April 9, 2014

Sunnyvale Plaza

Mid-Atlantic Region, United States

Nathan Braskey – Construction Option

Final Report

Faculty Consultant: Craig Dubler

http://www.engr.psu.edu/ae/thesis/portfolios/2014/nfb5026/index.html

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Mid-Atlantic Region, United States

Figure: Hotel Atrium and Statue

Building Information:

Size:

752,000 Square Feet

22 Stories

15 Above Grade

7 Below Grade

Delivery Method:

Design - Build / GMP

Construction Date:

July 2011 - May 2011

Project Team:

Architect:

Cooper Carry, Inc.

Landscape Architect:

Lee and Associates, Inc.

CM / GC:

Hensel Phelps

Structural Engineer:

Thornton Tomasetti

A + F Engineers

MEP Engineer:

GHT Limited

Civil Engineer:

AMT, LLC Consulting Engineers

Electrical Contractor:

Truland Group, Inc.

Special Thanks To:

Hensel Phelps Construction Co.

Images Property Of:

Cooper Carry

Figure: Underground Grand Ballroom

Construction

- Unique top - down construction
- Slurry wall construction
- Extensive concourse excavation
- Existing building incorporation
- Road redesign and construction
- Pursuing LEED Silver certification

Electrical

- 460/265V
- 4000A Switchboards
- 4 PEPCO Vaults on North Side
- 3 Electrical rooms per floor

Architectural

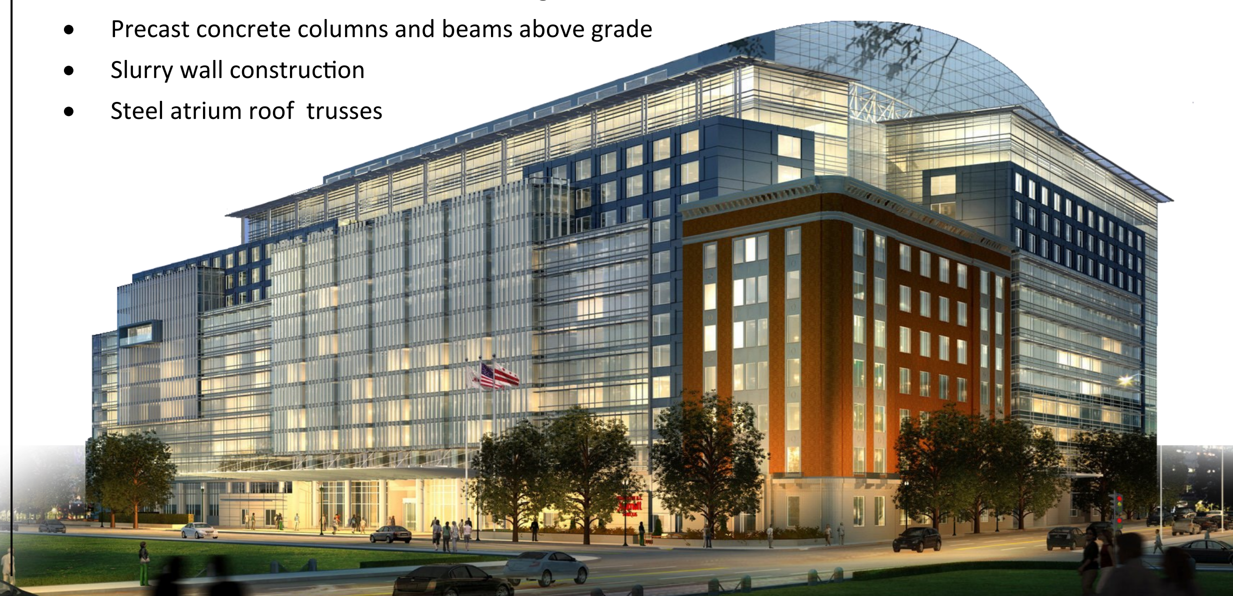
- 1,175 Guestrooms
- 87 Meeting rooms, 49 suites
- Grand ballroom and two junior ballrooms
- Five restaurants
- Football field sized skylight
- Curtain wall building enclosure

Mechanical

- Variable Air Volume System
- 6 Cooling towers on roof
- Electric heating
- Fan coil units for every guestroom

Structural

- Concrete encased steel columns below grade
- Precast concrete columns and beams above grade
- Slurry wall construction
- Steel atrium roof trusses



EXECUTIVE SUMMARY

During the 2013-2014 academic year, Sunnyvale Plaza was analyzed to determine several alternative solutions to create cost or schedule savings within the design or construction process. Through extensive research and coordination with the project team, four primary areas were determined for the focus of each analysis. The following report consists of four analyses conducted through the senior thesis project. It is important to stress that this report is strictly educational and is not intended to evaluate the project team or their efforts.

Analysis 1: Utilization of a Stormwater Harvesting System - Plumbing Breadth

The first analysis consisted of determining the possibility of implementing a stormwater harvesting system within the hotel to cut water utility costs over a large period of time. Due to the large roof area, a great amount of water can be collected and stored for use as a non-potable water source. Implementing the system would create an up-front cost of approximately $60,725 and an annual savings of approximately $27,765. This produces a payback period of approximately 2.5 years. After the payback period, the system will generate a savings of $27,765 per year.

Analysis 2: Analysis of Current Excavation Method

The second analysis consisted of researching and evaluating the excavation process utilized by the project team. It was determined that due to the complexity of the project site and surrounding public area that there was no other option that would benefit the construction process. The report also elaborates on the extreme safety concerns involved in the excavation process.

Analysis 3: Removal of Renovated Building Section - Structural Breadth

The southeast corner of the hotel consisted of a renovated Plumber's Union Building that was maintained due to historical requirements. This analysis examined the cost and schedule changes when utilizing façade retention to preserve the exterior façade while demolishing the existing structure. The steel utilized for the retaining structure can be designed to be recycled into the building once the façade is reconnected to the lower superstructure, creating very little material costs. It was determined that utilizing the façade retention method would create a cost savings of approximately $832,700. The façade retention method will also allow the hotel construction to finish approximately 30 days earlier than expected. This schedule decrease was evaluated in further detail within Analysis 4.

Analysis 4: Profitability of Early Scheduled Opening

The final analysis consisted of examining the profitability of forecasting an earlier opening date for the hotel. The original opening date fell just after The National Cherry Blossom Festival, a large festival with a large demand for tourism. Three similar hotels were examined throughout several months to determine the total average rate for a similar hotel room during the months of January, February, and March. Utilizing the 30 day decrease in the construction schedule from the façade retention method in Analysis 3 allowed the hotel to forecast an opening date just before the festival. This created a total revenue of approximately $14,482,000. After factoring an expected occupancy and profit margin, it was determined that the hotel can generate approximately $1,588,000 in profit during the festival. The two weeks of construction that was eliminated from the construction duration also created a general conditions savings of approximately $1,864,000. Thus, the total profit from opening one month early is approximately $2,139,227.

ACKNOWLEDGEMENTS

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Plan. Build. Manage.

TRULAND
BEYOND CURRENT

COOPER CARRY

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David Webb

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PACE Industry Members

Family and Friends

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PROJECT INFORMATION

PROJECT BACKGROUND

The concept for Sunnyvale Plaza came in 1999 with a proposal to construct a convention headquarters neighboring the city's convention center. Initial estimates proposed that the hotel would cost roughly $200 million, which would need to be reduced by about $30 million in order to be profitable. A proposal from a nearby hotel to expand into a convention headquarters was also vying for approval, but was later rejected due to a risk of poor revenue production. The September 11 attacks on the United States caused a substantial economic downturn that postponed the awarding of the proposal until late October of 2002. Economists alleged that the initial financing proposal was controversial in that it would lower sales tax revenue within the area. In April of 2004, the city council began debating on whether or not to consider building the headquarters on a different site. On December 3, 2004, the council voted in favor of continuing the plan to build on the original site. On August 22, 2005, the Plumbers Union Building was sold to the developer to obtain more of the property to develop. In June of 2006 the first financing package was approved by the council and in February of 2007 private financing came together to complete the proposal. On September 24, 2007, after several reconsiderations for the size of the hotel to reduce financing, the developer signed an agreement to jointly finance the hotel. Ground was finally broken on November 10, 2010 and construction began.

Sunnyvale Plaza is a 752,000 square foot high-rise hotel surrounded by a dense city within the Eastern United States. Consisting of several ballrooms and restaurants, the hotel will be able to support guests for the 11 stories of guestrooms. The below-grade floors will also include parking garage space and a concourse to the convention center next door. The hotel is also constructed on the same lot as two existing buildings in opposite corners. This creates a challenge of implementing one of the buildings into the new structure and avoiding disruption of the other.

Building Name:	"Sunnyvale Plaza"
Location and Site:	Mid - Atlantic Region, United States
Occupancy:	Principal: R-1 Residential Secondary: Group A-2: Restaurants Group A-3: Meeting Rooms, Ballrooms, Exhibit Halls Group B: Meeting Rooms, Office Space, Commercial Kitchens Group M: Retail Group S-1: Loading Docks, Storage Group S-2: Parking, Boiler Room, Mechanical, Electrical, Storage
Approximate Size:	752,000 S.F. Gross Floor Area
Number of Stories:	22 Floors, 15 Above Grade
Owner:	Withheld By Request
Architect:	Thompson, Ventulett, Stainback, P.C.
General Contractor:	Hensel Phelps
Construction Manager:	Hensel Phelps
Structural Engineer:	GEI Consultants, Inc.
MEP Engineer:	GHT Limited
Civil Engineer	LLC Consulting Engineers
Landscape Architect:	Lee and Associates, Inc.

Table 0-1: Sunnyvale Plaza Contract Information

Construction Start: April 2012
Estimated Construction Completion: May 2014
Project Delivery Method: Design - Build / Guaranteed Maximum Price

HISTORICAL REQUIREMENTS

The Plumber's Union Building located in the southeast corner of the jobsite is historically recognized and required to be maintained and incorporated into the new construction. The Union Building consists of a 5,000 square foot building footprint and seven above grade levels. The structural system within the building will be maintained and the levels will be converted into guestrooms and a fitness area.

CLIENT INFORMATION

Sunnyvale Project is a new facility that is an expansion of a very successful franchise throughout the United States. The contract consists of a Design - Build, Guaranteed Maximum Price contract. Due to the complexity of each portion of the hotel construction, a higher amount of contractors were involved compared to a typical construction project.

EXISTING CONDITIONS

The existing project site consists of two building located in opposite corners of each other. The northwest corner of the lost includes an existing PEPCO Substation that will remain within the site as a separate building. The construction area is very close to the substation, and at some places is within feet of the closest walls. The other existing building is located in the southeast corner which creates an acute angle within the site. This brick building will be stripped and renovated to tie into the new construction. The exterior brick façade and structural components will be maintained due to historical requirements. These two buildings create a more restricting construction area that requires the care and attention of additional properties. The project site is also located within a dense city between two popular and heavily used streets.

The natural water table is located approximately 40 feet below-grade. As the excavation is expected to extend to approximately 135 feet below-grade, the shallow water table creates limitations within the excavation process.

BUILDING SYSTEMS OVERVIEW

ARCHITECTURE

Sunnyvale Plaza is a 22 story structure with 11 floors of guest rooms and 7 floors below grade. A small existing building on the corner of the lot is implemented into the construction and façade of the new building. The hotel consists of 1,175 guest-rooms, 87 meeting rooms, and 49 suites. The first and second floors of the hotel also include five restaurants. A 30,000 square foot grand ballroom and two 10,800 square foot junior ballrooms are located just below the first level followed by a multi-level parking garage for valet parking services. The center of the structure features an open atrium through all 15 above-grade stories with a statue piece. Within the garage, a concourse passageway was added to enter the neighboring parking garage. This concourse created complications with protecting the street and mechanical pipes overhead.

EXCAVATION AND SUBSTRUCTURE

Sunnyvale Plaza required a very unique excavation process. Due to the extensive depth of the hotel, typical excavation practices would not be possible. The project team utilized a top-down excavation process in which each below-grade slab was poured on-grade then excavated from underneath. Several areas were left open through each slab to allow for cranes and larger equipment to transport the excavated material out of the site. The slurry wall acted as the exterior shoring during construction. This excavation process, although necessary, was very lengthy and required an entire year more than typical excavation processes.

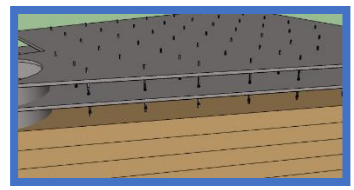


Figure 0-1: Excavation of Level M1

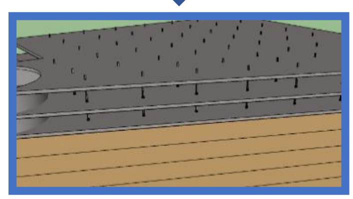


Figure 0-2: Level M1 Slab-On-Grade

Ground was broken on November 10, 2010 for Sunnyvale Plaza. Due to the more complicated excavation process, construction was expected to be extended by an entire year. Each below-grade slab was poured on-grade, then excavated underneath. This process was done one level at a time down to the bottom level. Utilizing this unique method made it possible to excavate to such a large depth below the street. A slurry wall construction was also used to secure the subgrade levels. The perimeter of the building was excavated, reinforced, and poured first. This slurry wall created a suitable shoring method and a secure subgrade exterior support system.

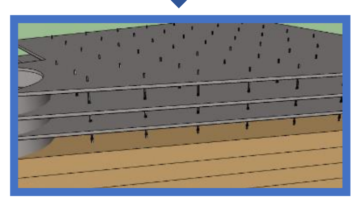


Figure 0-3: Excavation of Level M2

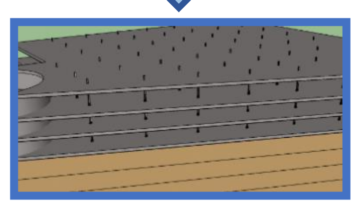


Figure 0-4: Level M2 Slab-On-Grade

SUPERSTRUCTURE

Sunnyvale Plaza contains a very unique structural system that began during the excavation process. The below-grade structural system consists of steel columns encased in concrete with typical reinforcement. A slurry wall also extends around the entire substructure, up to 115' below-grade. The slurry wall consisted of 4,000 psi normal weight concrete. Every below-grade slab was poured on-grade and excavated underneath. Slabs consist of typical composite metal decking and normal weight concrete. The concourse construction creates the need for temporary steel columns while excavating through each slurry wall. The underground utilities also needed to be temporarily supported during construction. The superstructure consists of precast concrete beams and columns with typical reinforcing bars. Steel columns typically ranged from W14x90 to W14x342 with two W14x665 columns. Concrete columns and beams ranged in size from 12x12 to 50x66.

The superstructure utilizes pre-cast columns and beams with a steel composite deck. Utilizing pre-cast assembly methods created a faster erection process for the above-grade structure. The entire above grade structure took about four months to complete. The structural frame was broken into two towers, North and South.

MECHANICAL SYSTEM

The mechanical system for Sunnyvale Plaza consists of a variable air volume system. Six cooling towers are located on the roof of the hotel while several air handling units are located on the first floor, third floor, and all below-grade levels. The above-grade mechanical rooms are located near each corner of the building. These rooms are typically electrical rooms on other floors. Each guestroom consists of a fan coil unit to control and condition the room separately. Electric heating coils are utilized for heating of the hotel. The atrium skylight is expected to provide a substantial amount of direct sunlight heat throughout the year which will most directly translate to the lobby and restaurants.

ELECTRICAL SYSTEM

Sunnyvale Plaza utilizes a 460/265 electrical distribution system which is provided by The Potomac Electrical Power Company. The hotel consists of nine 460/265 Volt, 4,000 Amp switchboards that turn down to 208 Volt, 400 Amp panelboards. Panelboards are located within the three electrical room on each of the above-grade levels. Electrical rooms are located near each corner primary corner of the building near the elevator lobbies. The emergency power panelboards are located on the below-grade levels. The emergency power runs vertically up the entire tower and branches around each floor.

BUILDING ENCLOSURE

The underground garage exterior utilizes a slurry wall construction, which is not very common within the area. The slurry wall was considered the most economical way to construct and excavate the underground portion of the structure. Above ground, the façade consists of metal and glass panels utilizing a curtain wall construction. This curtain wall consists of 2,400 wall units and 29,000 punched window units. Storefront glass, steel sunshades, and glass cable walls also make up portions of the curtain wall.

The primary roof consists of a glass skylight, about the size of a football field, to allow light into the atrium. A majority of the overall roof consists of this glass covering. Around the skylight are several roof pieces at varying levels. Lower roof pieces located at the top of the existing structure and across the front edge of the building are utilized for rooftop terraces and picnic areas. The roof, in whole, consists of 5,200 square feet of rooftop terrace overlooking the city center.

The first phase of the building envelope began late in February of 2013. While this side of the curtain wall began early, the other sides did not begin until April. The first phase was the North Elevation, followed by the West Elevation, East Elevation, and South Elevation. The procedure for the envelope construction began with the installation of the exterior frame and punch windows. Once the frame was secured, the primary curtain wall components were installed. These consisted of hundreds of metal panels and windows. Each elevation of the curtain wall consisted of a duration of about 100 - 150 workdays.

BUILDILNG FIT-OUT

The primary mechanical and electrical chases are located within the four corners of the building. Neighboring the elevator areas are telecom/data and mechanical/electrical rooms. These rooms are used to house panelboards and vertical shafts for ducts and mass conduit runs.

LEED SUSTAINABILITY

The project team is pursuing a LEED Silver certification with a total of 36 expected points for Sunnyvale Plaza. There are also 5 extra points that are a possibility, which would be enough to earn LEED Gold certification. The hotel will be one of the largest hotels in the United States to earn a LEED certification. LEED credits being pursued include Alternative Transportation, Water Efficient Landscaping, Storm-water Design, Heat Island Effect, Construction Waste Management, Low-Emitting Materials, and Innovation in Design.

SCHEDULE

In June of 2006 the first financing package was approved by the council and in February of 2007 private financing came together to complete the proposal. On September 24, 2007, after several reconsiderations for the size of the hotel to reduce financing, the developer signed an agreement to jointly finance the hotel. The official Request For Proposal was released in April of 2001, for a 1,100-room convention headquarters hotel. The original design created 1,500 rooms. After various attempts to gather funding, the hotel design was scaled back from the original design to 1,150 rooms. Sunnyvale released details of the design in October of 2008. The design was submitted to the National Capital Planning Commission late in 2008 and approved early in February of 2009. The project began construction in July of 2011.

Sunnyvale Plaza is expected to reach substantial completion on March 28, 2014 and open for use on April 25, 2014. The total project duration is approximately 34 months to final completion. Table (0-2) shows the breakdown of scheduled phases throughout the construction process. The following section also defines schedule risks and acceleration scenarios as well as the critical path of the construction phases.

Phase	Start Date	End Date	Duration
Design	11/1/2008	3/27/2013	1149
Procurement	12/26/2012	8/16/2013	168
Excavation & Substructure	3/25/2013	7/15/2013	81
Superstructure	4/2/2013	7/15/2013	75
Building Envelope	2/22/2013	11/13/2013	189
Building Fit-Out	8/1/2012	3/12/2014	421
Finishes	2/4/2013	3/17/2014	291

Table 0-2: Summary Schedule

CRITICAL PATH

The phases that drive the project schedule most consist of the excavation and the skylight construction. The slurry wall construction and excavation are the most extensive and critical phases of the project schedule as the rest of the structure relies heavily on the completion of the substructure. Both the substructure and skylight are crucial parts of the critical path and require attention.

The construction of the superstructure cannot begin until the substructure of Level S3 has been completed. Therefore, the excavation and substructure must stay on track to ensure that the superstructure construction can begin on-time. Also, the superstructure can only reach the eleventh floor above grade until the rest of the substructure is secured. Thus, it is critical that the substructure stays on schedule to ensure that the superstructure can continue to advance during construction.

The skylight structure is also a very important part of the critical path. The structural components of the skylight cannot be installed until the superstructure is complete. Therefore the skylight is the last structural element installed in the superstructure. The finishes for Sunnyvale Plaza cannot be installed until the building is sealed and conditioned. Therefore the final pieces of glass around the perimeter need to be installed before most of the finishes can begin. Due to the installation of the large statue, the skylight installation is already limited to other activities being completed and must be closely monitored within the schedule.

Figure 0-5: Skylight Construction

Figure 0-6: Skylight Construction

SCHEDULE RISKS

As mentioned in the previous section, a major risk for the project is the high quality finishes being installed in the guestrooms that make up a majority of the hotel. Theses finishes cannot begin until the skylight is completed and the building is dried in. It is crucial to avoid damaging any of the finishes due to the tight schedule of all of the guestrooms. If any damages are reported, extra work will need to be done to maintain the schedule. Due to the high amount of guestrooms in the hotel, it would be difficult to make up for any delays due to damages.

As a major hotel located in a city center, there is high risk in completing on time. The hotel consists of 1,175 guestrooms, which generate a high amount of revenue. Due to this, the liquidated damages for each day that the hotel is not open is very high. As a convention center hotel, events and rooms are already being booked for the weeks immediately after the opening date.

SCHEDULE ACCELERATION

Due to the size and complexity of the project, it was difficult to pinpoint specific schedule acceleration strategies. Several strategies were utilized to help keep the schedule on track during different phases of construction. Acceleration techniques are continually being implemented when problems arise throughout the construction phases. Most techniques are minor and require extra work to catch up. Using a Short Interval Production Schedule helped keep the finishes of each guestroom on schedule. Accelerating the schedule to an earlier completion date was not heavily pursued due to the goal of creating a conference hotel. The primary purpose of Sunnyvale Plaza is to create a conference center hotel compared to a heavily used tourist hotel.

SHORT INTERVAL PRODUCTION SCHEDULE - SIPS

The use of a Short Interval Production Schedule was very important for this type of project. A SIPS is a detailed schedule that focuses on a day-to-day or weekly construction process. It is utilized for a process that is very repetitive and consistent throughout the entire progression. With over 1,000 hotel suites that are identical throughout the entire building, Sunnyvale Plaza is a prime situation to utilize this type of schedule. A separate SIPS was developed for the guestrooms and core corridors for all of the above-grade floors. The SIPS that was utilized for the guestrooms incorporate all portions of the typical hotel suite on a five day interval per section of each tower. Each floor is separated into two phases, North Tower and South Tower, and within each tower there are four more detailed phases. Each phase makes up approximately 14 hotel suites. As each phase in a tower is completed, the contracting team moves to the next phase and continues to the next floor.

It is important to maintain consistent movement throughout the guestrooms on each floor. Due to the high capacity of the short interval production schedule, if one team falls behind, the entire schedule can be delayed. This can cause a great constructability challenge for the entire finishes phase of the project. By utilizing a short interval production schedule, completion of each phase can be more closely monitored to ensure that the schedule is on-time. Utilizing this strategy to keep the schedule on track is not necessarily an acceleration technique, but surely creates a consistent and efficient work flow. It is difficult to determine, but can be a benefit to the overall project schedule.

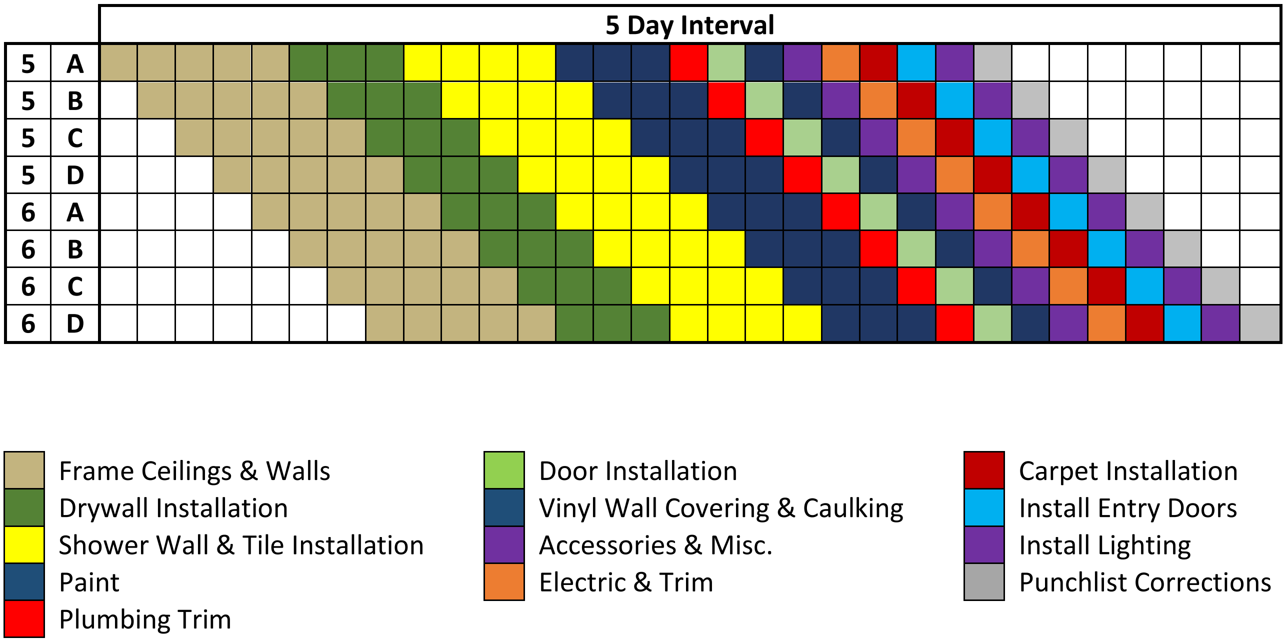


Figure 0-7: SIPS Summary Schedule

PROJECT COST EVALUATION

The prime cost for the entire project is approximately $500 million. This cost seemed fairly high for a hotel within the Mid-Atlantic City. This extreme cost can be expected due to the complexity of the construction process and unique additions within the building. These additions include an underground concourse with an elaborate reorganization of the underground utilities and the extensive excavation process due to the complicated project site.

The data shown in Table 0-3 is based on RSMeans 2013 cost distribution data for a hotel, 8-24 story. This data was collected to approximate the breakdown of costs for each major system within the hotel. The system costs are calculated from the actual prime cost and RSMeans breakdown of sub-total building costs.

Building Cost Evaluation		
	Cost	Cost / Sq. Ft
Prime Cost	$ 500,000,000.00	$ 665.00
Building Systems		
Superstructure	$ 66,000,000.00	$ 87.78
Exterior Enclosure	$ 48,500,000.00	$ 64.51
Plumbing	$ 95,500,000.00	$ 127.02
HVAC	$ 51,500,000.00	$ 68.50
Fire Protection	$ 24,500,000.00	$ 32.59
Electrical	$ 46,500,000.00	$ 61.85

Table 0-3: Building Cost Evaluation

BUILDING SYSTEMS COST

The assemblies MEP estimate was assessed using Reed Construction RSMeans Data. The estimated cost for the mechanical, electrical, and plumbing system totaled $78,200,105. This cost is translated to approximately $104 per square foot. This is substantially lower than the RSMeans construction costs breakdown. Analysis of this cost breakdown yields several possibilities for error.

The construction cost breakdown for the plumbing system was extensively higher than the other building systems. This is believed to be inaccurate as it is roughly double the cost of any other system. Calculating an average building systems cost for the other systems yields a cost of roughly $43 million per building system.

Another source of error originates from the lack of options available within RSMeans Data. This made it difficult to choose the exact components that make up the mechanical and electrical system. Components that were similar were chosen for any components that were not available. Certain components were substantially different and needed to be extrapolated to make up for the extensive size difference. This limited data can create various errors throughout the entire estimate that in-turn add up to a substantial difference for each building system.

Assemblies Item	Overall Cost	Percentage of Cost
Mechanical System	$ 38,858,400.00	50%
Electrical System	$ 13,685,365.00	18%
Plumbing System	$ 16,932,960.00	22%
Total Assemblies Cost	$ 78,200,105.00	
Cost / S.F.	$ 103.99	

Table 0-4: Assemblies Systems Breakdown

The structural system of Sunnyvale Plaza differs between the substructure and superstructure. The below-grade structure consists of steel columns and a slurry wall construction. The superstructure is made up of all concrete construction and steel deck. The substructure is unique in that it is also connected to the neighboring convention center. This created a complicated condition for working underneath an active street. The complete structural system was estimated to cost about $47 million using a detailed structural estimate method. The total cost for the structural system using RS Means Square Foot Analysis was estimated at $66 million. This detailed estimate is approximately 29% less than the square foot approximation. This can be due to and value engineering utilized to succeed on such a complicated project. Reed Construction Data RS Means Online was utilized to estimate the structural components. The following descriptions define the breakdown of each structural system.

Structural Item	Cost	Breakdown
Total Structural Cost	$ 47,000,000.00	-
Steel Construction	$ 8,400,000.00	18%
Atrium Construction	$ 1,240,000.00	3%
Slurry Wall Construction	$ 9,800,000.00	21%
Concrete Structural System	$ 27,000,000.00	57%

Table 0-5: Structural Systems Breakdown

GENERAL CONDITIONS COST

The general conditions estimate was created utilizing a general project team format for the general contractor and conditions represented by the construction process. The general conditions estimate includes the field personnel on the project team, all temporary utilities utilized on the jobsite, insurance, scheduling, and other contingencies. Reed Construction Data RS Means Online was utilized to estimate the general conditions components.

General Conditions Summary		
	Total Cost	Cost / Month
General Conditions	**$ 22,360,661.02**	**$ 657,666.50**

Table 0-6: General Conditions Summary

Field Personnel

The general contractor utilizes a unique project team. This project team consists of two field engineers and three office engineers. There are also numerous levels of superintendents which include area superintendents, project superintendents, and general superintendents. The project also included project engineers, project managers, and executive project managers. Employing such an extensive project team was necessary due to the complexity and size of the project. This produced a much larger field personnel cost.

Field Personnel: $ 8,750,000

Office Trailers

A minimal amount of trailers were utilized for the project team. The available area around the building perimeter was very small, and did not allow any room for office trailers. Therefore, trailers were staged on a neighboring parking lot and had minimal space to take advantage of. This produced a lower cost in office trailer use.

Office Trailers: $ 18,000

Temporary Utilities

The most extensive part of the temporary utilities was the power needed for the entire project and to light the entire building. All 22 floors were being utilized at the same time and needed temporary lighting. The temporary utilities included three tower cranes, one near each corner of the building. Other temporary utilities consist of restrooms, heating for two winters, fences, and waste management.

Temporary Utilities: $ 1,006,911

Commissioning

Commissioning is a very important part of any complicated project today. Measurement and Verification was a crucial portion of the final schedule and generated a substantial cost towards the general conditions estimate.

Commissioning: $ 1,250,000

Due to the high general conditions costs, any schedule delays can result in substantially more loss. Just one week of extra work can cost up to $30,000. Therefore it is inherent that the project schedule is maintained and closely controlled to reflect the completion date.

ANALYSIS 1: UTILIZATION OF A STORMWATER HARVESTING SYSTEM - PLUMBING BREADTH

PROBLEM IDENTIFICATION

Water utilities where Sunnyvale Plaza is located are very expensive. With such a high volume of restroom facilities located within the hotel, the water utility is a major expense to the hotel manager. The hotel consists of 1,175 guestrooms, 49 suites, 5 restaurants, and 5 below-grade levels with meeting rooms and ballrooms. There are approximately 1,365 restrooms consisting of 1,534 water closets, 1,468 sinks, and 1,347 showers. The hotel is estimated to utilize approximately 437,000 gallons of water every day, adding up to approximately 157 million gallons annually. This amount of water can cost approximately $760,000 in potable water utilities annually. Stormwater utility bills can also add substantial costs to the annual cost of maintaining the hotel.

BACKGROUND INFORMATION AND RESEARCH

Stormwater harvesting systems can create a large amount of reusable water for the mechanical and plumbing systems. With such a high volume of restroom facilities located in Sunnyvale Plaza, utilizing a water recycling system can be of great benefit. Pursuing a stormwater harvesting system will also earn several LEED points that can improve the overall certification of the hotel. “LEED 2009 (v3) has a total of 12 points available for stormwater, wastewater and water efficiency. Runoff reduction can meet both water quality and water quality requirements for stormwater, which provides 2 points. Reducing or eliminating potable water for outdoor use offers up to 4 points and reducing potable water for indoor use provides up to 4 points. Finally, innovative wastewater strategies offer 2 points” (Contech Engineered Solutions LLC, 2013).

Utilizing a stormwater harvesting system may create more up-front costs, but can generate substantial long-term savings and improve the value of the hotel. It is also important to analyze the construction schedule increase due to the addition of the system. This analysis will include a plumbing breadth analysis.

DESIGN AND ANALYSIS GOALS

Implementing a stormwater harvesting system will create long-term savings for the hotel manager. Although up-front costs may deter the choice to implement a collection system, long-term financial analysis will prove that the system is a cost-effective solution to minimizing water usage within the city. The rainwater collection system will also generate more LEED points and increase the value of the hotel. Reducing the amount of potable water needed and the amount of stormwater being drained away from the building will create substantial long-term savings due to the high cost of utilities in the city. The system will include a rooftop collection system and piping through the elevation of the hotel to the storage tank within the basement.

PLANNING AND PRECUREMENT

Research was completed to create an estimate for the amount of water used during a typical day of operations. The amount of water was estimated based on the amount of guestrooms and restroom facilities located throughout the hotel. It is assumed that the rainwater collection system will not be able to gather enough rainwater to fulfill the entire hotel, therefore this analysis focuses on just the restroom facilities and not the restaurants located on the first and second floor or the mechanical systems.

Research concluded that a typical hotel room consisting of one bed uses a maximum of 329 gallons per day and a minimum of 166 gallons per day. This averages to approximately 243 gallons per day. This creates approximately 157,400,000 gallons of water used in the guestrooms annually. This amount of water will be utilized to estimate the amount of savings while utilizing the stormwater harvesting system. Table 1-1 illustrates the breakdown of water usage per bed.

Annual	Beds	Gal / Bed / Year	Gal / Year
Bed - Min	1800	59,967.00	107,940,600
Bed - Max	1800	114,915.00	206,847,000
Average	1800	87,441.00	157,393,800

Monthly	Beds	Gal / Bed / Month	Gal / Month
Bed - Min	1800	4,998.00	8,996,400
Bed - Max	1800	9,577.00	17,238,600
Average	1800	7,287.50	13,117,500

Daily	Beds	Gal / Bed / Day	Gal / Day
Bed - Min	1800	166.60	299,880
Bed - Max	1800	319.23	574,620
Average	1800	242.92	437,250

Table 1-1: Water Usage Breakdown

The roof area was examined to determine the amount of rainwater that can be collected from the hotel. Research was completed on the amount of rainfall per year within the city and the expected amount of rainwater during each storm. Data was collected from the National Oceanic and Atmospheric Administration Average Rainfall Database (Average Rainfall, 2014). The full rainfall data can be found in Appendix A. These estimates were calculated utilizing the average amount of time between storms and the average amount of stormwater per month during the previous year. Based on this calculation it is estimated that approximately 17,455 gallons of water can be collected from each storm throughout the year. The amount of rainwater gathered is also compared based on the duration of the storm. Table 1-2 and Table 1-3 illustrate the rainwater collection calculations.

Month	Roof Area (sq. ft.)	Total Accumulation (cubic feet)	Accumulation / Day (cubic feet)	Accumulation / Day (gallons)
January	84143	19,703.49	635.60	4,754.58
February	84143	18,371.22	656.12	4,908.07
March	84143	24,401.47	787.14	5,888.23
April	84143	21,456.47	715.22	5,350.17
May	84143	27,977.55	902.50	6,751.16
June	84143	26,505.05	883.50	6,609.03
July	84143	26,154.45	843.69	6,311.24
August	84143	20,544.92	662.74	4,957.62
September	84143	26,084.33	869.48	6,504.13
October	84143	23,840.52	769.05	5,752.87
November	84143	22,227.78	740.93	5,542.50
December	84143	21,386.35	689.88	5,160.66
Average			**762.99**	**5,707.52**

Table 1-2: Monthly Rainwater Collection

Accumulation / Month (cu. ft.)	Accumulation / Day (cu. ft.)	Accumulation / Hour (cu. ft.)	Accumulation / Storm (10 storms / Month)	
23,334.83	777.83	32.41	2,333.48	cu. ft.
			17,455.62	gallons

Table 1-3: Rainwater Accumulation

Utilizing the entire roof area creates too large of an area to appropriately collect rainwater throughout the year. The roof will be split into two zones with separate collection paths leading to the underground storage tank. The zones meet at the peak of the glass skylight, assuming that the rainwater will appropriately split at this peak. The rest of the zones are made up by the different levels and open area neighboring each half of the skylight. The two zones can be seen in Figure 1-1 and Figure 1-2. The red

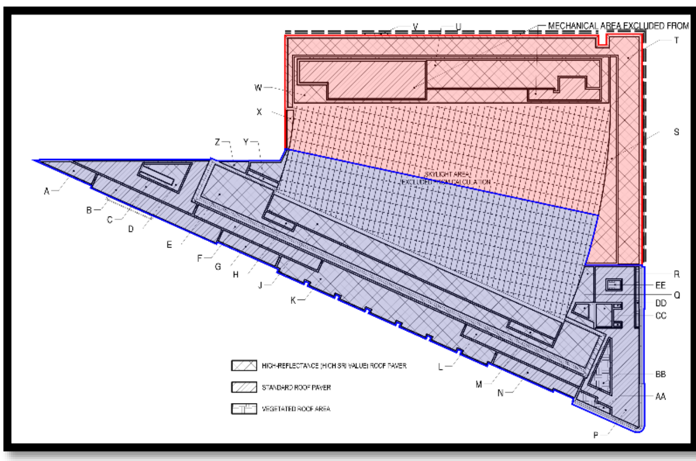


Figure 1-1: 2-Dimensional Zone Distribution

Figure 1-2: 3-Deminsional Zone Distribution

zone consists of a surface area of approximately 36,791 square feet and the blue zone consists of a surface area of approximately 47,352 square feet. The red zone consists of 43.7% of the total roof area and the blue zone consists of 56.3% of the total roof area. The separation of these two zones will allow for appropriate filtration before entering the storage tank. This does substantially increase the cost for roof drainage pipes to the filtration systems.

Table 1-4 illustrates the rainwater collection calculations for the red zone and Table 1-5 illustrates the rainwater collection calculations for the blue zone.

Month	Roof Area (sq. ft.)	Total Accumulation (cubic feet)	Accumulation / Day (cubic feet)	Accumulation / Day (gallons)
January	36791	8,615.23	277.91	2,078.91
February	36791	8,032.70	286.88	2,146.02
March	36791	10,669.39	344.17	2,574.59
April	36791	9,381.71	312.72	2,339.33
May	36791	12,233.01	394.61	2,951.90
June	36791	11,589.17	386.31	2,889.76
July	36791	11,435.87	368.90	2,759.55
August	36791	8,983.14	289.78	2,167.69
September	36791	11,405.21	380.17	2,843.89
October	36791	10,424.12	336.26	2,515.41
November	36791	9,718.96	323.97	2,423.42
December	36791	9,351.05	301.65	2,256.47
Average			**333.61**	**2,495.58**

Table 1-4: Rainwater Collection - Red Zone

Month	Roof Area (sq. ft.)	Total Accumulation (cubic feet)	Accumulation / Day (cubic feet)	Accumulation / Day (gallons)
January	47352	11,088.26	357.69	2,675.67
February	47352	10,338.52	369.23	2,762.05
March	47352	13,732.08	442.97	3,313.64
April	47352	12,074.76	402.49	3,010.84
May	47352	15,744.54	507.89	3,799.26
June	47352	14,915.88	497.20	3,719.27
July	47352	14,718.58	474.79	3,551.69
August	47352	11,561.78	372.96	2,789.93
September	47352	14,679.12	489.30	3,660.24
October	47352	13,416.40	432.79	3,237.46
November	47352	12,508.82	416.96	3,119.07
December	47352	12,035.30	388.24	2,904.20
Average			**429.38**	**3,211.94**

Table 1-5: Rainwater Collection - Blue Zone

RESULTS

The implementation of a rainwater recycling system via collection across the entire roof area allows for an average of 1.31% savings in potable water utilities within the hotel. Although this may seem small, it creates a substantial amount of long term savings through water utility costs. Table 1-6 illustrates the amount of savings per month throughout the year.

Month	Roof Area (sq. ft.)	Accumulation / Day (cubic feet)	Accumulation / Day (gallons)	Gall / Day Used	% Savings
January	84143	635.60	4,754.58	437,250	1.09%
February	84143	656.12	4,908.07	437,250	1.12%
March	84143	787.14	5,888.23	437,250	1.35%
April	84143	715.22	5,350.17	437,250	1.22%
May	84143	902.50	6,751.16	437,250	1.54%
June	84143	883.50	6,609.03	437,250	1.51%
July	84143	843.69	6,311.24	437,250	1.44%
August	84143	662.74	4,957.62	437,250	1.13%
September	84143	869.48	6,504.13	437,250	1.49%
October	84143	769.05	5,752.87	437,250	1.32%
November	84143	740.93	5,542.50	437,250	1.27%
December	84143	689.88	5,160.66	437,250	1.18%
Average		**762.99**	**5,707.52**	**437,250**	**1.31%**

Table 1-6: Total Rainwater Collection

Table 1-7 illustrates the breakdown of monthly savings for the red zone and Table 1-8 illustrates the breakdown of the monthly savings for the blue zone.

Month	Roof Area (sq. ft.)	Accumulation / Day (cubic feet)	Accumulation / Day (gallons)	Gall / Day Used	% Savings
January	36791	277.91	2,078.91	437,250	0.48%
February	36791	286.88	2,146.02	437,250	0.49%
March	36791	344.17	2,574.59	437,250	0.59%
April	36791	312.72	2,339.33	437,250	0.54%
May	36791	394.61	2,951.90	437,250	0.68%
June	36791	386.31	2,889.76	437,250	0.66%
July	36791	368.90	2,759.55	437,250	0.63%
August	36791	289.78	2,167.69	437,250	0.50%
September	36791	380.17	2,843.89	437,250	0.65%
October	36791	336.26	2,515.41	437,250	0.58%
November	36791	323.97	2,423.42	437,250	0.55%
December	36791	301.65	2,256.47	437,250	0.52%
Average		**333.61**	**2,495.58**	**437,250**	**0.57%**

Table 1-7: Monthly Savings - Red Zone

Month	Roof Area (sq. ft.)	Accumulation / Day (cubic feet)	Accumulation / Day (gallons)	Gall / Day Used	% Savings
January	47352	357.69	2,675.67	437,250	0.61%
February	47352	369.23	2,762.05	437,250	0.63%
March	47352	442.97	3,313.64	437,250	0.76%
April	47352	402.49	3,010.84	437,250	0.69%
May	47352	507.89	3,799.26	437,250	0.87%
June	47352	497.20	3,719.27	437,250	0.85%
July	47352	474.79	3,551.69	437,250	0.81%
August	47352	372.96	2,789.93	437,250	0.64%
September	47352	489.30	3,660.24	437,250	0.84%
October	47352	432.79	3,237.46	437,250	0.74%
November	47352	416.96	3,119.07	437,250	0.71%
December	47352	388.24	2,904.20	437,250	0.66%
Average		**429.38**	**3,211.94**	**437,250**	**0.73%**

Table 1-8: Monthly Savings - Blue Zone

The estimated amount of water utilized by the hotel guestrooms creates approximately $63,000 in costs every month. The stormwater utility also costs approximately $1,500 every month. Table 1-9 illustrates the breakdown of water utility costs within the city. This data was collected via the DC Water and Sewer Authority (2014). The full water and sewer rate data can be found in Appendix C.

Water Rate	Ccf (Hundred Cubic Feet)	1,000 Gallons	Gallons Used	Total Cost
Monthly	$ 3.61	$ 4.83	13,117,500	$ 63,357.53
Annual	$ 3.61	$ 4.83	157,393,800	$ 760,212.05

Stormwater Fee	per ERU (Equivalent Residential Unit)	ERU / Guestroom	Guestrooms	Total Cost
Month	$ 2.67	0.473	1,175	$ 1,483.92

Table 1-9: City Water Rates

The total annual savings for the potable water utility amount to approximately $9,960. The total annual savings for the stormwater utility amount to approximately $17,800. If the stormwater fee is negotiable, a total of $27,800 can be saved each year. Table 1-10 illustrates the total savings available by implementing a stormwater harvesting system.

Water Utility	
Savings / Month	$ 829.98
Savings / Year	$ 9,958.78
Stormwater Utility	
Savings / Month	$ 1,483.92
Savings / Year	$ 17,807.03
Total Savings	
Savings / Month	$ 2,313.90
Savings / Year	$ 27,765.81

Table 1-10: Total Available Savings

The costs of implementing the rainwater storage system include a 25,000 gallon fiberglass storage tank, a submersible sump pump to carry the rainwater, two 5,500 square foot filtration stations, and miscellaneous equipment needed to complete the system. Two pumps are required due to the high surface area available across the roof. This is why the roof is split into two zones for drainage. A 25,000 gallon tank was utilized to store the rainwater. It is estimated that approximately 17,500 gallons of water will be collected during each storm throughout the year. Table 1-11 illustrates the estimated amount of storms per a typical month within the location of Sunnyvale Plaza. Table 1-12 illustrates the expected amount of rainwater accumulated per storm throughout the year.

Minutes Between Storms	Hours Between Storms	Hours / Month	Storms
4536	75.6	732	9.68

Table 1-11: Estimated Storms per Month

Accumulation / Month	Accumulation / Day	Accumulation / Hour	Accumulation / Storm (10 storms / Month)	
23,334.83	777.83	32.41	2,333.48	cu. ft.
174,556.21	5,818.54	242.44	17,455.62	gallons

Table 1-12: Expected Rainfall per Storm

Below is listed the breakdown of components required for the rainwater collection system. The cost breakdown is also illustrated in this figure. RSMeans Cost Data information can be found in Appendix B.

Product Code	Item	Quantity	Unit	Cost / Item	Total Cost
221113740160	Pipe, Plastic, Fiberglass - 6" Diameter	100	L. Ft.	$ 66.84	$ 6,684.00
221426133920	Roof Drain 6" Pipe	2	Each	$ 814.63	$ 1,629.26
221426134920	Roof Terrace Drain 6" Pipe	1	Each	$ 768.05	$ 768.05
221429167160	Rainwater Pump, Submersible Sump - 1/2 HP	1	Each	$ 388.46	$ 388.46
221453132100	Rainwater Storage Tank, Fiberglass - 25,000 Gallon	1	Each	$ 48,707.10	$ 48,707.10
221455103210	Rainwater System Vortex Rainwater Filter - 5,500 SF	2	Each	$ 1,273.86	$ 2,547.72
	Total				**$ 60,724.59**

Table 1-13: Rainwater System Takeoff

The total cost of the stormwater harvesting system in 2014 amounts to approximately $60,725. This cost is extrapolated to estimate the projected dollar value throughout the next four years. This extrapolation was calculated by determining the average inflation rate over the past 14 years. The full table of data can be found in Appendix D. “This Inflation Table provides the current U.S. Inflation Rate plus Monthly Inflation Rate data back to January 2000” (McMahon, 2014). This helps estimate the exact payback period for the cost of implementing the system into the hotel. The estimated payback period consists of 2.35 years. Table 1-14 and Table 1-15 illustrate the payback period calculations.

3 Year Payback Cycle		
Cost of System: 2014		Annual Savings
$ 60,724.59		$ 27,765.81
2 Year Inflation	Dollar Value: 2016	Payback Period (Years)
4.87%	$ 63,681.01	2.29
3 Year Inflation	Dollar Value: 2017	Payback Period (Years)
7.30%	$ 65,159.22	2.35
4 Year Inflation	Dollar Value: 2018	Payback Period (Years)
9.74%	$ 66,637.43	2.40

Table 1-14: Payback Period Estimation

Cost of System	Duration	Payback Year	Inflation Rate	Dollar Value	Payback Period (Years)
$ 60,724.59	1	2015	2.43%	$ 62,202.80	2.24
$ 60,724.59	2	2016	4.87%	$ 63,681.01	2.29
$ 60,724.59	**3**	**2017**	**7.30%**	**$ 65,159.22**	**2.35**
$ 60,724.59	4	2018	9.74%	$ 66,637.43	2.40
$ 60,724.59	5	2019	12.17%	$ 68,115.64	2.45
$ 60,724.59	6	2020	14.61%	$ 69,593.85	2.51
$ 60,724.59	7	2021	17.04%	$ 71,072.06	2.56
$ 60,724.59	8	2022	19.47%	$ 72,550.27	2.61
$ 60,724.59	9	2023	21.91%	$ 74,028.48	2.67
$ 60,724.59	10	2024	24.34%	$ 75,506.69	2.72

Table 1-15: Payback Period Estimation

CONSTRUCTABILITY

Implementing the rainwater collection system into the hotel will create extra work during the construction phase. It is important to ensure that the extra work will not create any delays in the critical path. It is estimated that the total duration of the system will take 17 work days. This is not a critical extension to the overall schedule because the critical path primarily consists of the structural elements and enclosure of the hotel. The principal concern with delays is the installation of the storage tank. This tank will require a crane to lower it into the staging area.

RECOMMENDATION

It is recommended that the stormwater recycling system be implemented into the new building design. The long-term savings create a payback period of approximately 2.35 years, with a profitability of approximately $28,000 each year after the payback period. The system also creates a higher value for the overall hotel and can earn several points towards the next level of LEED certification.

ANALYSIS 2: ANALYSIS OF CURRENT EXCAVATION METHOD

PROBLEM IDENTIFICATION

The project team was required to utilize top-down excavation for Sunnyvale Plaza. This excavation process took an extensive amount of extra time to complete. The duration was estimated to be an entire year more than typical excavation methods. The only benefit of utilizing top-down excavation was to allow the team to begin construction upward before the excavation was complete.

BACKGROUND INFORMATION AND RESEARCH

The excavation process utilized by the project team consisted of a top-down excavation. This procedure included pouring each below-grade slab as an on-grade pour with various openings located throughout the slab, then digging the soil out from underneath. Once the first three levels below grade were completed, construction upwards to the eleventh level was allowed to begin. The top-down excavation was found to be necessary due to the depth that the excavation was required to achieve and as a result of the two existing structures located on-site.

Figure 2-1: Sunnyvale Plaza Elevation

The removal of soil was the most extensive process throughout the entire excavation. Aside from the 135 foot depth of excavation, the soil needed to be removed through a tunneling process. This process was difficult due to unforeseen circumstances throughout each level. The columns that were poured were not perfectly aligned and would not always sit where they were expected to on each floor. This created a guessing game for the tunneling crew while moving throughout each level. As the levels were cleared, the soil was removed through openings within each slab. The first three slabs below grade consisted of four openings to allow for the removal of the soil. All of the levels below the first three only utilized two openings for the soil removal. The soil was lifted from each level utilizing a specially designed bucket via the cranes located on-site. The slow process of removing the soil created a lengthy excavation process.

It was especially limiting because the soil was relocated to an off-site location that was only open during typical work hours. This created a limiting window of time for soil removal from the jobsite. Weather also played a major role in delaying the excavation process. Any type of inclement weather halted the excavation process for the day.

Each slab could not be poured until several trades performed work on the in-slab materials. First, structural steel and reinforcing was placed within the building. Once the steel was placed, large steel plates were welded together to create shear studs. Finally, electrical and plumbing trades place in-slab materials.

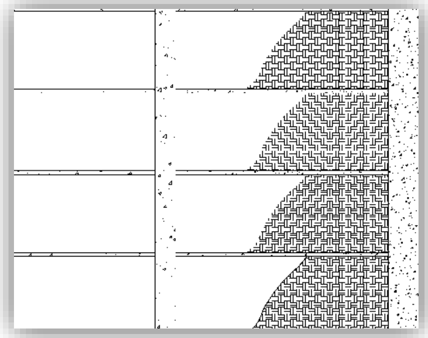


Figure 2-2: Excavation Elevation Detail

A large amount of soil was also required to stay at the edge of each slab against the slurry wall. This soil was required until the slabs reached full structural strength. This soil helped retain the slurry wall and hold the slabs while they cured.

LOCATION

The location of the project site was very constraining towards the type of excavation that was available. The project exists within a tight city block in a large metropolitan area. This location created several critical problems involved in a typical construction process. “One of the largest concerns was the amount of noise generated from the hammering of H-Piles involved in a typical excavation shoring technique” stated David Webb, Director of Safety at Hensel Phelps (2014). Driving each H-Pile into the ground would create a substantial amount of noise for the neighboring area, which would become a problem for the project team. The driving of H-Piles would also create large amount of vibration in the area. These vibrations would likely disrupt the two existing buildings located within the project site.

EXISTING CONDITIONS

The buildings located within the project site also create a critical problem for the excavation process. The pressure of the two buildings, located in opposite corners from each other, create extra force on the excavated area. This extra force would likely cause a cave-in if traditional excavation and shoring methods were employed. This also created limited room that would be allowed for tie-backs within traditional shoring. Tying back into the ground would not be available in the corners where the buildings are located. Tie-backs are also not available in many other areas throughout the project site.

A project engineer familiar with the project, stated that "the location of the hotel was a big factor because you couldn't tie back the walls' (Engineer, 2014). The project site is surrounded by two primary road systems and two minor streets. These primary roads have a significant amount of underground utilities that would obstruct the use of tie-backs on the East and South sides of the excavation. The East side also includes the concourse tunnel underneath the street, which generates even less area available for tie-backs.

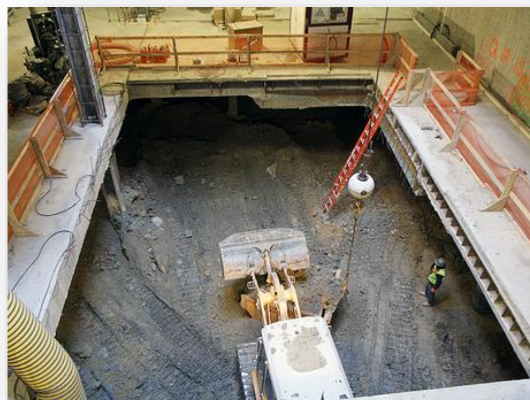


Figure 2-3: Excavation Opening

The project team also determined that the natural water table was located approximately 40 feet below grade. This created an extensive amount of moisture for the lower below-grade levels and produced a higher risk of cave-in below 40 feet. Water pumps were utilized to lower the water table to the full depth of the excavation and were used throughout the entire excavation process.

EXCAVATION DIFFICULTIES

The sheer size of the excavation created the need for an excessive amount of large structural elements. To perform a traditional excavation would require too large of H-Piles for the project site which would also require equipment that was larger than what the project team had available. The size of the H-Piles and structural elements that would be required for a typical excavation was too excessive for the small project site and would be too tall to utilize within a city.

SAFETY

Another major concern of the excavation was the safety of the procedure. The primary concern for utilizing traditional excavation methods was that the surrounding soil would cave into the excavated area due to the depth of the area and the weight of the existing buildings. The excavated area was approximately 135 feet deep, which would require extensive support from traditional shoring methods. The additional restriction of tie-back usage would result in minimal support for the surrounding soil, thus allowing the risk of a cave-in.

The slurry wall was also a high risk factor involved in the chosen excavation process. The entire depth of the slurry wall was dug out to fill with reinforcement and concrete. This concluded with a hole that was approximately 135 feet deep and several feet wide. The reinforcing steel was built on site to the full depth, then lowered into the slurry hole. This created a large steel structure within the project site, which was also a safety concern.

Figure 2.4: Project Site

High pressure pump lines were used to fill the entire slurry hole with concrete. Aside from being very dangerous to work around, if the lines were to blow a massive release of pollutants would be released. As the project site is located in a heavily urban area, an enormous discharge of pollutants is a high concern for the project team. The concrete utilized with the pumps had a very low consistency. This type of concrete was utilized to ensure that the concrete would be able to reach the full depth of the slurry hole without creating a honeycombing flaw. The concrete also needed to pass through the rebar that was placed into the slurry hole. This low consistency concrete created the risk of a laborer to sink within the slurry hole while the concrete was being poured. If a laborer were to fall into the slurry concrete while it was still fluid, there would a high chance that he could sink underneath the surface.

Another major safety concern during the top-down excavation method was the tunneling underneath each below-grade slab. This tunneling procedure consisted of digging out the soil underneath each slab to create a surface to pour the next slab-on-grade. Several openings were left in the slabs to dig out the soil underneath after the curing process was completed. A total of four openings were left in the first three slabs and two openings were left in each of the remaining slabs. Also, each slab could not be poured until several trades performed work on the in-slab materials.

Heavy equipment was lowered into the openings once the initial soil was removed. This equipment was utilized to excavate the soil from underneath each slab where the openings did not allow. This equipment produced a large amount of exhaust within the underground spaces. Aside from the exhaust from equipment as the excavation process grew deeper oxygen levels began to drop. Standard mining ventilation methods were utilized to ensure that the oxygen levels in the lower levels were safe enough to perform work. An expert in ventilation design for tunnels was employed full time to ensure safe ventilation procedures and continuous air monitoring was performed throughout the construction process.

A safety program was also implemented to ensure safe tunneling and underground work procedure. All employees involved in the below-grade work enrolled in the tunneling safety program. A confined space rescue program was coordinated with a confined space rescue team. Practice for the rescue program was performed semi-regularly during the excavation process.

ANALYSIS 3: REMOVAL OF RENOVATED BUILDING SECTION - STRUCTURAL BREADTH

PROBLEM IDENTIFICATION

The brick union building that is located on the southeast corner of the project site will be renovated and included in the new hotel construction. This existing building created a large amount of deconstruction work and temporary structural requirements throughout the lower levels. Complicated concrete construction also took place within the lower levels of the existing structure. This created a lengthier construction process and other unforeseen delays.

BACKGROUND INFORMATION AND RESEARCH

The union building was kept as a historic feature of the new hotel. Efforts to keep the façade of the existing building through façade retention will be analyzed to maintain the historic brick feature of the hotel. The building is fairly small, but accounted for a lengthy deconstruction process. Several key additions within the lower floors also took extensive time. This can all be avoided with the construction of a new building.

Figure 3-1: Image of Existing Building

The existing building also created problems with the excavation process, leading to a much more extensive excavation. The benefits of completely destroying the existing building may lead to unforeseen benefits in the excavation process.

Utilizing façade retention can create faster approach to incorporating the historical elements of the city while still remaining sustainable. In a study of the sustainable development of façade retention, Elisavet Dimitrokali (2010) stated that “façade retention serves sustainability to a certain extend by creating contemporary interior spaces for the occupants, by maintaining heritage for next generations, by gaining financial aid and extra profit, by reducing embodied and operational energy compared to that used for the existing building and by re-using existing structures and not creating extra waste.” Ensuring that the façade retention method is economically feasible for the construction team will be a primary goal for the analysis.

DESIGN AND ANALYSIS GOALS

Utilizing façade retention to allow for the complete demolition of the Plumber’s Union Building may allow for a more productive and efficient construction process. Allowing for the complete demolition will allow the new construction to take the place of the existing building, instead of utilizing an old structural system. This will employ a newer structural system and add value to the hotel. Although costs may increase due to the use of new construction materials, the schedule is expected to decrease substantially due to the ease of construction. Utilizing this schedule decrease in conjunction with an earlier opening date will allow for a greater increase in revenue. This increased revenue will counteract the extra cost of the new construction materials.

The schedule may also decrease due to the elimination of unforeseen problems while renovation occurs. “Hidden costs are common in renovations: issues that are not obvious without penetrating ceilings, walls or grade-level slabs. As-built drawings for older buildings, even if available, do not accurately represent existing conditions or the level of construction quality” (Vazzano, 2013). The project team encountered several problems within the lower levels of the building renovation that created delays in the project schedule. Utilizing new construction will avoid any unforeseen delays and allow for the owner to create a building to best suit their needs.

PLANNING AND PRECUREMENT

The preliminary design parameters were determined through research and interviews with structural engineers with experience within the Mid-Atlantic Region. Several initial factors led to the design of the façade retention system. The primary factors included the size of the façade and the maximum allowable distance from the façade to build the retention structure. Jeff Overmiller recommend to first identify the distance from the building that can be utilized for a bracing system. He stated that “site parameters drive the type of system utilized for the wall’ (Overmiller, 2014). The bracing system will be constructed around the exterior of the façade. This will allow for the easiest construction of the structural frame where there is no existing building. This will also avoid the complication of deconstruction and new construction around the structural frame.

Since the street was initially closed for construction to below-street utilities, a large amount of room was available for the construction of the façade retention structure. The system was expected to form similar to a standard truss system with concrete blocks located at the street level to act as dead weight. This weight will keep the structure from overturning due to wind. Structural rakers are also typically used as a façade retention system. Due to the height of the Plumber’s Union Building a truss system will be utilized.

The façade retention structure consists of horizontal steel beams that are channeled against the exterior and interior faces of the wall across each window level. These beams are connected utilizing a through bolt to grab onto the wall. Vertical steel columns are then connected to the exterior horizontal beams approximately 17 feet apart. The vertical truss system is then connected to the vertical steel columns to create a system of structural bracing elements. This bracing system will transfer the load of the wind to the concrete blocks located on the street.

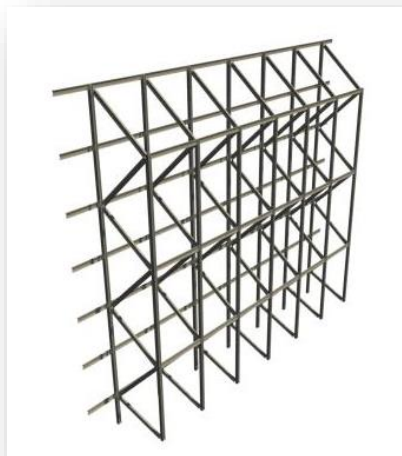


Figure 3-2: Façade Retaining Structure

The horizontal wall span was estimated by utilizing the equivalent distance of the vertical wall spans between each level. It is assumed that if the wall can span that height while being structurally stable, then it can appropriately handle the same horizontal wall span. Therefore the floor to floor height directly relates to the approximate horizontal span of each truss system.

The structural frame will be laterally braced at every joint and utilize pinned connections for each beam connection. Lacing on the outside will also keep the bracing plane. Although the primary force will come from the wind load pushing perpendicularly on the structure, it is important to maintain that the frames are braced against each other as well.

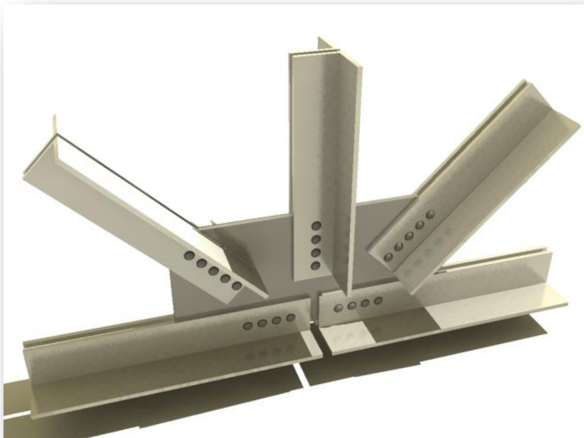


Figure 3-3: Pinned Steel Connection

The initial analysis that was conducted involved determining the wind load that may be present on the wall during construction. This load would ultimately transfer throughout the truss system to the concrete blocks located at the opposite corner of the load. These concrete blocks must contain enough normal-weight concrete to ensure that the façade and retaining structure will not overturn.

STRUCTURAL DESIGN

The total façade that required retention support consisted of a 126 foot wall along the east street and a 53 foot wall along the south street. These walls were made up of four inch red brick on twelve inch concrete masonry units. Both walls are approximately 95 feet tall, and will employ seven occupied levels.

The wind load design was calculated in coordination with ASCE 7-10: Minimum Design Loads for Buildings. The existing structure was classified as Risk Category III. Risk Category III consists of buildings and other structures, the failure of which could pose a substantial risk to human

Figure 3-4: Façade Rendering

life. This category was required due to the density of the surrounding area.

ASCE Chapter 26 was utilized to determine the general requirements of the wind load calculations. Figure 26.5, which can be found in Appendix E consists of basic wind speeds for Occupancy Category III Buildings. The maximum wind speed for the designed location was estimated to be 120 miles per hour. This value is a nominal design load for a three second gust wind at 33 feet above ground level.

ASCE Chapter 28: Wind Loads on Buildings was utilized to determine the primary force on the façade. The force located within the first twenty percent of each wall consisted of a 22.8 pound per square foot force. This was approximately the first 25 feet of the east wall and 5 feet of the south wall. The remaining length of each wall would sustain a force of 15.1 pounds per square foot. Therefore the 22.8 pound per square foot load was utilized to calculate the force on the steel retention structure.

The initial plan was to utilize a steel truss frame at every 8.5 foot interval along each wall. This was later changed to approximately twice the distance, placing each truss at 17 foot intervals. The distance was changed due to the low amount of force transferred from the wind load. Utilizing a 17 foot interval creates a 17 foot section of wall transitioning force to each truss frame.

Horizontal cross beams were placed at each window opening level, at approximately twelve foot intervals. The effective wall area per beam created a total force of approximately 9,000 pounds per cross beam. This force will ultimately transition to the vertical truss sections. The window area was then removed from the effective area to create a total force of 7,900 pounds. Utilizing a safety factor of 1.2 allowed for a load of 9,500 pounds per connection to the truss system.

The calculation of force throughout the truss system was done utilizing standard truss calculations employed in Engineering Mechanics and Physics courses at Penn State University. The calculations can be found in Appendix F.

Figure 3-5: Retained Façade Rendering

The general steel length and forces for each member included in the truss framing system is defined in Table 3-1. Utilizing this table allowed for the calculation of total steel needed for estimating purposes. A standard W8x31 steel beam was utilized to fulfill the structural loads within the system. The same beam was utilized to create consistency within the system and to be utilized within the hotel structure once the façade retention is completed.

Beam:	Force (lb):	L. F.	Size:	Allowable Load (kips):
AB	18,602	18.5	W8 x 31	162
AC	11,957	24	W8 x 31	101
BC	3,230	18.5	W8 x 31	162
BD	14,250	24	W8 x 31	101
CD	15,372	18.5	W8 x 31	162
CE	9,301	24	W8 x 31	101
DE	15,372	18.5	W8 x 31	162
DF	14,250	24	W8 x 31	101
EF	1,465	18.5	W8 x 31	162
EG	19,955	24	W8 x 31	101
FG	1,465	18.5	W8 x 31	162
FH	14,250	24	W8 x 31	101
GH	17,137	18.5	W8 x 31	162
GI	5,705	12	W8 x 31	283
HJ	27,378	2	W8 x 31	374
	Horizontal Beams	2530	W8 x 31	
	L.F. Per Truss:	**287.5**		
	Total Steel Length:	**6267.50**		

Table 3-1: Steel Beam Schedule

The final load found on the concrete dead weight at the street corner of the façade retention structure was found to be approximately 27,400 pounds. Utilizing an approximate weight of 3,915 pounds per cubic yard for normal weight concrete, an estimated 7 cubic yards per truss would be needed to provide enough weight to prevent the structure from overturning. Utilizing a concrete block with the dimensions of 2 yards x 2 yards x 2 yards creates a concrete block of eight cubic yards. This allows for enough weight to sustain the façade retention.

RESULTS

The results and comparison of utilizing a façade retention process in place of the renovation process employed by the construction team are outlined below. Most data, when not obtainable through existing data collection was determined through RSMeans Cost Data. RSMeans Cost Data can be found in Appendix G.

FAÇADE RETENTION AND NEW CONSTRUCTION ESTIMATE

Two different estimates were completed to approximate the cost of the new building construction to replace the Plumber's Union Building. The only phases of construction that were utilized are the deconstruction of the existing building, the demolition of the existing building, and the construction of a new structural system. All other phases are assumed to be completed with negligible difference in cost.

The first estimate involved utilizing the detailed structural takeoff to determine the value of the structural system throughout the entire building. An assumption was made that if the existing building were destroyed and rebuilt, it would directly reflect the structural system of the new construction for the hotel. Therefore, the cost per square foot for the structural concrete and steel of the addition of the hotel was determined utilizing a previous detailed structural takeoff. This cost per square foot was then used to calculate the general cost of the area in which the Plumber's Union Building is located. This estimate concluded a cost of approximately $1,950,000 for the new structural addition.

Structural Cost:	Steel Structural System	$ 8,400,000.00
	Concrete Structural System	$ 27,000,000.00
	Total:	**$ 35,400,000.00**
Cost / SF:	Steel Structural System	$ 11.17
	Concrete Structural System	$ 35.90
	Total:	**$ 47.07**
Plumber's Floor Area	Per Floor	$ 5,172.00
	Total:	**$ 41,376.00**
Structural Estimate	Structural Cost / Floor	$ 243,469.15
	Total Structural Cost	**$ 1,947,753.19**

Table 3-2: New Construction Square Foot Extrapolation

The second estimate consisted of utilizing RSMeans Construction Data to estimate the cost for a new hotel of seven stories and 70,000 square feet of floor area. The structural systems were then pulled from that whole building estimate to determine the cost of building a new structure. This estimate concluded a cost of approximately $2,180,000 for the new structural addition.

Line Item	Description	Cost
A1010	Standard Foundations	$ 66,000.00
A1030	Slab on Grade	$ 52,500.00
B1010	Floor Construction	$ 1,383,500.00
B1020	Roof Construction	$ 173,500.00
B2010	Exterior Walls	$ 502,500.00
	Total	**$ 2,178,000.00**

Table 3-3: New Construction RSMeans Estimate

Utilizing these two estimates averages a total cost of $2,063,000 for the addition of a new structural system to replace the Plumber's Union Building.

Estimate	Description	Cost
Estimate 1	Extrapolation	$ 1,947,753
Estimate 2	RSMeans Takeoff	$ 2,178,000
	Average:	**$ 2,062,877**

Table 3-4: New Construction Average

Additional costs involved in replacing the Plumber's Union Building includes the cost of the façade retention structure. The retaining structure consists primarily of steel structural columns and concrete dead weight anchors blocks. The structure consists of approximately 6,300 linear feet of structure steel beams. Typical W8x31 columns were chosen to fulfill the demand of the wind load on the truss framing. Normal weight concrete would be utilized to prevent from overturning.

Line Number	Description	Unit	Bare Material	Bare Labor	Bare Equipment	Total O&P
51223790250	W8x31	L.F.	338,319.65	34,596.60	18,363.78	449,066.38

Table 3-5: Façade Retention Steel Line Item

Employing 104 cubic yards of normal weight concrete fulfilled the demand for dead weight anchoring on the structure. The cost for the entire steel retaining structure and concrete blocks totaled approximately $483,000.

Line Number	Description	Unit	Bare Material	Bare Labor	Bare Equipment	Total O&P
33053403850	Structural Concrete	C.Y.	22,389.12	5,987.28	46.80	33,913.36

Table 3-6: Façade Retention Concrete Line Item

Total Retaining Structure Cost	
Steel (Material)	$ 338,320
Steel (Assembly)	$ 110,746
Steel (Disassembly)	$ 110,746
Concrete	$ 33,913
Total:	**$ 593,726**
True Cost:	**$ 255,406**

Table 3-7: Retaining Structure Total Cost

Although the upfront cost of the retention structure is approximately $500,000, the true cost of the process will only include the labor of assembling and disassembling the structure and the concrete materials. The steel materials utilized by the retention structure are an appropriate size to be utilized within the hotel itself. This reuse of materials will provide a savings of approximately $340,000.

An additional cost to the façade retention process includes the demolition of the existing Plumber's Union Building once the façade is retained. This cost is the smallest of the entire process and only attributes to approximately $257,000 of the entire process.

Line Number	Description	Quantity	Unit	Bare Labor	Bare Equipment	Total O&P
24116130600	Building Demolition	494,000	C.F.	83,980	113,620	256,880

Table 3-8: Building Demolition Line Item

Therefore, the entire procedure of utilizing a façade retention structure and constructing a new structural system in place of the Plumber's Union Building would cost approximately $2,575,163.

Total Façade Retention Cost Estimate	
Demolition	$ 256,880
Façade Retention Structure	$ 255,406
Building Structure - New	$ 2,062,877
Total:	**$ 2,575,163**

Table 3-9: Façade Retention Total Cost

RENOVATION ESTIMATE

Two RSMeans items were determined to fit the type of renovation utilized by the construction team. Due to the wide difference in price through these items, an average of the two was utilized. An average of the maximum and minimum of each renovation item was utilized to determine the final average cost.

Line Number	Description	Unit	Bare Labor	Bare Equipment	Bare Total	Total O&P
24116190225	Minor Building Deconstruction - Pre 1970, Average	SF Flr.	$93.75	$0.00	$93.75	$154.50
24119211000	Selective Demolition, Gutting, Building Interior, Average	SF Flr.	$4.10	$2.38	$6.48	$9.34
Average	Deconstruction / Selective Demolition - Average	SF Flr.	$48.93	$1.19	$50.11	$81.92

Table 3-10: Renovation Line Items

Thus, the average cost of renovation for the construction team consisted of $81.92 per square foot of floor area within the Plumber's Union Building. This data was utilized to determine a square foot cost accuracy for the renovation process.

Description	Quantity	Unit	Bare Labor	Bare Equipment	Bare Total	Total O&P
Deconstruction / Selective Demolition - Average	41,600	SF Flr	$ 2,035,280	$ 49,400	$ 2,084,680	$ 3,407,872

Table 3-11: Renovation Line Item - Average

Therefore a total cost of renovation for the Plumber's Union Building was estimated to be approximately $3,407,872. This is higher than the total estimate for the façade retention process. The use of façade retention will create a savings of approximately $832,700 in direct construction costs. Total data can be found in Table 3-12.

Method	Cost
Renovation	$3,407,872
Façade Retention	$2,575,163
Difference	**$832,709**

Table 3-12: Cost Comparison

RENOVATION DURATION

The second portion of the results comparison consists of analyzing the duration in which each process will require. The duration for the renovation process utilized by the construction team was estimated utilizing the same methods that were employed to estimate the cost of the renovation process. The two items gathered from RSMeans Cost Data were averaged to determine the labor hours required to renovate the Plumber's Union Building.

Line Number	Description	Unit	Crew	Daily Output	Labor Hours
24116190225	Minor Building Deconstruction - Pre 1970, Average	SF Flr.	6 Clab	20	2.56
24119211000	Selective Demolition, Gutting, Building Interior, Average	SF Flr.	B16	300	0.1095
Average	Deconstruction / Selective Demolition - Average	SF Flr.		160	1.33

Table 3-13: Renovation Duration Line Item

The critical path schedule for Sunnyvale Plaza reflected a total duration of 236 days for the renovation process. The collected RSMeans data requires 16.5 crews to reflect the correct duration by the construction schedule. This hypothetical number will be utilized to reflect similar crew sizes during the façade retention analysis.

Description	Quantity	Unit	Crew	Daily Output	Labor Hours
Deconstruction / Selective Demolition - Average	41600	SF Flr.	16.5 x	4290	1889

Table 3-13: Renovation Duration Line Item - Average

1 Crew	16.5 Crews	Unit
31167	1889	Labor Hours
3896	236	Days
779	47	Weeks
195	12	Months
16	1	Years

Table 3-14: Crew Size Comparison

Thus, the actual renovation duration of 236 days set by the construction schedule is comparable to utilizing approximately 16.5 work crews through RSMeans Data. Utilizing this theoretical computation will allow for an accurate demolition and construction duration comparison for the façade retention process.

FAÇADE RETENTION DURATION

The first phase of the façade retention process consists of construction of the façade retention structure. This structure consists of approximately 6,268 linear feet of steel. The comparable duration of constructing the structural steel for the retaining structure requires approximately 16.5 days. It is estimated that the deconstruction of the retaining steel will also take approximately 16.5 days. This deconstruction process will not directly impact the construction schedule because it can be done at any time after the façade is connected to the structure. The comparable duration of pouring the concrete dead weight blocks consists of approximately 4 days.

Line Number	Description	Quantity	Unit	Crew	Output	Labor Hours	Days
51223790250	W8x31	6268	L.F.	E2 x 5	58.03	130.36	16.30

Table 3-15: Façade Retention Steel Line Item

Line Number	Description	Quantity	Unit	Crew	Output	Labor Hours	Days
33053403850	Structural Concrete	104	C.Y.	C14C x 5	6.93	31.05	3.88

Table 3-16: Façade Retention Concrete Line Item

The second phase of the façade retention process consists of the demolition of the Plumber's Union Building behind the retained façade. The entire building fills approximately 494,000 cubic feet of space, of which requires approximately 124 labor hours to demolish. The comparable duration of demolition the entire union building requires approximately 15.5 days.

Line Number	Description	Quantity	Unit	Crew	Daily Output	Labor Hours	Days
24116130600	Building Demolition	494000	C.F.	B3 x 16	699.47	123.5	15.44

Table 3-17: Building Demolition Line Item

The final phase of the façade retention process consists of the construction of a new structure behind the retained façade. To develop an appropriate estimation for the duration in which the new construction would require, previous square foot estimate data was utilized. This data was employed utilizing the cost and size of the entire project. Utilizing this data will create a more accurate duration estimate concerning the additional structure. This data is most accurate because the additional structure will be constructed during the rest of the structural construction. Therefore, construction productivity will be higher than if the construction team was just building the Plumber's Union Building.

Structural Duration:	Days	75
	Labor Hours	600
Duration / SF:	Days	0.00010
	Labor Hours	0.00080
Plumber's SF	Per Floor	5,172.00
	Total:	**41,376.00**
Structural Duration:	Days / Floor:	0.52
	Total Additional Duration:	**4.13**

Table 3-18: New Construction Duration Extrapolation

Therefore, the addition of the Plumber's Union Building structural frame to the entire project will create an extra 4.5 days of construction. Utilizing the façade retention process creates a total duration of approximately 36.5 days. This is substantially lower than the scheduled 236 days required to renovate the building.

Total Façade Retention Duration	
Demolition	15.5 Days
Retention Structure	16.5 Days
Building Construction - New	4.5 Days
Total:	**36.5 Days**

Table 3-19: Total Façade Retention Duration

SCHEDULE ANALYSIS

Although the durations are significantly different, it is important to analyze the phasing of the schedule to determine if there is actually any decrease in the critical path. While the Plumber's Union Building does not fall directly within the critical path, it is possible to save time by completing work early. The existing schedule portrays the Level 8 structure being completed on May 6, 2013. This ensures that the new construction structure consisting of Level 0 through Level 7 are to be completed before May 6, 2013.

The schedule also shows the fit-out for the new construction of Level 6 beginning on April 25, 2013 and Level 7 beginning on April 8, 2013. These start dates vary between each level that is involved in the Plumber's Union Building. Table 3-20 depicts each lead time determined between the new construction fit-out start dates and the renovation fit-out start dates for each level. The average lead-time for all seven levels totals approximately 30.3 workdays. Therefore, a schedule decrease of 30 workdays is determined to be available when utilizing the façade retention method.

Fit-Out Start Dates			
Level	**PUB**	**New**	**Lead-Time (Workdays)**
1	May 9, 2013	February 18, 2013	57
2	May 2, 2013	April 11, 2013	15
3	May 9, 2013	March 21, 2013	35
4	May 9, 2013	March 18, 2013	37
5	May 9, 2013	March 11, 2013	42
6	May 9, 2013	April 25, 2013	10
7	April 30, 2013	April 8, 2013	16

Table 3-20: Fit Out Schedule Analysis

CONSTRUCTABILITY

Another positive outcome of utilizing the façade retention method is the use of new construction materials. Through renovation the old, possible deteriorated, structural system is maintained to be reused. This creates less value for the hotel due to the possibility of failure earlier in the life of the hotel.

Utilizing new construction materials will create more value for the hotel structural system and increase the life expectancy of the structural system.

RECOMMENDATION

The façade retention method that was estimated and analyzed is approximately 230 faster and requires approximately $832,708 less than the renovation process. Although the façade retention method is substantially faster, only approximately 30 days can be decreased by the overall construction schedule. Utilizing the faster method will allow for the hotel to open earlier than the expected opening date and create more revenue for the hotel owner. The profitability of this opportunity is further analyzed in Analysis 4.

The use of façade retention to maintain the historic features will allow the existing building to be completely destroyed and rebuilt with the rest of the hotel. This will create a less complex construction process while still maintaining the historic feature. The schedule duration will be reduced substantially due to the implementation into the entire building structural construction. This will also benefit in allowing the hotel to open early. This decrease in schedule is evaluated in the last analysis.

ANALYSIS 4: PROFITABILITY OF EARLY SCHEDULED OPENING

PROBLEM IDENTIFICATION

The hotel is forecasted to open approximately one month after The National Cherry Blossom Festival takes place. This festival consists of 25 days of events, ending just 18 days before the opening of the hotel. Due to the primary focus of the hotel being a convention center headquarters, a uniquely forecasted opening was not entirely explored.

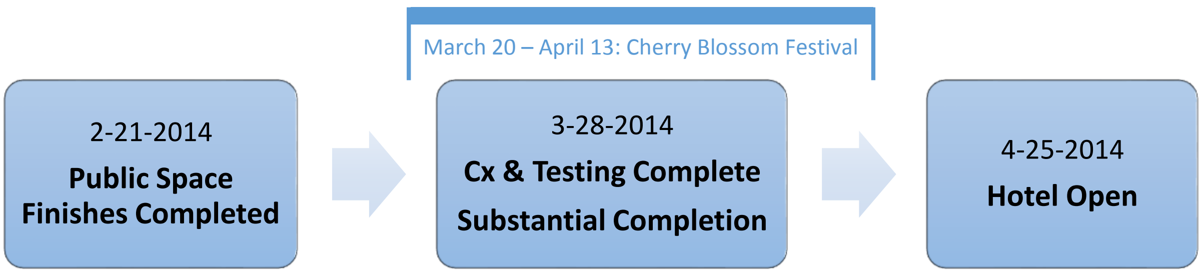


Figure 4-1: Hotel Opening

It is important to guarantee an on-time completion when forecasting an opening just before a national festival. Any delays in the hotel opening can result in problems arising from reserved guestrooms and events. Forecasting an opening date just before the national festival can allow for the hotel to fill capacity and charge higher rates for guestrooms.

BACKGROUND INFORMATION AND RESEARCH

Research was conducted to gain a better understanding of hotel operations and expectations. This research will includes extensive guestroom rate data collection and interviews with hotel industry members. Guestroom rates were compiled from three similar hotels within the surrounding area. This will help improve the final process in which to forecast the hotel opening.

ANALYSIS GOALS

The evaluation of an earlier opening date will create visual evidence towards the benefits of accelerating the construction schedule. Utilizing expansive data collected throughout the proximity of Sunnyvale Plaza will allow for a comprehensive analysis of the hotel rates that can be set for the extra duration that the hotel is available. Utilizing this analysis in conjunction with the façade retention analysis will show a benefit in accelerating the construction schedule. This result will show that utilizing the façade retention method, although more costly, will increase the schedule and allow for enough revenue to counteract the costs.

PLANNING AND PROCEDURE

The profitability of opening earlier than the festival was analyzed in one month increments from January 20th to March 20th with the last month being aligned with the festival. This is to analyze the benefits of exceeding the one month decrease of the schedule duration. With this data, an increase in revenue can be calculated for the hotel for each extra month that the schedule in decreased. The primary target is to open at least one month in advance to create availability for the Cherry Blossom Festival. Hotel rates and occupancy during this festival are increased due to the high demand of tourists. Therefore, this timeframe creates the most profitable opportunity.

The first half of March was separated to create a separate grouping for the specific festival dates. This will allow the analysis to reflect the difference between standard hotel rates throughout March and the increased hotel rates throughout the festival duration.

Three hotels within the same hotel chain as Sunnyvale Plaza were monitored throughout the months of January, February, and March to determine the average rate for a standard hotel room across different durations between the reservation date and check-in date. The check-in dates were set every month to determine fluctuation throughout the beginning of the year. The three hotels that were chosen were of similar quality and proximity of Sunnyvale Plaza.

The average rates were then examined to determine an overall average rate for each month of the schedule. These averages were then multiplied by the amount of hotel rooms found in Sunnyvale Plaza. Therefore this analysis does not cover any revenue that may be earned through the restaurant, ballroom, or meeting room services.

RESULTS

The first hotel that was utilized to collect room rate data is just south of Sunnyvale Plaza and consists of 16 floors, 796 guestrooms, and 13 suites. The hotel also contains 41 meeting rooms and a new lobby. This hotel was given a 3 out of 5 rating from popular travel services. This hotel is just smaller than Sunnyvale Plaza concerning guestrooms services.

The rates did not fluctuate greatly throughout the various booking durations during the study. The room rates did grow as the booking date became closer to the festival dates and increased by almost $100 during the festival.

	Hotel 1					
	1/20/2014		2/20/2014		3/20/2014	
Date Checked	**Duration Until**	**Rate**	**Duration Until**	**Rate**	**Duration Until**	**Rate**
12/16/2013	35	269.00	66	304.00	94	459.00
12/30/2013	21	269.00	52	239.00	80	369.00
1/13/2014	7	269.00	38	258.00	66	352.00
1/27/2014			24	250.00	52	369.00
2/10/2014			10	239.00	38	329.00
2/24/2014					24	279.00
3/10/2014					10	309.00
Average		269.00		258.00		352.29

Table 4-1: Hotel 1 Room Rate Data

The second hotel that was utilized to collect room rate data is farther southwest of Sunnyvale Plaza and consists of 15 floors, 457 guestrooms, and 2 suites. The hotel also contains 14 meeting rooms, 2 concierge levels, and a new lobby. The hotel was also given a 3 out of 5 rating from popular travel services. With just 457 guestrooms, this hotel is less than half the size of Sunnyvale Plaza.

Similarly to the first hotel study, the rates for Hotel 2 also did not fluctuate greatly throughout the first several months. The rates steadily grew through January and February, also increasing by almost $100 during the festival duration. A pattern is begging to appear that rates do not substantially differ depending upon booking time, but definitely vary due to the date in which the hotel stay is booked.

	Hotel 2					
	1/20/2014		2/20/2014		3/20/2014	
Date Checked	Duration Until	Rate	Duration Until	Rate	Duration Until	Rate
12/16/2013	35	249.00	66	304.00	94	459.00
12/30/2013	21	249.00	52	299.00	80	399.00
1/13/2014	7	249.00	38	288.00	66	384.00
1/27/2014			24	250.00	52	399.00
2/10/2014			10	299.00	38	359.00
2/24/2014					24	359.00
3/10/2014					10	329.00
Average		249.00		288.00		384.00

Table 4-2: Hotel 2 Room Rate Data

The third hotel that was utilized to collect room rate data is located much farther southwest of Sunnyvale Plaza compared to Hotel 1 and Hotel 2 and consists of 15 floors, 737 guestrooms, and 35 suites. The hotel also contains 29 meeting rooms, and one concierge level. This hotel contains less guestrooms and meeting rooms than Sunnyvale Plaza, but more suites.

This hotel was typically more expensive to rent from than the other two hotels within the study. Between January and March, the rate for a standard guestroom increased by almost $150. The rate for a standard guestroom also increased by approximately $200 during the festival duration.

	Hotel 3					
	1/20/2014		2/20/2014		3/20/2014	
Date Checked	Duration Until	Rate	Duration Until	Rate	Duration Until	Rate
12/16/2013	35	264.00	66	304.00	94	459.00
12/30/2013	21	264.00	52	304.00	80	459.00
1/13/2014	7	264.00	38	301.00	66	402.00
1/27/2014			24	250.00	52	349.00
2/10/2014			10	349.00	38	399.00
2/24/2014					24	399.00
3/10/2014					10	349.00
Average		264.00		301.60		402.29

Table 4-3: Hotel 3 Room Rate Data

The average rate between all three hotels was generally equal concerning the difference in quality and location. Hotel 3 increased at a higher rate as the festival dates grew closer, while Hotel 1 and Hotel 2 increased at a smaller rate. The rate for a guestroom during the festival was fairy similar between Hotel 1 and Hotel 2, and substantially higher for Hotel 3. The average increase in guestroom rates between January and February was only $22, while the increase from February to March was approximately $100. The average difference in rates between a typical March date and a festival date was approximately $110. Due to the high increase of guestroom rates in March, the first half of the month is enough to create as much revenue as January or February. The increased rate during the entire festival duration grosses the hotel more than 1.5 times the typical monthly revenue. The data shown in Table 4-4 is based on a 100% occupancy.

Opening	Rates - 100% Occupancy			Average	Rooms	Revenue / Day	100% Revenue / Month
January	$269.00	$249.00	$264.00	$261.00	1175	$306,675.00	**$9,506,925.00**
February	$258.00	$288.00	$302.00	$283.00	1175	$332,525.00	**$9,310,700.00**
1/2 March	$353.00	$384.00	$403.00	$380.00	1175	$446,500.00	**$8,483,500.00**
Festival	$429.00	$449.00	$600.00	$493.00	1175	$579,275.00	**$14,481,875.00**

Table 4-4: Hotel Revenue Analysis

An income statement was utilized to determine the average profit margin within the last four years of business for the hotel chain. This report was generated by MorningStar, an independent market analysis firm and can be found in Appendix H. The gross profit over the past four years was averaged to determine a common rate for the market. The average profit margin was determined to be approximately 12.45%, slightly lower than most recent years. It should be noted that the past two years have had a substantial increase in profit margin compared to previous data. The data shown in Table 4-5 depicts the change in profit over the past four years.

Year	Revenue	Cost of Revenue	Gross Profit	Profit Margin
2010	$11,691	$10,216	$1,475	12.62%
2011	$12,317	$11,039	$1,278	10.38%
2012	$11,814	$10,229	$1,585	13.42%
2013	$12,784	$11,070	$1,714	13.41%
Average	**$12,152**	**$10,639**	**$1,513**	**12.45%**

Table 4-5: Average Profit Data

The occupancy data found in Table 4-6 was determined through an average occupancy and average daily room rate analysis conducted by the actual hotel chain. The average occupancy during a standard working day is approximately 66.4%. This occupancy was utilized to determine the occupancy of the first 2.5 months of the year. The highest range of occupancy was approximately 88.1%, which was utilized to determine the occupancy for the festival duration. This higher occupancy is expected due to the high demand for tourism during the festival. It is very possible that during the festival the hotel reaches more than 88.1% occupancy, which will generate even more profit. Table 4-6 reflects the amount of profit that will be generated for the owner including profit margin and occupancy.

Opening	Revenue / Day	Rev / Month	Profit Margin	Occupancy	Profit / Month
January	$306,675	$9,506,925	12.45%	66.4%	$785,918
February	$332,525	$9,310,700	12.45%	66.4%	$769,697
1/2 March	$446,500	$8,483,500	12.45%	66.4%	$701,314
Festival	$579,275	$14,481,875	12.45%	88.1%	$1,588,437

Table 4-6: Hotel Profit Data

Through the façade retention method utilized in Analysis 3, it was determined that the hotel can open on March 14, 2014 due to a duration decrease and schedule re-sequencing. This allows the hotel to open just four days before The National Cherry Blossom Festival. Although this creates very little opportunity for a soft opening, it allows the hotel to supply tourists with living accommodations for the entire duration of the festival. This generates approximately $1,590,000 in profit for the hotel owner.

GENERAL CONDITIONS

The general conditions estimate was created utilizing a general project team format for the general contractor and conditions represented by the construction process. The general conditions estimate includes the field personnel on the project team, all temporary utilities utilized on the jobsite, insurance, scheduling, and other contingencies. Reed Construction Data RS Means Online was utilized to estimate the general conditions components. The estimate was scaled to approximate costs per work week for the project. A detailed general conditions estimate data can be found in Appendix I.

Field Personnel

The general contractor utilizes a unique project team. This project team consists of two field engineers and three office engineers. There are also numerous levels of superintendents which include area superintendents, project superintendents, and general superintendents. The project also included project engineers, project managers, and executive project managers. Employing such an extensive project team was necessary due to the complexity and size of the project. This produced a much larger field personnel cost.

Field Personnel: $ 6,103,750

Office Trailers

A minimal amount of trailers were utilized for the project team. The available area around the building perimeter was very small, and did not allow any room for office trailers. Therefore, trailers were staged on a neighboring parking lot and had minimal space to take advantage of. This produced a lower cost in office trailer use.

Office Trailers: $ 18,000

Temporary Utilities

The most extensive part of the temporary utilities was the power needed for the entire project and to light the entire building. All 22 floors were being utilized at the same time and needed temporary lighting. The temporary utilities included three tower cranes, one near each corner of the building. Other temporary utilities consist of restrooms, heating for two winters, fences, and waste management.

Temporary Utilities: $ 1,006,911

Item	Cost	Percentage
Temporary Utilities	$ 1,006,911.00	5%
Field Personnel	$ 6,103,750.00	27%

Table 4-7: General Conditions Items

Utilizing the estimated cost per week for temporary utilities and field personnel, an average monthly savings of approximately $551,000 was determined. Aside from the general revenue of the hotel during each extra day of operation, finishing the project early will create substantial savings due to decreased labor time.

Item	Cost	Percentage
Temporary Utilities / Week	$ 111,721.72	5%
Field Personnel / Week	$ 25,975.00	27%
Total Cost / Week	$ 137,697.72	
Total Cost / Month	$ 550,790.88	

Table 4-8: Total General Conditions Costs

TOTAL SAVINGS

The total savings that can be generate from an earlier opening involve the revenue from actual hotel operations and the decrease in general conditions costs due to a decreased schedule. Opening just in time for The Cherry Blossom Festival creates a revenue of approximately $14,481,875 and a profit of approximately $1,588,437. The decrease in general conditions creates a savings of approximately $550,790. Thus, the opening of Sunnyvale Plaza just before the festival generates a total profit of approximately $2,139,227. This data can be found in Table 4-9.

Item	Profit
Early Opening	$1,588,437
General Conditions	$550,790
Total	**$2,139,227**

Table 4-9: Total Profit

CONSTRUCTABILITY

A primary concern when accelerating the schedule for a hotel is the involvement of such a high volume of employees. It will be important to maintain that the employees are trained well in advance to ensure that they are prepared for the opening day. This will need to be planned ahead of time if the acceleration happens during the last phases of construction. There is much less of a concern if the forecasted opening is targeted during the planning stages of the construction process.

A positive outcome of opening Sunnyvale Plaza just before The Cherry Blossom Festival is avoiding the risk of a low revenue opening. Hotel openings are preferred during a high revenue season to protect from the risk of business failure. Sunnyvale Plaza was originally forecasted to open for the summer due to the high business season. Opening just one month early will create a low-risk opening period due to the high revenue availability during the festival. The hotel will then be more secure for the summer.

RECOMMENDATION

It is recommended that utilizing the façade retention method will create a suitable decrease in schedule to create substantial profit for the hotel owner. Utilizing this method will allow the hotel to open just before The National Cherry Blossom Festival and create approximately $2,139,277 in profit for the hotel owner.

Appendix A:

Monthly Rainfall Data

WEATHERDB » AVERAGE RAINFALL FOR US CITIES » DETAIL

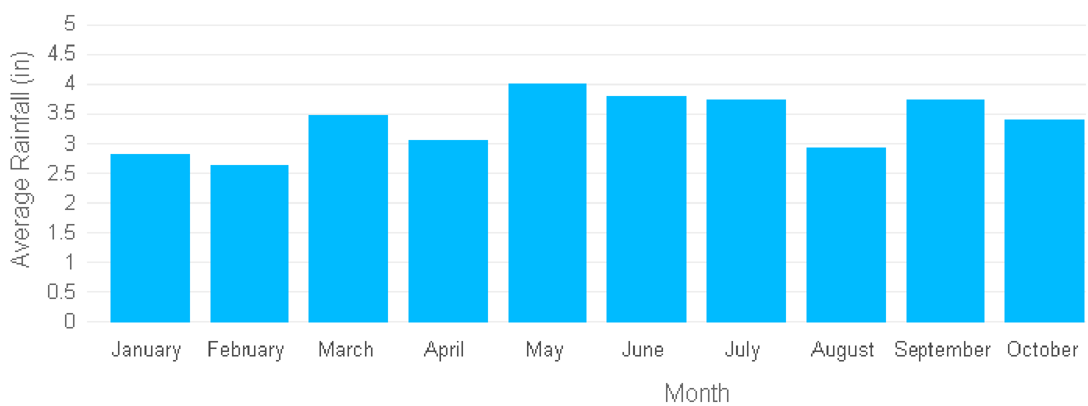
Average Rainfall

Add to List

Navigate To...

Monthly Rainfall

Average By Month | This Year | Year to Date



Month	Average Rainfall
January	2.81 in
February	2.62 in
March	3.48 in
April	3.06 in
May	3.99 in
June	3.78 in

http://average-rainfall.weatherdb.com/l/58/Washington-District-Of-Columbia 1/3

July	3.73 in
August	2.93 in
September	3.72 in
October	3.40 in
November	3.17 in
December	3.05 in

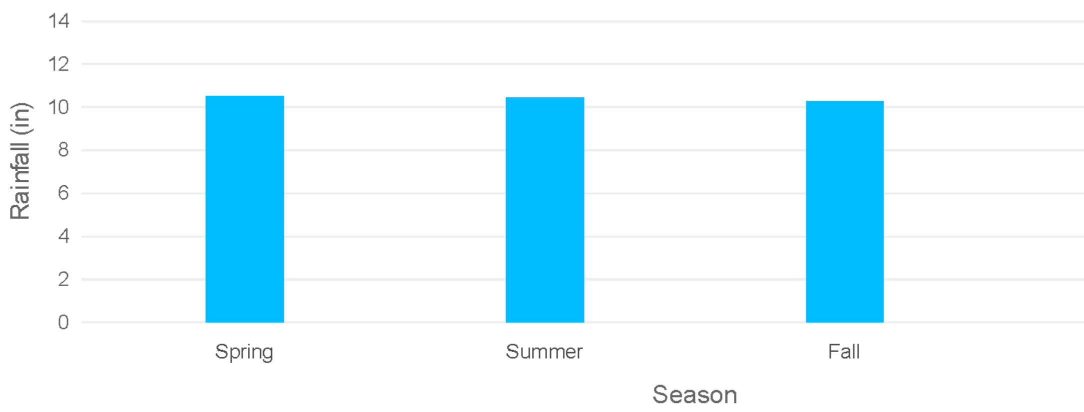
AVERAGE ANNUAL PRECIPITATION

Washington, District Of Columbia

District Of Columbia

All Average Rainfall

Seasonal Rainfall



Season	Rainfall
Spring	10.53 in
Summer	10.44 in
Fall	10.29 in
Winter	8.48 in

Rainfall Records

Appendix B:

Stormwater Harvesting System Takeoff

RSMeans

Cost Estimate Report
RSMeansOnline

Date: 03-Feb-14

StormwaterHarvestingEstimate
Year 2014
Unit Detail Report

Prepared By:
Nathan Braskey
Penn State University

LineNumber	Description	Quantity	Unit	Total Incl. O&P	Ext. Total Incl. O&P
Division 22 Plumbing					
221113740160	Pipe, plastic, fiberglass, filament wound, general service, 6" diameter, includes couplings 10' OC, and hangers 3 per 10'	100.00	L.F.	$66.84	$6,684.00
221426133920	Drain, roof, flat metal deck, cast iron body, 12" cast iron dome, 6" pipe size	2.00	Ea.	$814.63	$1,629.26
221426134920	Drain, roof, terrace planting area, cast iron, 2", 3" and 4" pipe size, includes perforated overflow	1.00	Ea.	$768.05	$768.05
221429167160	Pump, submersible sump, automatic, plastic, 1/2 H.P., 1-1/4" discharge	1.00	Ea.	$388.46	$388.46
221453132100	Rainwater storage tank, fiberglass, 25000 gal, includes 22" manway, straps, 8" I/O, 8" vent	1.00	Ea.	$48,707.10	$48,707.10
221455103210	Rainwater system and component, components, vortex Rainwater Filter:, in-Ground, 5500 S.F.	2.00	Ea.	$1,273.86	$2,547.72
Division 22 Plumbing Subtotal					**$60,724.59**

Subtotal		**$60,724.59**
General Contractor's Markup on Subs	**0.00%**	**$0.00**
Subtotal		**$60,724.59**
General Conditions	**0.00%**	**$0.00**
Subtotal		**$60,724.59**
General Contractor's Overhead and Profit	**0.00%**	**$0.00**
Grand Total		**$60,724.59**

 1-800-334-3509 softwaresupport@rsmeans.com 1

Appendix C:

Water Rates & Metering

Rates & Metering

We have all the information you need about rates and water meters. You can even sign up to receive a notice if your water usage is higher than normal.

In partnership with District Councilmembers, DC Water co-hosted its 4th annual ward town hall meeting series during March and April. As in previous years, DC Water General Manager George Hawkins toured the District to talk about water projects and issues impacting communities throughout the city. More than 300 residents from the District's 8 wards attended this year's meetings.

Following the town hall meetings, the DC Water Board of Directors held a Public Hearing on Wednesday, May 8, 2013 at the Washington Metropolitan Council of Governments, 777 North Capitol Street, NE at 6:30 pm. Customers attended this important hearing and testified in person about our service, our goals and our rate proposal. The Board considered comments and approved the following rate increases in the meeting held on July 3, 2013.

For more information on the FY 2014 Approved Operating and Capital Budgets, please visit this link.

2014 Rates

Fig. 1 in Ccf and equivalent gallons
1Ccf = 748 gallons

Approved FY 2014 (Effective 10/1/2013)		
Rate Class	**Ccf (hundred cubic feet)**	**1,000 Gallons**
Water Rate		
Residential	$3.61	$4.83
Multi-Family	$3.61	$4.83
Non-Residential	$3.61	$4.83
Sewer Rate		
Residential	$4.41	$5.89
Multi-Family	$4.41	$5.89
Non-Residential	$4.41	$5.89
PILOT (Payment In Lieu Of Taxes) Fee		
Residential	$0.53	$0.71
Multi-Family	$0.53	$0.71
Non-Residential	$0.53	$0.71
The Right of Way (ROW) Fee		

Residential	$0.17	$0.22
Multi-Family	$0.17	$0.22
Non-Residential	$0.17	$0.22
Groundwater Sewer Charge*		
Residential	$2.33	$3.11
Multi-Family	$2.33	$3.11
Non-Residential	$2.33	$3.11
	per ERU (Equivalent Residential Unit)	
Clean Rivers Impervious Area Charge		
Residential		$11.85
Multi-Family		$11.85
Non-Residential		$11.85
Stormwater Fee		
Residential		$2.67
Multi-Family		$2.67
Non-Residential		$2.67

Fig. 2 Approved Average Monthly Residential Water and Sewer Bill for 2014*

	FY 2014 †
DC Water Retail Rates*	$53.65
Clean Rivers Impervious Area Charge	$11.85
DC Water Customer Metering Fee**	$3.86
Subtotal DC Water Rates & Charges	$69.36
Increase Over Prior Year	$5.09
District of Columbia PILOT Fee*	$3.55
District of Columbia Right of Way Fee*	$1.14
District of Columbia Stormwater Fee*	$2.67

Subtotal District of Columbia Charges	$7.36
Total Amount Appearing on DC Water Bill	$76.72
Increase Over Prior Year	$5.36

**Assumes average monthly consumption of 6.69 Ccf or 5,004 gallons.*

***The DC Water Customer Metering Fee varies by meter size. The fee given here is the lowest fee and operates as a baseline.*

† FY 2014 is effective October 1, 2013

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Understanding Rates

DC Water bills residential, commercial and government customers on a monthly basis. The water and sewer bills incorporate DC Water charges and District of Columbia charges together on the same bill. The District of Columbia charges are collected by DC Water, who in turn, passes those fees on to the District. The District fees include PILOT (payment in lieu of taxes), ROW (right-of-way) and stormwater.

DC Water charges for water, sewer, customer metering and impervious area. Water and sewer charges are billed volumetrically, that is, they are based on how much water a household or business consumes. The Clean Rivers Impervious Area Charge (CRIAC) is a sewer fee that takes into account the area on a property that is made of impermeable surface, which contributes to runoff and combined sewer overflows. The CRIAC generates funds to cover the cost of the Clean Rivers Project (also referred to as the Combined Sewer Overflow Long Term Control Plan detailed under the "What We Do" section of this website,) a $2.6 billion capital project mandated by the federal government. The customer metering fee is a flat fee based on the meter's size.

How rates are set

Rates are set annually through a year-long process that begins with DC Water developing a budget based on capital and operating needs. Once the budget is approved by the Board of Directors, a rate structure is proposed and communicated via the DC Register, newspapers, town hall public meetings and a public hearing. These are all opportunities for the public to comment on the proposed rates. The DC Water Board of Directors votes on the rate proposal in July, to be implemented in the October bill.

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What can you find in this section?

Public Hearing Testimony (PDF 339 kb)

Appendix D:

Annual Inflation Rate Research

InflationData.com

Your Place in Cyber Space for Inflation Data

▶ Inflation Rate ▶ Historical Data ▶ Inflation Index ▶ Salary Calculator

You are here: Home > Current Inflation Rate

Current Consumer Price Index (CPI-U) 233.049

Current Inflation Rate
1.50%

Released January 16, 2014 for December 2013
Provided by InflationData.com

Web Masters: Get This Widget

Current Inflation Rate

by TIM MCMAHON *on* JULY 18, 2013

Inflation Rate in Percent for Jan 2000-Present

We calculate the ***Inflation rate*** (see table below) to two decimal places while the Bureau of Labor Statistics only calculates ***inflation*** to one decimal place. Therefore, while being based on the same government Consumer Price index (CPI-U) our data provides a "finer" view.

January and February 2012 is a perfect example, according to the government statistics both months had ***inflation rates*** of 2.9%. However, our data shows inflation in January as 2.93% and in February as 2.87%. Therefore instead of the inflation rate being "flat" it is actually falling slightly. Of course this could just be a statistical anomaly but..

Using this enhanced view we might be alerted to watch for the possibility of a bigger decline... which in fact did happen as inflation rates for the following months fell to 2.65%, then 2.30% and 1.7%, 1.66%, and finally 1.41% before beginning to rise again.

In another example we see August 2003 and September with the Government saying inflation rates were 2.2% and 2.3% respectively. This would lead us to believe that inflation rose .1% during that period. In actuality however, it rose from 2.16% to 2.32% or a .16% increase, substantially more than .1%! Once again this finer view gives us a better picture that inflation might be rising more than it appeared to be.

The Inflation table below is updated monthly and provides ***the current US Inflation Rate*** plus Monthly Inflation Rate data back to January 2000. The Inflation rate is calculated using the Current Consumer Price Index (CPI-U) published monthly by the Bureau of Labor Statistics. CPI Index Release Dates

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InflationData.com — **Current Annual Inflation Rate**

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave
2013	1.59%	1.98%	1.47%	1.06%	1.36%	1.75%	1.96%	1.52%	1.18%	0.96%	1.24%	1.50%	1.47%
2012	2.93%	2.87%	2.65%	2.30%	1.70%	1.66%	1.41%	1.69%	1.99%	2.16%	1.76%	1.74%	2.07%
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

2011	1.63%	2.11%	2.68%	3.16%	3.57%	3.56%	3.63%	3.77%	3.87%	3.53%	3.39%	2.96%	3.16%
2010	2.63%	2.14%	2.31%	2.24%	2.02%	1.05%	1.24%	1.15%	1.14%	1.17%	1.14%	1.50%	1.64%
2009	0.03%	0.24%	-0.38%	-0.74%	-1.28%	-1.43%	-2.10%	-1.48%	-1.29%	-0.18%	1.84%	2.72%	-0.34%
2008	4.28%	4.03%	3.98%	3.94%	4.18%	5.02%	5.60%	5.37%	4.94%	3.66%	1.07%	0.09%	3.85%
2007	2.08%	2.42%	2.78%	2.57%	2.69%	2.69%	2.36%	1.97%	2.76%	3.54%	4.31%	4.08%	2.85%
2006	3.99%	3.60%	3.36%	3.55%	4.17%	4.32%	4.15%	3.82%	2.06%	1.31%	1.97%	2.54%	3.24%
2005	2.97%	3.01%	3.15%	3.51%	2.80%	2.53%	3.17%	3.64%	4.69%	4.35%	3.46%	3.42%	3.39%
2004	1.93%	1.69%	1.74%	2.29%	3.05%	3.27%	2.99%	2.65%	2.54%	3.19%	3.52%	3.26%	2.68%
2003	2.60%	2.98%	3.02%	2.22%	2.06%	2.11%	2.11%	2.16%	2.32%	2.04%	1.77%	1.88%	2.27%
2002	1.14%	1.14%	1.48%	1.64%	1.18%	1.07%	1.46%	1.80%	1.51%	2.03%	2.20%	2.38%	1.59%
2001	3.73%	3.53%	2.92%	3.27%	3.62%	3.25%	2.72%	2.72%	2.65%	2.13%	1.90%	1.55%	2.83%
2000	2.74%	3.22%	3.76%	3.07%	3.19%	3.73%	3.66%	3.41%	3.45%	3.45%	3.45%	3.39%	3.38%

Note: Red indicates Deflation, NA indicates data not yet released.

Get more Historical Data from InflationData.com   Web Masters: Get This Widget

To calculate inflation from a month and year to a later month and year, Try our Inflation calculator

About Tim McMahon

Work by editor and author, Tim McMahon, has been featured in Bloomberg, CBS News, Wall Street Journal, Christian Science Monitor, Forbes, Washington Post, Drudge Report, The Atlantic, Business Insider, American Thinker, Lew Rockwell, Huffington Post, Rolling Stone, Oakland Press, Free Republic, Education World, Realty Trac, Reason, Coin News, and Council for Economic Education. Connect with Tim on Google+

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We also post the previous Inflation Rates in our Historical Inflation Tables. The Historical Consumer Price Index is also available in table format. What's the Difference Between the Consumer Price Index and Inflation? You can instantly see the current inflation trend in our chart of the Annual Inflation Rate.

Subscribe to our FREE monthly E-zine and we will keep you up-to-date on what is happening in the area of inflation, interest rates and market trends.

Webmasters- if you would like to use any of our charts please check our usage policy.

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Active Trading Methodologies

There is a big difference between "Trading" and "Investing". Investors research companies and then based on the fundamentals of the company they...

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Cost of Living Calculator
One person recommends this.

One person recommends this.

InflationData.com's Cumulative Inflation Calculator
2 people recommend this.

Inflation's Effect on Retirement Savings
5 people recommend this.

Why Inflation Is Theft
3 people recommend this.

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Appendix E:

Wind Load Factor Data

Table 1.5-1 Risk Category of Buildings and Other Structures for Flood, Wind, Snow, Earthquake, and Ice Loads

Use or Occupancy of Buildings and Structures	Risk Category
Buildings and other structures that represent a low risk to human life in the event of failure	I
All buildings and other structures except those listed in Risk Categories I, III, and IV	II
Buildings and other structures, the failure of which could pose a substantial risk to human life. Buildings and other structures, not included in Risk Category IV, with potential to cause a substantial economic impact and/or mass disruption of day-to-day civilian life in the event of failure. Buildings and other structures not included in Risk Category IV (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, hazardous waste, or explosives) containing toxic or explosive substances where their quantity exceeds a threshold quantity established by the authority having jurisdiction and is sufficient to pose a threat to the public if released.	III
Buildings and other structures designated as essential facilities. Buildings and other structures, the failure of which could pose a substantial hazard to the community. Buildings and other structures (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, or hazardous waste) containing sufficient quantities of highly toxic substances where the quantity exceeds a threshold quantity established by the authority having jurisdiction to be dangerous to the public if released and is sufficient to pose a threat to the public if released.[a] Buildings and other structures required to maintain the functionality of other Risk Category IV structures.	IV

[a]Buildings and other structures containing toxic, highly toxic, or explosive substances shall be eligible for classification to a lower Risk Category if it can be demonstrated to the satisfaction of the authority having jurisdiction by a hazard assessment as described in Section 1.5.2 that a release of the substances is commensurate with the risk associated with that Risk Category.

exceed the member design strength (also called "load and resistance factor design").

TEMPORARY FACILITIES: Buildings or other structures that are to be in service for a limited time and have a limited exposure period for environmental loadings.

TOXIC SUBSTANCE: As defined in 29 CFR 1910.1200 Appendix A with Amendments as of February 1, 2000.

1.1.2 Symbols and Notations

F_x A minimum design lateral force applied to level x of the structure and used for purposes of evaluating structural integrity in accordance with Section 1.4.2.

W_x The portion of the total dead load of the structure, D, located or assigned to Level x.

D Dead load.

L Live load.

L_r Roof live load.

N Notional load used to evaluate conformance with minimum structural integrity criteria.

R Rain load.

S Snow load.

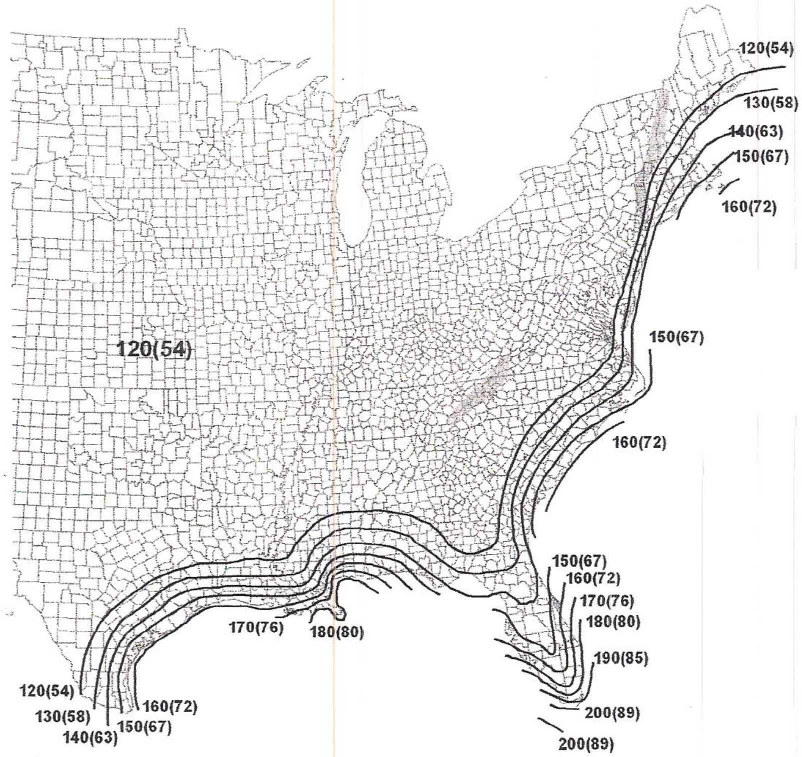
1.3 BASIC REQUIREMENTS

1.3.1 Strength and Stiffness

Buildings and other structures, and all parts thereof, shall be designed and constructed with adequate strength and stiffness to provide structural stability, protect nonstructural components and systems from unacceptable damage, and meet the serviceability requirements of Section 1.3.2.

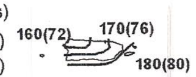
Acceptable strength shall be demonstrated using one or more of the following procedures:

a. the Strength Procedures of Section 1.3.1.1,
b. the Allowable Stress Procedures of Section 1.3.1.2, or
c. subject to the approval of the authority having jurisdiction for individual projects, the Performance-Based Procedures of Section 1.3.1.3.



Special Wind Region

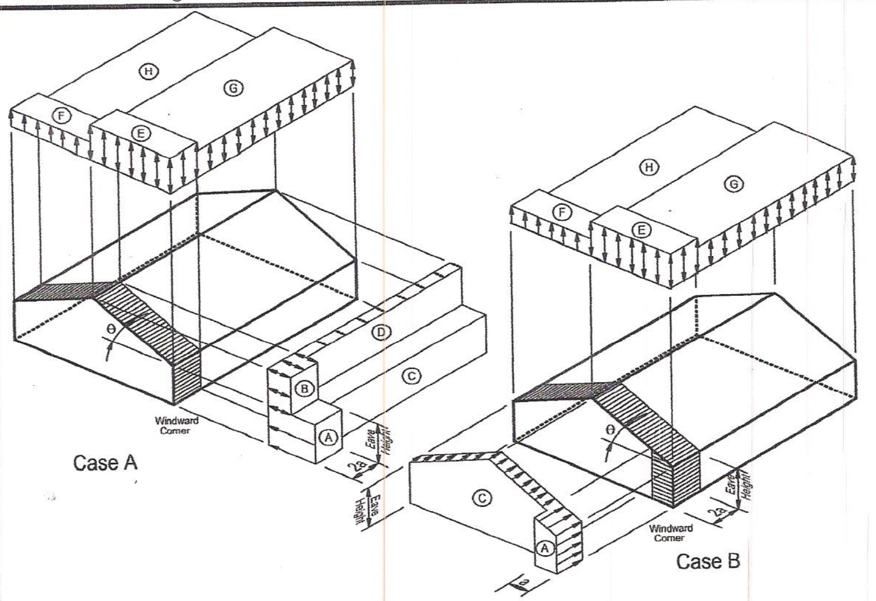
Location	Vmph	(m/s)
Guam	210	(94)
Virgin Islands	175	(78)
American Samoa	170	(76)
Hawaii – Special Wind Region Statewide	145	(65)



Puerto Rico

Figure 26.5-1B (*Continued*)

Main Wind Force Resisting System – Method 2		h ≤ 60 ft.
Figure 28.6-1	Design Wind Pressures	Walls & Roofs
Enclosed Buildings		



Notes:

1. Pressures shown are applied to the horizontal and vertical projections, for exposure B, at h=30 ft (9.1m). Adjust to other exposures and heights with adjustment factor λ.
2. The load patterns shown shall be applied to each corner of the building in turn as the reference corner. (See Figure 28.4-1)
3. For Case B use $\theta = 0°$.
4. Load cases 1 and 2 must be checked for $25° < \theta \leq 45°$. Load case 2 at 25° is provided only for interpolation between 25° and 30°.
5. Plus and minus signs signify pressures acting toward and away from the projected surfaces, respectively.
6. For roof slopes other than those shown, linear interpolation is permitted.
7. The total horizontal load shall not be less than that determined by assuming $p_S = 0$ in zones B & D.
8. Where zone E or G falls on a roof overhang on the windward side of the building, use E_{OH} and G_{OH} for the pressure on the horizontal projection of the overhang. Overhangs on the leeward and side edges shall have the basic zone pressure applied.
9. Notation:
   a: 10 percent of least horizontal dimension or 0.4h, whichever is smaller, but not less than either 4% of least horizontal dimension or 3 ft (0.9 m).
   h: Mean roof height, in feet (meters), except that eave height shall be used for roof angles <10°.
   θ: Angle of plane of roof from horizontal, in degrees.

CHAPTER 28 WIND LOADS ON BUILDINGS—MWFRS (ENVELOPE PROCEDURE)

Main Wind Force Resisting System – Method 2		h ≤ 60 ft.
Figure 28.6-1 (cont'd)	Design Wind Pressures	Walls & Roofs
Enclosed Buildings		

Simplified Design Wind Pressure, p_{S30} (psf) (Exposure B at h = 30 ft. with I = 1.0)

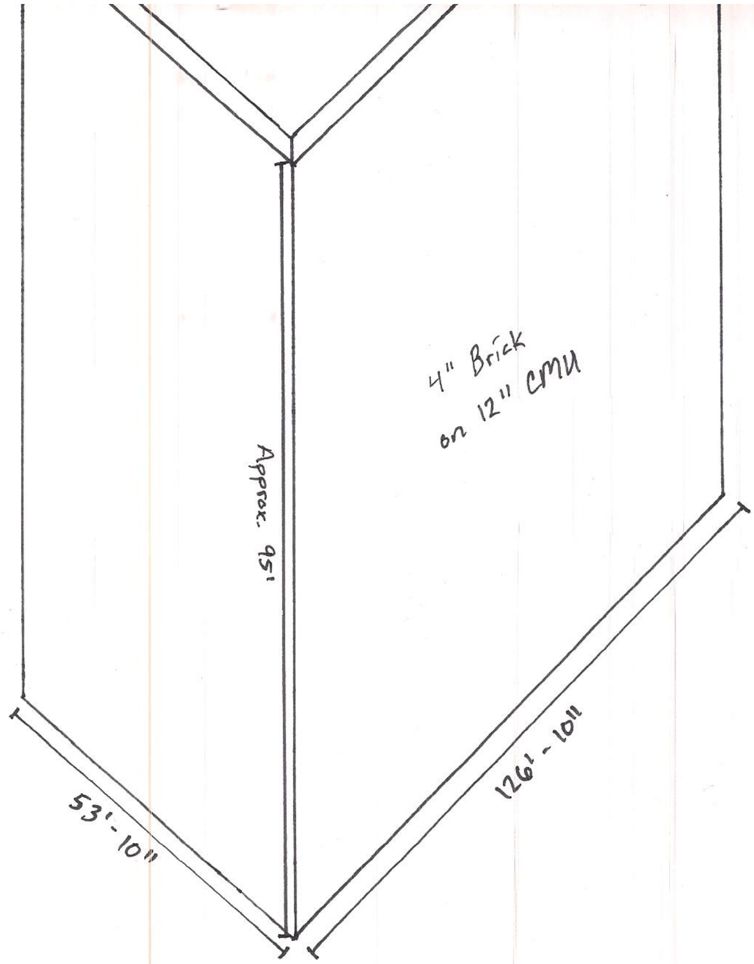
Basic Wind Speed (mph)	Roof Angle (degrees)	Load Case	Zones									
			Horizontal Pressures				Vertical Pressures				Overhangs	
			A	B	C	D	E	F	G	H	E_{OH}	G_{OH}
110	0 to 5°	1	19.2	-10.0	12.7	-5.9	-23.1	-13.1	-16.0	-10.1	-32.3	-25.3
	10°	1	21.6	-9.0	14.4	-5.2	-23.1	-14.1	-16.0	-10.8	-32.3	-25.3
	15°	1	24.1	-8.0	16.0	-4.6	-23.1	-15.1	-16.0	-11.5	-32.3	-25.3
	20°	1	26.6	-7.0	17.7	-3.9	-23.1	-16.0	-16.0	-12.2	-32.3	-25.3
	25°	1	24.1	3.9	17.4	4.0	-10.7	-14.6	-7.7	-11.7	-19.9	-17.0
		2	——	——	——	——	-4.1	-7.9	-1.1	-5.1	——	——
	30 to 45	1	21.6	14.8	17.2	11.8	1.7	-13.1	0.6	-11.3	-7.6	-8.7
		2	21.6	14.8	17.2	11.8	8.3	-6.5	7.2	-4.6	-7.6	-8.7
115	0 to 5°	1	21.0	-10.9	13.9	-6.5	-25.2	-14.3	-17.5	-11.1	-35.3	-27.6
	10°	1	23.7	-9.8	15.7	-5.7	-25.2	-15.4	-17.5	-11.8	-35.3	-27.6
	15°	1	26.3	-8.7	17.5	-5.0	-25.2	-16.5	-17.5	-12.6	-35.3	-27.6
	20°	1	29.0	-7.7	19.4	-4.2	-25.2	-17.5	-17.5	-13.3	-35.3	-27.6
	25°	1	26.3	4.2	19.1	4.3	-11.7	-15.9	-8.5	-12.8	-21.8	-18.5
		2	——	——	——	——	-4.4	-8.7	-1.2	-5.5	——	——
	30 to 45	1	23.6	16.1	18.8	12.9	1.8	-14.3	0.6	-12.3	-8.3	-9.5
		2	23.6	16.1	18.8	12.9	9.1	-7.1	7.9	-5.0	-8.3	-9.5
120	0 to 5°	1	22.8	-11.9	15.1	-7.0	-27.4	-15.6	-19.1	-12.1	-38.4	-30.1
	10°	1	25.8	-10.7	17.1	-6.2	-27.4	-16.8	-19.1	-12.9	-38.4	-30.1
	15°	1	28.7	-9.5	19.1	-5.4	-27.4	-17.9	-19.1	-13.7	-38.4	-30.1
	20°	1	31.6	-8.3	21.1	-4.6	-27.4	-19.1	-19.1	-14.5	-38.4	-30.1
	25°	1	28.6	4.6	20.7	4.7	-12.7	-17.3	-9.2	-13.9	-23.7	-20.2
		2	——	——	——	——	-4.8	-9.4	-1.3	-6.0	——	——
	30 to 45	1	25.7	17.6	20.4	14.0	2.0	-15.6	0.7	-13.4	-9.0	-10.3
		2	25.7	17.6	20.4	14.0	9.9	-7.7	8.6	-5.5	-9.0	-10.3
130	0 to 5°	1	26.8	-13.9	17.8	-8.2	-32.2	-18.3	-22.4	-14.2	-45.1	-35.3
	10°	1	30.2	-12.5	20.1	-7.3	-32.2	-19.7	-22.4	-15.1	-45.1	-35.3
	15°	1	33.7	-11.2	22.4	-6.4	-32.2	-21.0	-22.4	-16.1	-45.1	-35.3
	20°	1	37.1	-9.8	24.7	-5.4	-32.2	-22.4	-22.4	-17.0	-45.1	-35.3
	25°	1	33.6	5.4	24.3	5.5	-14.9	-20.4	-10.8	-16.4	-27.8	-23.7
		2	——	——	——	——	-5.7	-11.1	-1.5	-7.1	——	——
	30 to 45	1	30.1	20.6	24.0	16.5	2.3	-18.3	0.8	-15.7	-10.6	-12.1
		2	30.1	20.6	24.0	16.5	11.6	-9.0	10.0	-6.4	-10.6	-12.1
140	0 to 5°	1	31.1	-16.1	20.6	-9.6	-37.3	-21.2	-26.0	-16.4	-52.3	-40.9
	10°	1	35.1	-14.5	23.3	-8.5	-37.3	-22.8	-26.0	-17.5	-52.3	-40.9
	15°	1	39.0	-12.9	26.0	-7.4	-37.3	-24.4	-26.0	-18.6	-52.3	-40.9
	20°	1	43.0	-11.4	28.7	-6.3	-37.3	-26.0	-26.0	-19.7	-52.3	-40.9
	25°	1	39.0	6.3	28.2	6.4	-17.3	-23.6	-12.5	-19.0	-32.3	-27.5
		2	——	——	——	——	-6.6	-12.8	-1.8	-8.2	——	——
	30 to 45	1	35.0	23.9	27.8	19.1	2.7	-21.2	0.9	-18.2	-12.3	-14.0
		2	35.0	23.9	27.8	19.1	13.4	-10.5	11.7	-7.5	-12.3	-14.0
150	0 to 5°	1	35.7	-18.5	23.7	-11.0	-42.9	-24.4	-29.8	-18.9	-60.0	-47.0
	10°	1	40.2	-16.7	26.8	-9.7	-42.9	-26.2	-29.8	-20.1	-60.0	-47.0
	15°	1	44.8	-14.9	29.8	-8.5	-42.9	-28.0	-29.8	-21.4	-60.0	-47.0
	20°	1	49.4	-13.0	32.9	-7.2	-42.9	-29.8	-29.8	-22.6	-60.0	-47.0
	25°	1	44.8	7.2	32.4	7.4	-19.9	-27.1	-14.4	-21.8	-37.0	-31.6
		2	——	——	——	——	-7.5	-14.7	-2.1	-9.4	——	——
	30 to 45	1	40.1	27.4	31.9	22.0	3.1	-24.4	1.0	-20.9	-14.1	-16.1
		2	40.1	27.4	31.9	22.0	15.4	-12.0	13.4	-8.6	-14.1	-16.1

Unit Conversions – 1.0 ft = 0.3048 m; 1.0 psf = 0.0479 kN/m²

Appendix F:

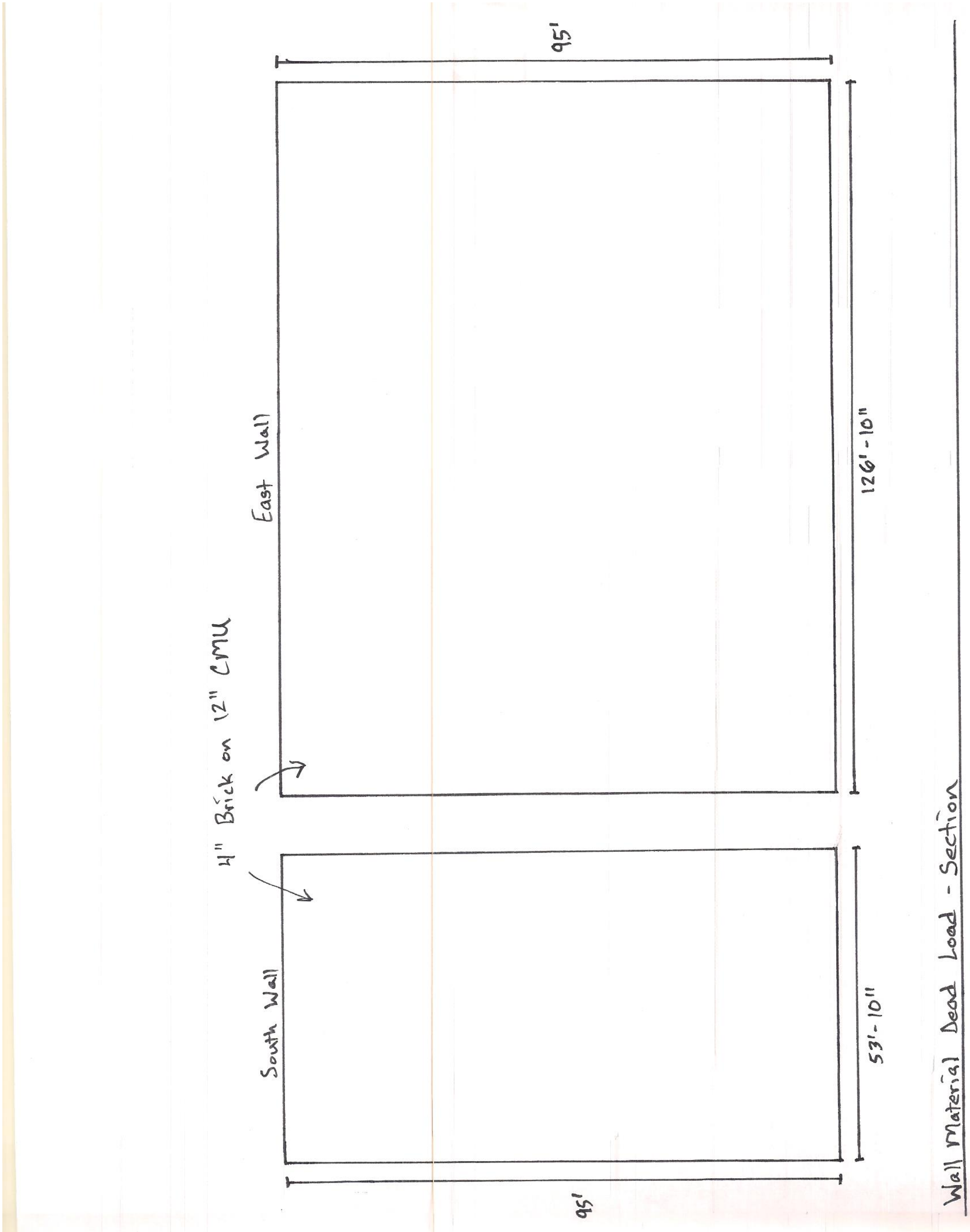
Structural Design Notes

Existing Conditions



Considerations

- Self-weight of wall components
  - CMU + Brick
  - Structural Aspect
- Wind load on two walls
  - Horizontal force for retaining structure


95'
126'-10"
East Wall
4" Brick on 12" CMU
South Wall
53'-10"
95'
Wall Material Dead Load - Section

Dead Load Calculations

95' wall height × 12" = 1,140" wall height

1,140" / 4" = 285 Levels of 4" Brick

1,140"/12" = 95 Levels of 12" CMU

Area of Walls:

South Wall:

95' × 53.83' = ~~[illegible]~~ 5,114.16 sq. ft.

East Wall:

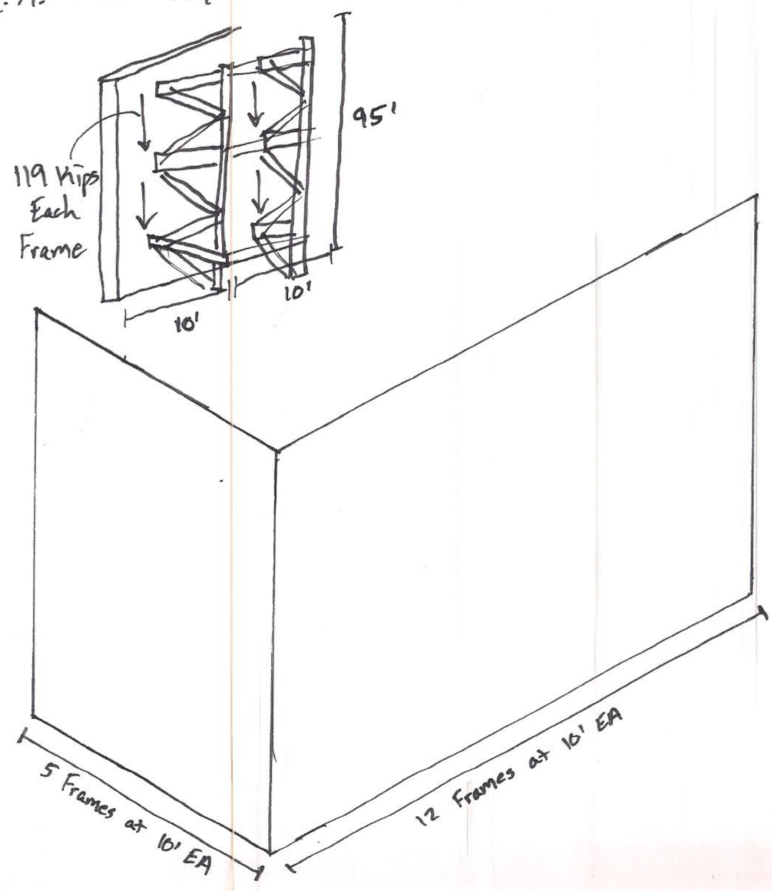
95' × 126.83' = 12,049.16 sq. ft.

Area of Frame Section – Retention Frame every 10'

95' × 10' = 950 sq. ft.

4" Brick at 40 lb/sq. ft. + 12" CMU at 85 lb/sq. ft. = 125 lb/sq. ft. material

950 sq. ft. × 125 lb/sq. ft. = 118,750 lb / retention frame



Wind Load Design

ASCE 7-10: Minimum Design Loads for Buildings

Table 1.5-1: Risk Categories

Risk Category III: Buildings and other structures, the failure of which could pose a substantial risk to human life

ASCE Chapter 26: Wind Loads - General Requirements

Figure 26.5-1B: Basic Wind Speeds for Category III Buildings

Wind Speed for desired location: 120 mph, 54 m/s

- Value is nominal design 3-second gust wind at 33ft above ground

ASCE Chapter 28: Wind Loads on Buildings

Figure 28.6-1: Main Wind Force Resisting System

Basic Wind Speed: 120 mph

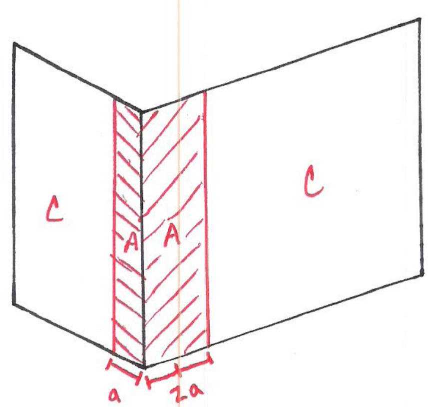
Roof Angle: 0°

Horizontal Pressures: A: 22.8 psf

B: -11.9 psf

C: 15.1 psf

D: -7.0 psf

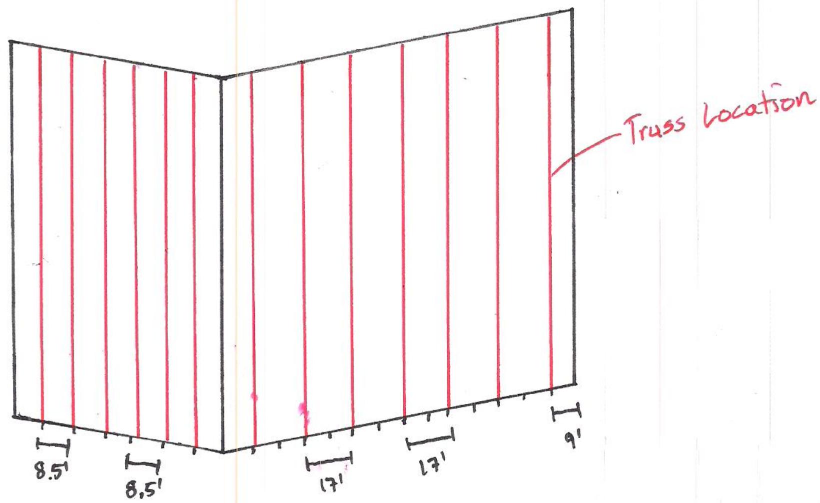


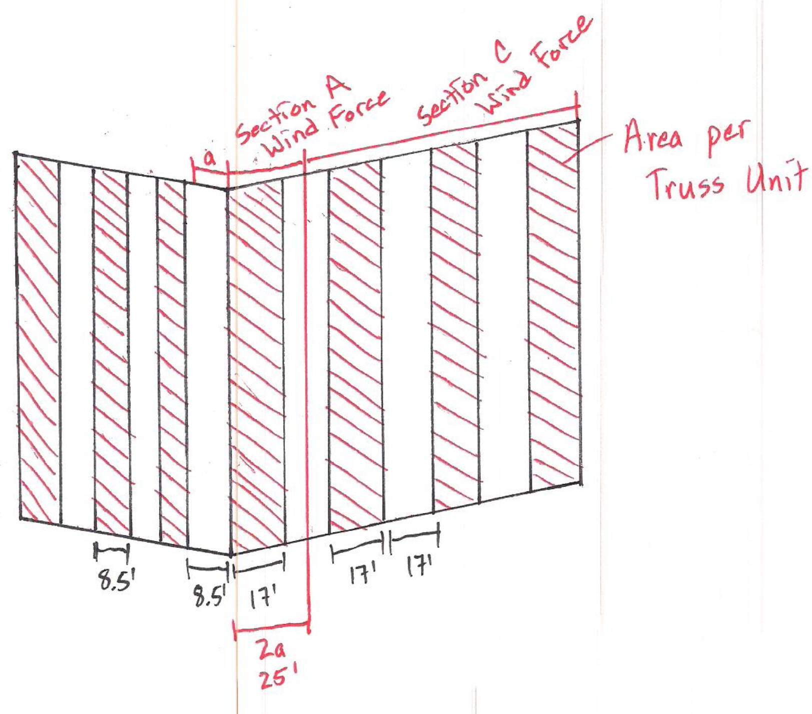
a: 10 percent of least horizontal dimension

$a_1 = 10\% \times 126'-10'' = 12'-8'' \rightarrow 2a = 25'-4''$

$a_2 = 10\% \times 53'-10'' = 5'-4''$

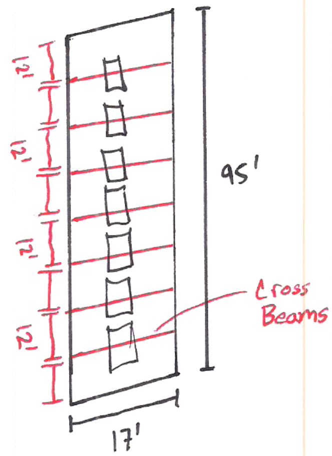
Framing


Truss Location
8.5'
8.5'
17'
17'
9'


a
Section A Wind Force
Section C Wind Force
Area per Truss Unit
8.5'
8.5'
17'
17'
17'
2a
25'

Wind Forces

Highest wind force on east section, 2a portion of wall



Effective Area = 1,615 sq. ft.

Max wind force = 22.8psf

Effective Area per Beam = 408 sq. ft.

× 22.8psf = 9,302.4 lb per beam

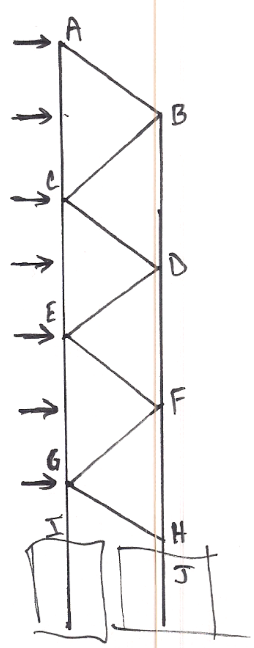
Window Area = 61.75 sq. ft. per window

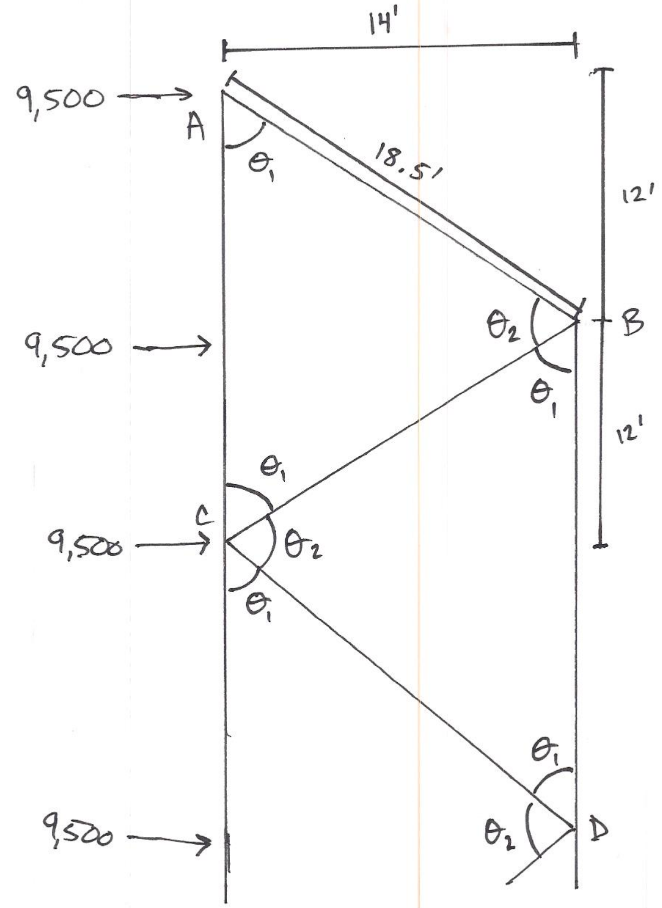
Effective Area = 408 − 61.75

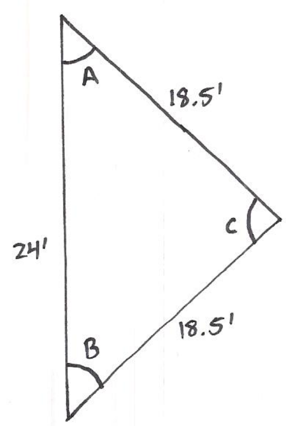
= 346.25 sq. ft.

× 22.8 psf = 7,894.5 lb per beam

× 1.2 SF = 9,500 lb force per connection



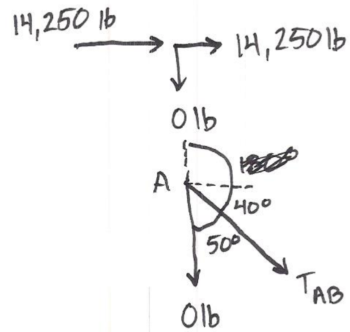




$$\cos A = (b^2 + c^2 - a^2)/2bc$$
$$= (18.5^2 + 24^2 - 18.5^2)/2 \times 18.5 \times 24$$
$$= 0.648649$$

$A = 50^\circ$
$B = 50^\circ$ > $\theta_1 = 50^\circ$
$C = 80^\circ$ $\theta_2 = 80^\circ$

Sections

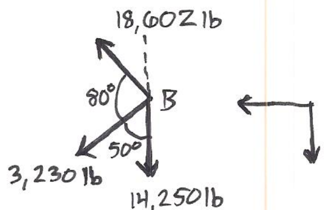


$\Sigma F_y = 0 = T_{AB} \sin 40 - T_{AC} \rightarrow T_{AC} = 11{,}957$ lb

$\Sigma F_x = 14{,}250 = 14{,}250 - T_{AB} \cos 40°$

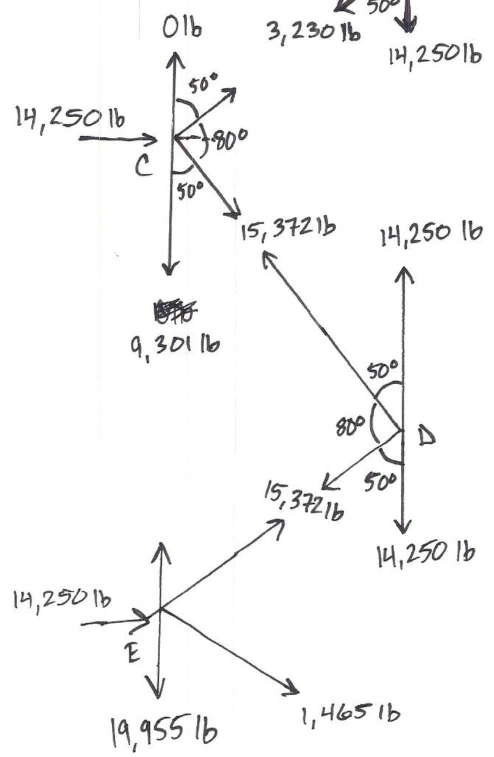
$T_{AB} \cos 40 = 14{,}250$

$T_{AB} = 18{,}602$ lb Compression



$\Sigma F_y = 18{,}602 \sin 50 = 14{,}250$ lb

$\Sigma F_x = 18{,}602 \cos 40 = 14{,}250$ lb



$\Sigma F_x = 14{,}250 - 3{,}230 \cos(40) - T_{CD} \cos(40) = 0$

$T_{CD} = 15{,}372$ lb

$\Sigma F_y = 3{,}230 \sin 50 - T_{CD} \sin 50 - T_{CE} = 0$

$= 3{,}230 \sin 50 - 15{,}372 \sin 50 = T_{CE}$

$T_{CE} = 9{,}301$ lb Tension

$\Sigma F_x = 15{,}372 \cos 40 - T_{DE} \cos 40 = 0$

$\Sigma F_y = 0 = 14{,}250 + 15{,}372 \sin 50 - T_{DE} \sin 50 - T_{DF}$

$T_{DE} = 15{,}372$ lb

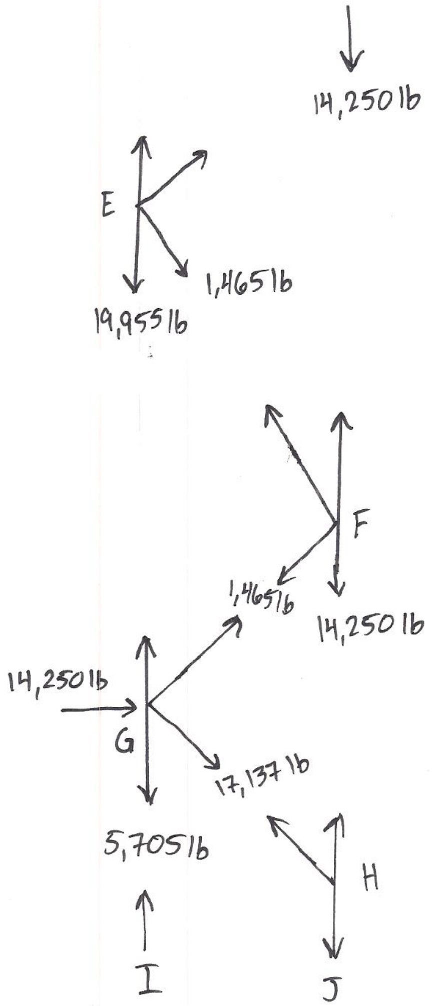
$T_{DF} = 14{,}250$ lb

$\Sigma F_x = 15{,}372 \cos 40 - 14{,}250 - T_{EF} \cos 40$

$T_{EF} = 1{,}465$ Tension

$\Sigma F_y = 9{,}301 + 15{,}372 \sin 50 - 1{,}465 \sin 50 - T_{EG}$

$T_{EG} = 19{,}955$ lb



$\Sigma F_x = 1{,}465\cos 40 - T_{FG}\cos 40$

$T_{FG} = 1{,}465 \text{ lb}$

$\Sigma F_y = 14{,}250 + 1{,}465\sin 50 + 1{,}465\sin 50 - T_{FH}$

$T_{FH} = 14{,}250 \text{ lb}$

$\Sigma F_x = 1{,}465\cos 40 - 14{,}250 - T_{GH}\cos 40$

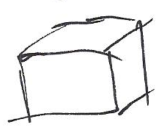
$T_{GH} = 17{,}137 \text{ lb}$

$\Sigma F_y = 19{,}955 - 1{,}465\sin 50 - 17{,}137\sin 50 - T_{GI}$

$T_{GI} = 5{,}705 \text{ lb}$

$\Sigma F_y = 17{,}137\sin 50 + 14{,}250 - T_{HJ}$

$T_{HJ} = 27{,}378 \text{ lb}$

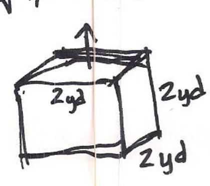


Concrete Block

Approx. weight of concrete = 3,915 lb / c.yd.

$27{,}378 / 3{,}915 = 6.99 = 7$ cubic yards of concrete

$\sqrt[3]{7} = 1.91 \rightarrow 2\text{yd} \times 2\text{yd} \times 2\text{yd}$ block = 8 cu.yd.



Forces on Members

T_{AB} = 18,602 lb

T_{AC} = 0 lb

T_{BC} = 3,230 lb

T_{BD} = 14,250 lb

T_{CD} = 15,372 lb

T_{CE} = 9,301 lb

T_{DE} = 15,372 lb

T_{DF} = 14,250 lb

T_{EF} = 1,465 lb

T_{EG} = 19,955 lb

T_{FG} = 1,465 lb

T_{FH} = 14,250 lb

T_{GH} = 17,137 lb

T_{GI} = 5,705 lb

T_{HJ} = 27,378 lb

8 cubic yards concrete per truss

× 13 trusses = 104 cubic yards
Normal Weight Concrete

Appendix G:

Renovation / Demolition Takeoff Data

Cost Estimate Report
RSMeansOnline

Date: 14-Mar-14

Renovation Estimate
Year 2014 Quarter 1
Unit Detail Report

Prepared By:
Nathan Braskey
Penn State University

LineNumber	Description	Quantity	Unit	Total Incl. O&P	Ext. Total Incl. O&P
Division 02 Existing Conditions					
024116130600	Building demolition, small buildings or single buildings, concrete, includes 20 mile haul, excludes salvage, foundation demolition or dump fees	489,000.00	C.F.	$0.52	$254,280.00
024116190225	Minor building deconstruction, salvage labor, average 2 story, pre 1970 house, 1400 SF, minimum	5,200.00	SF Flr.	$116.00	$603,200.00
024116190230	Minor building deconstruction, salvage labor, average 2 story, pre 1970 house, 1400 SF, maximum	5,200.00	SF Flr.	$193.00	$1,003,600.00
024119211000	Selective demolition, gutting, building interior, commercial building, includes disposal, excludes dumpster fees, minimum	5,200.00	SF Flr.	$7.78	$40,456.00
024119211020	Selective demolition, gutting, building interior, commercial building, includes disposal, excludes dumpster fees, maximum	5,200.00	SF Flr.	$10.90	$56,680.00
Division 02 Existing Conditions Subtotal					**$1,958,216.00**

Subtotal		**$1,958,216.00**
General Contractor's Markup on Subs	**0.00%**	**$0.00**
Subtotal		**$1,958,216.00**
General Conditions	**0.00%**	**$0.00**
Subtotal		**$1,958,216.00**
General Contractor's Overhead and Profit	**0.00%**	**$0.00**
Grand Total		**$1,958,216.00**

Appendix H:

Income Statement

4/3/14 Income Statement for [redacted] from Morningstar.com

[redacted]

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Quote Chart Stock Analysis Performance Key Ratios **Financials** Valuation Insiders Ownership Transcripts NEW Filings Bonds

Income Statement Balance Sheet Cash Flow

Statement Type	Data Type	Period	Show Report Dates	Data Scroll	View	Rounding	Export
Annual	As of Reported	5 Years	Ascending				

Fiscal year ends in December

USD in Million except per share data	2009-12	2010-12	2011-12	2012-12	2013-12	TTM
Revenue	10,908	11,691	12,317	11,814	12,784	12,784
Cost of revenue	9,673	10,216	11,039	10,229	11,070	11,070
Gross profit	1,235	1,475	1,278	1,585	1,714	1,714
Operating expenses	1,387	780	752	645	726	726
Sales, General and adm...	722	780	752	645	726	726
Restructuring, merger ...	51	—	—	—	—	—
Other operating expens...	614	—	—	—	—	—
Total operating expens...	**1,387**	**780**	**752**	**645**	**726**	**726**
Operating income	(152)	695	526	940	988	988
Interest Expense	118	180	164	137	120	120
Other income (expense)	(148)	36	(6)	46	29	29
Income before taxes	(418)	551	356	849	897	897
Provision for income t...	(65)	93	158	278	271	271
Net income from contin...	(353)	458	198	571	626	626
Other	7	—	—	—	—	—
Net income	(346)	458	198	571	626	626
Net income available t...	(346)	458	198	571	626	626
Earnings per share						
Basic	(0.97)	1.26	0.56	1.77	2.05	2.05
Diluted	(0.97)	1.21	0.55	1.72	2.00	2.00
Weighted average share...						
Basic	356	363	350	323	305	305
Diluted	356	378	362	323	313	313
EBITDA	(115)	909	688	1,131	1,144	1,144

financials.morningstar.com/income-statement/is.html?t=MAR&region=usa&culture=en-US&ownerCountry=USA 1/1

Appendix I:

General Conditions Estimate

Existing General Conditions Table				
Item	Quantity	Unit	Cost / Unit	Total Cost
Field Personnel				
Operations Manager	190	Weeks	$ 3,825.00	$ 726,750.00
Executive Project Manager	190	Weeks	$ 3,350.00	$ 636,500.00
Project Manager	190	Weeks	$ 2,900.00	$ 551,000.00
Project Engineer	190	Weeks	$ 2,325.00	$ 441,750.00
Office Engineer (3)	570	Weeks	$ 2,050.00	$ 1,168,500.00
General Superintendent	190	Weeks	$ 3,550.00	$ 674,500.00
Project Superintendent	190	Weeks	$ 3,100.00	$ 589,000.00
Area Superintendent	190	Weeks	$ 2,825.00	$ 536,750.00
Field Engineer (2)	380	Weeks	$ 2,050.00	$ 779,000.00
Temporary Utilities				
Power	342	CSF / Flr	$ 124.63	$ 42,623.46
Restrooms	48	Months	$ 222.42	$ 10,676.16
Heat	342	CSF / Flr	$ 36.20	$ 12,380.40
Trailer	48	Months	$ 375.00	$ 18,000.00
Crane (3)	48	Months	$ 18,150.00	$ 871,200.00
Fencing	1400	L.F.	$ 5.76	$ 8,064.00
Project Signs	250	S.F.	$ 37.50	$ 9,375.00
Waste Management	752	M.S.F.	$ 46.00	$ 34,592.00
Subtotal				**$ 7,110,661.02**
Measurement & Verification	0.25%	%	$ 500,000,000	$ 1,250,000.00
Insurance				
Builder's Risk	0.50%	%	$ 500,000,000	$ 2,500,000.00
General Liability	0.50%	%	$ 500,000,000	$ 2,500,000.00
Payment & Performance Bond	0.75%	%	$ 500,000,000	$ 3,750,000.00
Scheduling	0.05%	%	$ 500,000,000	$ 250,000.00
Miscellaneous Contingency	1.0%	%	$ 500,000,000	$ 5,000,000.00
Total Cost				**$ 22,360,661.02**

Detailed General Conditions Table				
Item	**Quantity**	**Unit**	**Cost / Unit**	**Total Cost**
Field Personnel				
Operations Manager	1	Weeks	$3,825.00	$3,825.00
Executive Project Manager	1	Weeks	$3,350.00	$3,350.00
Project Manager	1	Weeks	$2,900.00	$2,900.00
Project Engineer	1	Weeks	$2,325.00	$2,325.00
Office Engineer (3)	1	Weeks	$2,050.00	$2,050.00
General Superintendent	1	Weeks	$3,550.00	$3,550.00
Project Superintendent	1	Weeks	$3,100.00	$3,100.00
Area Superintendent	1	Weeks	$2,825.00	$2,825.00
Field Engineer (2)	1	Weeks	$2,050.00	$2,050.00
Temporary Utilities				
Power	342	CSF / Flr	$124.63	$42,623.46
Restrooms	0.25	Months	$222.42	$55.61
Heat	342	CSF / Flr	$36.20	$12,380.40
Trailer	0.25	Months	$375.00	$93.75
Crane (3)	0.25	Months	$18,150.00	$4,537.50
Fencing	1400	L.F.	$5.76	$8,064.00
Project Signs	250	S.F.	$37.50	$9,375.00
Waste Management	752	M.S.F.	$46.00	$34,592.00
Total Cost				**$137,696.72**

Appendix J:

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Figure 3-3:

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