13,690	12,125	10,270	9,250	8,000	7,290	6,390	
209.9	SR/DR	56.7 ft.	39,680	33,570	25,900	20,890	17,960	14,720	13,070	11,080	10,000	8,680	7,930		
196.8	SR/DR	56.4 ft.	39,680	33,310	25,680	20,720	17,810	14,590	12,940	10,970	9,920	8,590			
177.1	SR/DR	56.4 ft.	39,680	33,310	25,680	20,720	17,810	14,590	12,940	10,970	9,920				
164.0	SR/DR	55.7 ft.	39,680	32,820	25,300	20,410	17,540	14,370	12,740	10,800					
144.3	SR/DR	55.7 ft.	39,680	32,930	25,390	20,450	17,610	14,410	12,780						
131.2	SR/DR	56.1 ft.	39,680	33,200	25,610	20,650	17,760	14,550							
111.5	SR/DR	56.1 ft.	39,680	32,980	25,440	20,500	17,630								
98.4	SR/DR	55.4 ft.	39,680	32,650	25,180	20,280									

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Figure 3

Virginia Electricity Rate

Table 5.6.A. Average Retail Price of Electricity to Ultimate Customers by End-Use Sector, by State, January 2014 and 2013 (Cents per Kilowatthour)

	Residential		Commercial		Industrial		Transportation		All Sectors	
Census Division and State	January 2014	January 2013	January 2014	January 2013	January 2014	January 2013	January 2014	January 2013	January 2014	January 2013
New England	16.98	15.35	14.54	13.83	12.66	11.93	10.78	7.29	15.36	14.07
Connecticut	18.30	17.05	15.79	14.56	13.42	12.85	18.50	9.07	16.82	15.54
Maine	14.45	14.49	14.31	12.15	11.79	8.94	–	–	13.79	12.45
Massachusetts	16.38	14.28	13.77	13.92	12.98	12.44	NM	5.95	14.71	13.59
New Hampshire	16.54	16.01	15.30	13.67	12.79	12.20	–	–	15.49	14.50
Rhode Island	20.16	14.80	15.48	12.65	14.20	11.73	15.92	12.25	17.41	13.50
Vermont	16.94	16.50	14.26	14.31	10.36	10.08	–	–	14.47	14.21
Middle Atlantic	15.63	14.98	13.96	12.62	8.83	7.31	12.00	12.73	13.67	12.60
New Jersey	15.26	15.30	13.87	12.12	15.05	9.95	10.29	10.52	14.53	13.16
New York	19.52	18.04	16.37	14.79	7.41	6.50	13.08	14.36	16.51	15.20
Pennsylvania	12.74	12.35	10.09	9.33	8.37	7.09	8.71	8.27	10.72	9.94
East North Central	11.27	11.35	9.41	9.18	6.91	6.33	5.47	5.66	9.38	9.05
Illinois	9.76	10.13	8.31	7.58	6.32	5.47	5.11	5.41	8.27	7.82
Indiana	10.16	9.98	9.44	9.28	6.88	6.38	9.23	8.93	8.76	8.34
Michigan	13.85	13.65	10.52	10.45	7.79	7.50	13.59	8.77	11.05	10.86
Ohio	10.98	11.01	9.31	9.22	6.73	5.95	7.06	6.53	9.27	8.84
Wisconsin	13.11	13.13	10.34	10.41	7.32	7.29	–	–	10.44	10.42
West North Central	9.75	9.70	8.37	8.15	6.37	6.14	7.76	6.89	8.45	8.25
Iowa	10.00	10.14	8.01	7.89	5.48	5.43	–	–	7.85	7.79
Kansas	10.96	10.63	9.33	9.05	7.11	6.87	–	–	9.42	9.10
Minnesota	11.34	11.15	9.18	8.83	6.93	6.71	9.49	9.13	9.37	9.07
Missouri	8.87	8.83	7.67	7.55	5.59	5.35	6.20	5.45	7.84	7.79
Nebraska	8.98	8.73	8.19	7.94	6.67	6.47	–	–	8.06	7.81
North Dakota	7.79	7.71	7.78	7.42	7.12	6.56	–	–	7.60	7.28
South Dakota	9.44	9.30	8.21	7.90	6.93	6.72	–	–	8.56	8.32
South Atlantic	11.10	10.82	9.71	9.20	6.97	6.24	9.50	8.52	9.99	9.46
Delaware	12.48	12.85	10.93	10.06	10.67	8.36	–	–	11.65	10.98
District of Columbia	12.59	12.06	13.26	11.98	4.42	6.08	9.71	9.67	12.83	11.78
Florida	11.78	11.32	9.72	9.55	7.88	7.84	9.27	8.65	10.66	10.29
Georgia	10.86	10.24	10.80	9.47	7.08	5.64	9.00	7.03	10.07	8.93
Maryland	13.14	12.50	11.52	10.32	11.51	8.16	10.11	8.54	12.35	11.23
North Carolina	10.30	10.19	8.62	8.43	6.34	6.07	8.02	7.81	9.15	8.90
South Carolina	11.76	11.57	10.13	9.51	6.57	5.53	–	–	9.76	8.96
Virginia	10.09	9.99	8.04	7.87	6.79	6.74	8.03	8.09	8.89	8.72
West Virginia	9.01	9.37	7.71	8.20	5.99	6.11	9.92	9.55	7.83	7.95
East South Central	10.04	10.04	10.05	9.85	6.29	5.65	12.89	11.22	8.99	8.47
Alabama	10.74	10.84	10.75	10.41	6.20	5.60	–	–	9.25	8.77
Kentucky	9.42	9.25	8.88	8.70	6.13	5.11	–	–	8.19	7.21
Mississippi	10.48	9.99	10.78	9.62	6.64	6.11	–	–	9.38	8.62
Tennessee	9.74	10.03	10.00	10.23	6.41	6.47	12.89	11.22	9.20	9.32
West South Central	10.19	10.06	7.96	8.04	5.65	5.52	5.37	10.27	8.30	8.17
Arkansas	8.30	8.74	7.40	7.84	5.54	5.62	NM	NM	7.25	7.52
Louisiana	8.50	8.85	8.68	8.85	5.37	5.71	9.41	8.60	7.51	7.71
Oklahoma	8.33	8.01	7.44	6.77	5.23	4.67	–	–	7.29	6.74
Texas	11.19	10.89	7.96	8.09	5.82	5.59	5.08	10.52	8.79	8.60
Mountain	10.78	10.27	9.01	8.62	6.11	5.74	10.20	9.63	8.81	8.45
Arizona	10.92	10.25	9.29	9.05	6.14	6.04	–	–	9.36	9.08
Colorado	11.46	11.06	9.48	9.09	6.99	6.80	10.72	10.26	9.54	9.22
Idaho	8.89	8.68	7.26	6.73	5.40	4.79	–	–	7.52	7.13
Montana	9.88	9.82	9.31	9.23	5.81	5.00	–	–	8.84	8.35
Nevada	12.46	11.24	9.57	8.53	5.91	5.09	8.15	7.47	9.14	8.24
New Mexico	11.30	10.88	9.62	9.06	6.05	5.78	–	–	9.05	8.70
Utah	10.00	9.89	7.75	7.57	5.54	5.24	9.87	9.34	7.73	7.53
Wyoming	9.77	9.51	8.61	8.07	6.30	6.16	–	–	7.52	7.39
Pacific Contiguous	13.21	13.15	11.85	10.63	7.79	7.18	7.66	7.06	11.60	11.03
California	16.64	16.40	13.39	11.81	10.48	9.69	7.62	6.99	14.08	13.25
Oregon	10.08	9.66	8.66	8.22	6.05	5.40	8.46	8.59	8.80	8.35
Washington	8.59	8.50	7.91	7.73	4.35	4.01	8.36	8.14	7.33	7.15
Pacific Noncontiguous	27.51	27.48	25.71	25.04	26.10	26.99	–	–	26.42	26.44
Alaska	18.21	17.18	16.64	14.46	14.74	15.55	–	–	16.87	15.72
Hawaii	37.40	37.86	34.92	35.80	30.82	31.69	–	–	34.08	34.87
U.S. Total	11.65	11.47	10.34	9.79	6.98	6.45	10.29	10.24	10.13	9.66

See Technical notes for additional information on the Commercial, Industrial, and Transportation sectors.
Displayed values of zero may represent small values that round to zero. The Excel version of this table provides additional precision which may be accessed by selecting individual cells.
Notes: - See Glossary for definitions. - Values are preliminary estimates based on a cutoff model sample.
See Technical Notes for a discussion of the sample design for the Form EIA-826.
Utilities and energy service providers may classify commercial and industrial customers based on either NAICS codes or demands or usage falling within specified limits by rate schedule.
Changes from year to year in consumer counts, sales and revenues, particularly involving the commercial and industrial consumer sectors, may result from respondent implementation of changes in the definitions of consumers, and reclassifications.
Totals may not equal sum of components because of independent rounding.
Source: U.S. Energy Information Administration, Form EIA-826, Monthly Electric Sales and Revenue Report with State Distributions Report.

Figure 4

Performance Data

Table PD-3 — Heat Pump Reverse Cycle Heating Capacity (Btu)

Model No.[1]		PTHC 07			PTHC 09			PTHC 12			PTHC 15		
Voltage[3]		208	230	265	208	230	265	208	230	265	208	230	265
Amps		3.0	2.6	2.2	3.6	3.2	2.6	5.1	4.5	3.9	6.3	5.7	5.4
Watts		550	570	570	730	740	740	1000	1020	1020	1380	1390	1390
Btu[2]		6200	6400	6400	8000	8100	8100	10600	10800	10800	13500	13300	13300
COP[2]		3.3	3.3	3.3	3.2	3.2	3.2	3.1	3.1	3.1	2.8	2.8	2.8
cfm (dry)		230	235	235	230	235	235	290	310	310	335	345	345
Heating[2] Btu °F													
Outdoor Ambient	62	8200	8400	8400	10200	10300	10300	13000	13200	13200	16300	16400	16400
	57	7600	7800	7800	9600	9700	9700	12200	12400	12400	15300	15400	15400
	52	6900	7100	7100	8900	9000	9000	11400	11600	11600	14200	14300	14300
	47	6200	6400	6400	8000	8100	8100	10600	10800	10800	13200	13300	13300
Rating Point	(COP)	3.3	3.3	3.3	3.2	3.2	3.2	3.1	3.1	3.1	2.8	2.8	2.8
[2]	42	5500	5700	5700	7200	7300	7300	9800	10000	10000	12200	12300	12300
	37	4900	5100	5100	6400	6500	6500	9000	9200	9200	11200	11300	11300
	32	4300	4500	4500	5600	5700	5700	8200	8400	8400	10100	10200	10200
Watts	62	730	745	745	935	940	940	1230	1245	1245	1705	1715	1715
Outdoor Ambient	57	675	690	690	880	890	890	1150	1170	1170	1600	1610	1610
	52	610	630	630	815	825	825	1075	1095	1095	1485	1495	1495
	47	550	570	570	730	740	740	1000	1020	1020	1380	1390	1390
	42	490	505	505	660	670	670	925	945	945	1275	1285	1285
	37	435	450	450	585	595	595	850	870	870	1170	1180	1180
	32	380	400	400	510	520	520	775	795	795	1055	1065	1065

Notes:
1. All 265 volt models must use Trane's subbase or Trane's hard-wire junction box kit.
2. Heating capacity and efficiency is based on unit operation without condensate pump. Unit automatically switches to electric heat at 25°F outdoor coil temperature. Depending upon relative humidity conditions, this will occur at approximately 35 degrees outdoor ambient temperature.

Figure 5

1390 watts/1000 = 1.39kw x 24 hours/day = 33.36kwh/day x $0.10* = **$3.37/day**

$3.37/day x 301days = $1004.14 x 3 A/C units = **$3012.40**

Interview with Jim Haller of Southland Industries.

Q: What are some common complications with your warehouse and manufacturing operation?

A: Traffic creates the most problems for our deliveries and we don't have control over it. It is important to make sure we hit our delivery time on the site so that a crane is available for us to unload when we arrive. If we arrive later, we might not have access to the crane and might be forced to take the delivery back to the shop. Understanding the variables of an order are important for giving yourself enough time to manufacture everything and load the trucks in the most effective way.

Q: What scheduling conflicts arise when scheduling deliveries?

A: A two week look ahead is created to show what material goes where and when it needs to leave the warehouse. This way, the material is manufactured and loaded into trucks before its departure day.

Q: Is there a warehouse manager? What are their duties?

A: There isn't a designated manager. There are Forman who are in charge of each department; plumbing, pipe fitting, sheet metal. They are in charge of getting each delivery ready. They coordinate with each other when they are preparing to load a truck for a certain job.

Q: What items can be bought in bulk. Do you often do this?

A: Yes, materials are sometimes bought in bulk. Suppliers will keep 3-6 months' worth of certain material in stock in case Southland decides to buy a lot at once. Sheet metal is most commonly purchased in large quantities.

Q: What are some advantages of having a permanent warehouse facility?

A: Southland has freedom to run the operation how they want. They can work at a moderate pace or put more guys on to finish a larger job. Storage space is useful for placing material that needs to sit for a few days. If the facility does not have room, material can be placed outside in the yard.

SPECIALIST MANUFACTURERS OF TEMPORARY EVENT AND INDUSTRIAL STRUCTURES

Quote 04 March 2014

REF: HTS-USA HTS L 12m x 25m 4.2m Temp warehouse 3-4-14

Customer info:
Contact Name: Joe Bonacci
Company Name: Keystone Steel
Address:
Email: jabonacci21@gmail.com
Telephone Number: 5706143650
Intended Use: Construction Material Storage

Dear Joe - Please review the below information regarding your order. If the below products meet with your approval please fax back to 561-277-2487 or scan and email to jmcinnes@hts-usa.com. This order only becomes live once this document is returned completed and signed.

Höcker L12- 12M x 25M x 4.2M sw on 5M bay spacing (40' x 82'-13'8"eave)

Profile 252/122/4 4 channel -Sideheight 3 m – With PE book to meet IBC 2009 – 20# snow load- 90Mph wind load

Frame : including baseplates/stakes, sidewall bars and bottom wall bars, fix tensioners and set-up tools.

Product #	Description		$ Total.
L15 UK+USA 15x30-3.2msw	15x30m Frame & gable endwalls	7 Arches, 6 5m bays, 2 ends	$ 31,980.00
L15 UK+USA 15 x 30c	vinyl roof & gables white blackout	6 roof panels, 2 Gable ends	$ 5,860.00
Vinyl Side wall	2pcs 5x4.2 vinyl wall sections	16 vinyl wall bay panels + door infill	$ 4,520.00
Man door Metal-	2- metal man door with header beam/subframe & lockset hw $1,020.00 per		$ 2,040.00
Metal Roll up door	2- 14'6" x 14'6"metal roller shutter door wind loaded-chain drive		$ 5,860.00
Product cost to above spec-(not including freight duty and install budget #'s)			$ 50,260.00

Lead time: 4 Weeks plus shipping.
Payment terms: 50% deposit upon order, 50% payable FOB Germany,
Taxes & Duties: Taxes and duties will be payable by the importer (est 4% duty $2,000.00)
Shipping: Not included, most economical solutions will be sought; actual cost will be billed to customer. (Est. 1 40' container @ $5,800.00 shipping door to door.)
Delivery address: TBD

Name: ______________________________Title____________________________________

Company: ______________________________TAX ID number #______________________________

Sign: _______________________________________Date:________________________

Payment methods:

1. By check: **Payable to** RÖDER HTS HÖCKER GmbH, **please send to our German address:**
   RÖDER HTS HÖCKER GmbH
   Hinter der Schlagmühle 1
   Kefenrod - D-63699 - Germany
2. By Bank transfer: **Banker:** Commerzbank, Kaiserstrasse 30, Frankfurt, Germany, D-60261
   Account name: RÖDER HTS HÖCKER GmbH
   Account number: 1828 870 Sort code:513 400 13 Swift code: COBA DE FF 518
   IBAN: DE 5951 3400 1301 8288 7000Ref:Co name– FOLLOWED BY THE INV NUMBER

Note:

- **By signing this order confirmation you are agreeing to our terms and conditions of sale as attached**
- **Should payments terms be exceeded, interest of 6% per month will be added to your account.**

If you agree to all the above costs, information & payment terms, and wish to proceed with the orderlease complete the below section and fax all pages back to HTS-USA at 561-277-2487. On receipt your order will become live. Please note the goods remain the property of HTS-USA and RÖDER HTS HÖCKER GmbH until paid for in full.

American Sales and Distribution:
HTS-USA
605 SE 1st Ave, Suite F
Delray Beach, Florida 33444
Toll free:- +1-800-806-7404
Tel: +1 561-450-6974
Fax: +1 561-277-2487
www.hts-usa.com

Banking details:
Banker: HypoVereinsbank
Account no.: 898227472
Sort code: 700 202 70
Swift code: HYVEDEMMXXX
IBAN: DE40700202700898227472
Company no.: HRB 6517

Figure 6

Conduit Fill Chart

Click links below for product information.

Trade Size		Wire Size (THWN, THHN) Conductor Size AWG/kcmil																				
		14	12	10	8	6	4	3	2	1	1/0	2/0	3/0	4/0	250	300	350	400	500	600	700	750
	EMT	12	9	5	3	2	1	1	1	1	1											
1/2	IMC	14	10	6	3	2	1	1	1	1	1	1										
	GRC	13	9	6	3	2	1	1	1	1	1											
	EMT	22	16	10	6	4	2	1	1	1	1	1	1	1								
3/4	IMC	24	17	11	6	4	3	2	1	1	1	1	1	1								
	GRC	22	16	10	6	4	2	1	1	1	1	1	1	1								
	EMT	35	26	16	9	7	4	3	3	1	1	1	1	1	1	1	1					
1	IMC	39	29	18	10	7	4	4	3	2	1	1	1	1	1	1	1	1				
	GRC	36	26	17	9	7	4	3	3	1	1	1	1	1	1	1	1	1				
	EMT	61	45	28	16	12	7	6	5	4	3	2	1	1	1	1	1	1	1	1	1	
1 1/4	IMC	68	49	31	18	13	8	6	5	4	3	2	1	1	1	1	1	1	1	1	1	1
	GRC	63	46	29	16	12	7	6	5	4	3	2	1	1	1	1	1	1	1	1	1	
	EMT	84	61	38	22	16	10	8	7	5	4	3	2	1	1	1	1	1	1	1	1	1
1 1/2	IMC	91	67	42	24	17	10	9	7	5	4	4	3	3	2	1	1	1	1	1	1	1
	GRC	85	62	39	22	16	10	8	7	5	4	3	3	2	1	1	1	1	1	1	1	1
	EMT	138	101	63	36	26	16	13	11	8	7	6	5	4	3	2	1	1	1	1	1	1
2	IMC	149	109	68	39	38	17	15	12	9	8	6	5	4	3	3	2	2	1	1	1	1
	GRC	140	102	64	37	27	16	14	11	8	7	6	5	4	3	3	2	2	1	1	1	1
	EMT	241	176	111	64	46	28	24	20	15	12	10	8	7	6	5	4	4	3	2	2	1
2 1/2	IMC	211	154	97	56	40	25	21	17	13	11	9	7	6	5	4	4	3	3	2	1	1
	GRC	200	146	92	53	38	23	20	17	12	10	8	7	6	5	4	3	3	2	1	1	1
	EMT	364	266	167	96	69	43	36	30	22	19	16	13	11	9	7	6	6	5	4	3	3
3	IMC	362	238	150	86	62	38	32	27	20	17	14	12	9	8	7	6	5	4	3	3	3
	GRC	309	225	142	82	59	36	31	26	19	16	13	11	9	7	6	5	5	4	3	3	3
	EMT	476	347	219	126	91	56	47	40	29	25	20	17	14	11	10	9	8	6	5	4	4
3 1/2	IMC	436	318	200	115	83	51	43	36	27	23	19	16	13	10	9	8	7	6	5	4	4
	GRC	412	301	189	109	79	48	41	34	25	21	18	15	12	10	8	7	7	5	4	4	4
	EMT	608	443	279	161	116	71	60	51	37	32	26	22	18	15	13	11	10	8	7	6	5
4	IMC	562	410	258	149	107	66	56	47	35	29	24	20	17	13	12	10	9	7	6	5	5
	GRC	531	387	244	140	101	62	53	44	33	27	23	19	16	13	11	10	8	7	6	5	5

Above information referenced from tables C1, C4, and C8 of the 1996 NEC.

For information on the following types of conduit, see these tables in appendix C of the 1996 NEC.

- Rigid PVC Conduit, Schedule 80 Table C9
- Rigid PVC Conduit, Schedule 40 Table C10
- Flexible Metallic Conduit Table C3
- Liquidtight Flexible Metallic Conduit Table C7
- Liquidtight Flexible Nonmetallic Conduit (Type FNMCB) Table C5

If you have any other questions see the NEC Code Book or ask a Western Extralite Company

Figure 7

Table 1: American Wire Gauge (AWG) Cable / Conductor Sizes and Properties

AWG	Diameter [inches]	Diameter [mm]	Area [mm^2]	Resistance [Ohms / 1000 ft]	Resistance [Ohms / km]	Max Current [Amperes]	Max Frequency for 100% skin depth
0000 (4/0)	0.46	11.684	107	0.049	0.16072	302	125 Hz
000 (3/0)	0.4096	10.40384	85	0.0618	0.202704	239	160 Hz
00 (2/0)	0.3648	9.26592	67.4	0.0779	0.255512	190	200 Hz
0 (1/0)	0.3249	8.25246	53.5	0.0983	0.322424	150	250 Hz
1	0.2893	7.34822	42.4	0.1239	0.406392	119	325 Hz
2	0.2576	6.54304	33.6	0.1563	0.512664	94	410 Hz
3	0.2294	5.82676	26.7	0.197	0.64616	75	500 Hz
4	0.2043	5.18922	21.2	0.2485	0.81508	60	650 Hz
5	0.1819	4.62026	16.8	0.3133	1.027624	47	810 Hz
6	0.162	4.1148	13.3	0.3951	1.295928	37	1100 Hz
7	0.1443	3.66522	10.5	0.4982	1.634096	30	1300 Hz
8	0.1285	3.2639	8.37	0.6282	2.060496	24	1650 Hz
9	0.1144	2.90576	6.63	0.7921	2.598088	19	2050 Hz
10	0.1019	2.58826	5.26	0.9989	3.276392	15	2600 Hz
11	0.0907	2.30378	4.17	1.26	4.1328	12	3200 Hz
12	0.0808	2.05232	3.31	1.588	5.20864	9.3	4150 Hz
13	0.072	1.8288	2.62	2.003	6.56984	7.4	5300 Hz
14	0.0641	1.62814	2.08	2.525	8.282	5.9	6700 Hz
15	0.0571	1.45034	1.65	3.184	10.44352	4.7	8250 Hz
16	0.0508	1.29032	1.31	4.016	13.17248	3.7	11 k Hz
17	0.0453	1.15062	1.04	5.064	16.60992	2.9	13 k Hz
18	0.0403	1.02362	0.823	6.385	20.9428	2.3	17 kHz
19	0.0359	0.91186	0.653	8.051	26.40728	1.8	21 kHz
20	0.032	0.8128	0.518	10.15	33.292	1.5	27 kHz
21	0.0285	0.7239	0.41	12.8	41.984	1.2	33 kHz
22	0.0254	0.64516	0.326	16.14	52.9392	0.92	42 kHz
23	0.0226	0.57404	0.258	20.36	66.7808	0.729	53 kHz
24	0.0201	0.51054	0.205	25.67	84.1976	0.577	68 kHz
25	0.0179	0.45466	0.162	32.37	106.1736	0.457	85 kHz
26	0.0159	0.40386	0.129	40.81	133.8568	0.361	107 kHz
27	0.0142	0.36068	0.102	51.47	168.8216	0.288	130 kHz
28	0.0126	0.32004	0.081	64.9	212.872	0.226	170 kHz
29	0.0113	0.28702	0.0642	81.83	268.4024	0.182	210 kHz
30	0.01	0.254	0.0509	103.2	338.496	0.142	270 kHz
31	0.0089	0.22606	0.0404	130.1	426.728	0.113	340 kHz
32	0.008	0.2032	0.032	164.1	538.248	0.091	430 kHz
33	0.0071	0.18034	0.0254	206.9	678.632	0.072	540 kHz
34	0.0063	0.16002	0.0201	260.9	855.752	0.056	690 kHz
35	0.0056	0.14224	0.016	329	1079.12	0.044	870 kHz
36	0.005	0.127	0.0127	414.8	1360	0.035	1100 kHz
37	0.0045	0.1143	0.01	523.1	1715	0.0289	1350 kHz
38	0.004	0.1016	0.00797	659.6	2163	0.0228	1750 kHz
39	0.0035	0.0889	0.00632	831.8	2728	0.0175	2250 kHz
40	0.0031	0.07874	0.00501	1049	3440	0.0137	2900 kHz

Figure 8

System Details

Turbine Power: 4000 watts
Turbine Voltage: 240 volts
Inverter Power: 5000 watts
Inverter Voltage: 48 volts

DC Feeder

A= W/V= 4000/240 = 16.67Amps (current through conductor)

- (2) # 9's in 1/2" conduit

AC Feeder

$A = 5000W/(480V*\sqrt{3}) = \underline{6.01 \text{ Amps}}$

- (4) # 13's in 1/2" conduit

4kw * 24hrs/day * $0.0804/kWh = $7.72/day

$7.72/day * 365 days = $2817.8/year