Project X

NYC, NY

Luke Gray

Construction Management

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October 4, 2010

LUKE GRAY
CONSTRUCTION MANAGEMENT

PROJECT X
NEW YORK

MECHANICAL, ELECTRICAL, LIGHTING

MECHANICAL-AHU'S RANGING FROM 8650-6300CFM ON EACH FLOOR, SUPPLEMENTARY HYDRONIC FIN TUBE BASEBOARD RADIATION ALONG THE PERIMETER

ELECTRICAL-POWER IS DISTRIBUTED WITH 208/120V, 3-PHASE , 4 WIRE PANELS ON EACH FLOOR; DRY TYPE TRANSFORMER

LIGHTING-THERE ARE MANY TYPES LAMPS USED WITHIN THE BUILDING INCLUDING FLUORESCENT, INCANDESCENT, METAL HALIDE, H.I.D. FIXTURES. THE EMERGENCY LIGHTING FOR THE BUILDING IS SUPPLIED BY FLUORESCENT FIXTURES WITH A 90 MINUTE EMERGENCY BATTERY PACK.

ARCHITECTURAL & STRUCTURAL

FOUNDATION-REINFORCED MAT SLAB
10" DEEP TWO-WAY FLOOR SLAB
COLUMN LAYOUT 24' X 24'
THE EXTERIOR WALLS NATURAL BRICK WITH THREE CURTAIN WALL SLOTS TO BREAK UP THE BRICK FACADE THAT BLENDS SEAMLESSLY INTO THE SURROUNDING HISTORICALLY RICH TOWN-HOUSES
THERE ARE THREE LEVELS OF 12" INTENSIVE GREEN ROOFS

CM-SKANSKA
ARCHITECT-MA ARCHITECTS
STRUCTURAL-ROBERT SILMAN
MECHANICAL-FMC ASSOCIATES
LIGHTING-RS LIGHTING DESIGN
DURATION-AUGUST 2008-JULY 2010
SIZE-54,640SF
BUILDING USE-OFFICES & THEATRE

HTTP://WWW.ENGR.PSU.EDU/AE/THESIS/PORTFOLIOS/2011/LAG290/INDEX.HTML

Acknowledgements

I would like to thank all of my friends and family who supported me throughout this senior thesis project. Most of all I appreciate my wife's day in and day out support. This project started and enthusiastically and overwhelming has ended in success. This research would not have been possible without the support of the following people.

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I. Executive Summary

The main purpose behind this senior thesis research is increase productivity and efficiency by utilizing today's technology in design to construction. Reducing rework from design to facility management is a multidimensional process. Tracking the work flow of information from facility management to design results in the identification of valuable data, which can be used for the building information model.

Alternative Structural Bracing for the Theatre

This depth study into the constructability looks at the alternate methods of bracing. The cost and strength of the bracing was found to be equal to the original design. The primary advantage is that the alternative bracing reduces site congestion and concrete slab shoring. RAM Elements and Revit were utilized for the quantity take-offs to expedite the estimating process.

Connecting the Electrical System to the Existing Combined Heat and Power Plant

This analysis examines the peak load shaving to create energy savings. After creating an energy model, the required electrical equipment was selected and priced. The outcome shows a return on investment of less than five years, with an annual electricity savings of $8,147.

Utilization a Matrix schedule

The crowded construction site of New York City proved to be the ideal selection for creating a matrix schedule. By dividing up the site plan into zones a feasible alternative was easily found. Scheduling the underground utility work in the beginning phase of construction potential delays from underground work can be prevented.

Building Information Model and Facility Management Integration

This section studies a critical industry issue of integrating the BIM and FM while focusing on what information owners are using in the field. By understanding what technicians are using in the field it becomes clear what information is critical to implement within the BIM. Another key to the BIM and FM integration is organizing the information in a structured format from design to construction. As a result, information can be successfully passed to the owner.

II. Project Overview

Project Summary Schedule

The procurement phase consists of a variety of activities. Since, design decisions were ongoing during the construction project. Procurement phase of construction of is extended because the project is a fast-track project. The procurement stages includes: prepare bidders list, review of bid documents, owner review, finalize bidders, bid period, evaluation of bidder, owner approval of bidders, and awarding subcontractor. In addition, procurement includes the submittal, fabrication and develop, and mobilization of trades.

Throughout the construction process there were many complicated huddles to overcome. For example, the demotion phase which lasted duration of 31 weeks. This phase was extensive, because there were many requirements by New York City Department of Building, Department of Transportation, protective measures taken to protect adjacent structures, protective walkway, and scaffold for the Alley way. The demolition progressed linearly from the Roof Parapet to the 1st floor with duration of 60 days. The longest phase was the demolition of the 2nd floor, which compiled of 26 days. This was needed to allow the tradesmen time to demo the around theatres walls by hand demolition, which remained in place. In addition, the south and north adjacent buildings needed to be braced.

Excavation and foundations were a great engineering feat. Underpinning and footing heel blocks were needed to ensure there was no settlement of the playhouse's existing brick walls. Other measures included: sheeting and tie backs, addition underpinning of adjacent structures, and installation of a dewatering system. The primary foundation system is a matt slab. From the foundation stage the project progressed into the building frame and exterior frame.

Cast-in-place concrete frame supports the 10" 2-way concrete slab. The concrete columns and concrete slab was constructed with duration of 5 days per floor. The masonry perimeter walls were laid with at a rate of eight days per floor. The concrete superstructure is on the critical path to completion. Since, the superstructure was poured from October to February 24-7 temporary heat was needed to ensure a timely curing of the concrete. Temporary heat was also needed for the building finishes. Following the superstructure on the critical path to completion is the MEP and interior fit out.

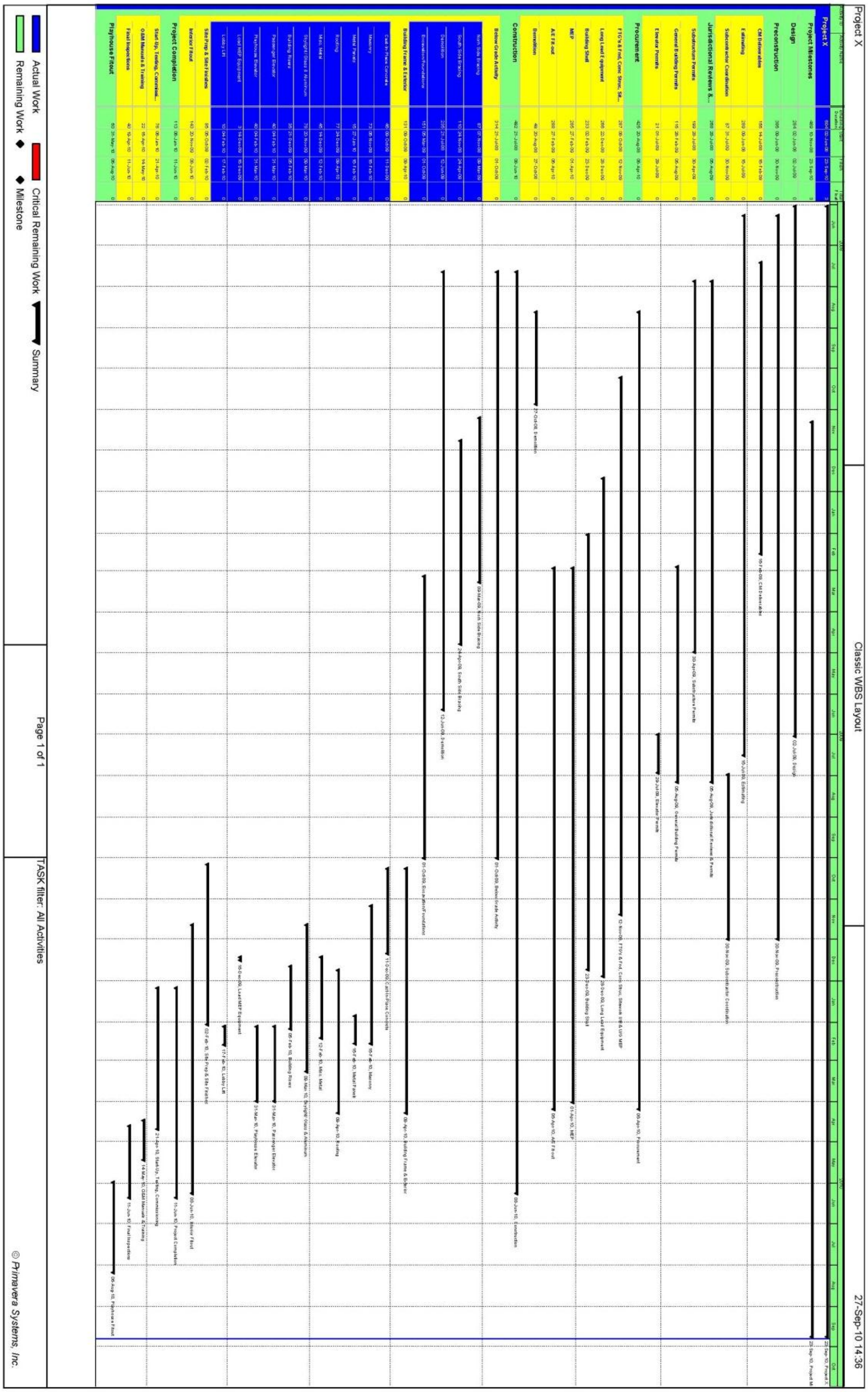


Figure 1: Project Summary Schedule

Building Systems Summary

Material used same day as delivered, because there was no room for material storage. Long lead time items were needed to be coordinated prematurely to ensure a timely delivery. In addition safety nets were used along the perimeter walls to protect adjacent structure, one being a neighbor's greenhouse.

BUILDING SYSTEMS SUMMARY		
YES	NO	WORK SCOPE
X		Demolition Required
X		Structural Steel Frame
X		Cast-in-Place Concrete
	X	Precast Concrete
X		Mechanical System
X		Electrical System
X		Masonry
X		Curtain Wall
X		Support of Excavation

Table 1: Shows Building Systems Summary

Demolition

The demolition of the existing building started with the removal of the hvac units from the roof. From there the Con Edison power and gas, Verizon services were cut off. Before demolition could start, an existing conditions survey of adjacent building was conducted. Through construction vibration monitoring was used. Asbestos Abatement was performed by owner. A protective sidewalk bridge was used to permit pedestrians flow during non-working hours.

The demolition of the existing 33,000SF building consists of four separate townhouses that were merged together during the 1940's.The existing building is compiled of brick and mortar, which has been primarily demoed by excavators. While, the playhouse required hand demolition method The building has historical and cultural significance in that it houses a 4,400SF playhouse on the ground and basement levels which is scheduled to remain. As part of the project, the interior of the theatre will be demolished and rebuilt. The playhouse portion of the building is located at the southern end of the site's 8,430 SF footprint. Four walls of the original theatre which is located on the basement and ground floor level will remain throughout construction.

These four walls mortared together with various stone and brick will be temporarily preserved by shoring the walls with steel beam structural system. This is a very challenging task because there is a dentist office on the south side. In addition there are restaurants adjacent to the building which lends to daily delivery. Also there are apartments on the north and west side and a small one way street on the east side. The playhouse portion of the building is located in the southern end of the site

Figure 2: Shows an Excavator in the Demolition Phase

Figure 3: Shows Hand Demolition method being utilized

Structural Steel Frame

A temporary steel frame was used to preserve the existing theatre walls and the adjacent building. This made construction activity very difficult due to the structural bracing. The steel bracing was anchored to the adjacent building's masonry wall. Double l-angle steel wielded together was used for vertical members and round hollow structural sections (hss) steel tubing was used for the lateral members shown in Figures 3 and Figure 4. The existing adjacent structure required additional c-channel to reinforce the neighboring structure by tying into the floor wood trusses of the neighboring structure; because the wall was not load bearing wall it was only two courses thick.One lane of traffic was closed during construction to allow for a crawler crane to be used.

Figure 4: Shows Temporary Structural Steel Bracing

Figure 5: Shows Congested Site Due to Structural Steel Bracing

Cast-in-Place Concrete

Conventional concrete two-way plate structure construction is utilized throughout the building with reinforcement specified by middle strip and column strip details. All of the concrete is 5000psi concrete. The floor construction is a 10" deep flat plate slab. The columns' sizes range from 12"x24" to 18"x36". The anticipated columns loads at cellar level for the new structure are about 1,000 kips (dead plus live load). The column layout is 24-feet on center. At the exterior column in the slabs stud rails by Decon are used to enhance the shear capacity of the floors along the eastern side of building. 12"x12" and 12"x13" beams are used to brace the slab along the east and west sides of the elevator. The cast-in-place concrete construction presented the construction team with many obstacles.

The concrete slabs and columns were poured at a rate of one floor per week, with a crew of 25 men. This progress was hindered by the complexities of the regulations for the new cast-in-place scissor stairs.The construction crew laid out the formwork to accommodate the conduct and water holes ahead of time before the pure, so that the penetrations did not weaken the structural integrity of the slab. One of the challenges encountered was pouring the 2st floor above the theatre. 26 feet of scaffolding was used to support the formwork and concrete; this logistical nightmare was intensified due to the steel structural bracing as shown in the Figure 6. Simon forms were used for the vertical formwork of the foundation walls and the load bearing wall in the theatre. A pump truck was used to place the cast-in-place concrete. Power trowel were used to finish the elevated slab..

Throughout construction vibration monitoring has been used to guarantee none of the adjacent buildings are disturbed. Despite the precautions taken to preserve the walls of the playhouse, the north wall had to be removed because of it's the structural integrity.

Figure 6: Pump Truck Placement Method

Figure 7: Shows the Addition of Shoring to the Steel Bracing

Foundation

The Foundation is a 30" thick matt slab on top of a 3" concrete mud slab. New 1' 4" thick foundation walls are used to support the office portion of the building. The playhouses existing walls support the 2nd through 6th. Buttresses laterally brace the existing masonry walls of the playhouse. In addition, there are Tie beams that span the playhouse in the north and south direction within the matt slab. Underneath the playhouse's tie beams is a new concrete footing. As addressed in the existing conditions new underpinning was added under the adjacent buildings along the north south and eastern sides of the building.

Figure 8: Shows the Sheeting (Lagging) and Piles on the East Side (Mac Dougal Street)

Figure 9: Show the Sheeting (Lagging) and Piles on the West Side (Mac Dougal Street)

Mechanical System

The primary HVAC system is constant air volume with vav boxes to regulate the temperature within the office building. Sound lining is installed in all of the ductwork. There are two air handling units in the theatre both are 8650CFM located on the basement floor. Also, electric cabinet heaters are provided in the vestibule of the theatre and the office building in order to supplement for the excess of loads contributed by the entrance doors on the first floor. The basement of the office building is 4700CFM. The first floor has two 6000CFM air handling units. The office building air handling units are 6300cfm on the second to the fifth floor. The University's central plant will provide chilled water and hot water for cooling and heating via new underground source piping. The on campus Cogeneration Plant will allow for future utility tie-in.The hot water will come from this neighbor building through an underground tunnel; this caused the street separating the two buildings to be closed while the tunnel was excavated.

This building is unique in that the heat exchanger and the water pumps are located across the street. The heat exchanger is located on the cellar floor is 200GPM on the primary side and 40GPM on the secondary side. The hot water is supplied by a 200GPM pump and the chilled water is supplied with a 360GPM pump. These pumps are equipped with variable frequency drives. Electric unit heaters are provided in the mechanical and electrical rooms. Hydronic fin tub baseboard radiation is provided behind the windows of the building to compensate for the additional infiltration loads. This building is unique in that the heat exchanger and the water pumps are located across the street. Hence the coordination was very difficult.

Figure 10: Illustrates the Heat Exchanger in the Neighboring Building Possessed by the Owner

Fire Protection

The main supply for the sprinkler system is a 6" pipe, which will be connected to an existing supply. In addition, there is a 3" x 3" x 4" Siamese connection for the sprinkler system. Each floor is equipped with a new floor control valve assembly. Also the building has a water flow detector on each floor. In the Lobby and corridor areas there are concealed sprinkler head with quick response. Open areas with no ceilings, closets, and steam/boiler rooms have upright sprinkler. Soffit areas and perimeter offices have a quick response head extended coverage with horizontal sidewall in order to reach a broader area. The minimum pressure at each sprinkler head is 7 psi. The design criterion is a wet pipe system. The light hazard office areas were designed for 0.100gpm/sq.ft. The light hazard areas are designed for a maximum coverage per sprinkler head of 225 sq. ft. The ordinary hazard storage areas were designed for 0.16 gpm/sq.ft. Ordinary hazard areas are designed for a 225 sq.ft. maximum coverage per sprinkler head. Fire protection is supplied by a 400gpm 20hp electric fire pump and a jockey pump which is 9gpm 3/4hp.

Electrical System

The existing play house service has been completely removed. The new service includes both the theatre and the office building. The new Con Edison service is split at the basement entrance one 3 sets of 4#5000MCM, 1#1/0GND in (3) 3-1/2"C to the theatre. Alternatively, the office building's service is (8) sets of 4 #500MCM 1#1/0GND in (3) 3-1/2" C passes through a 2500A service switch then into the office building's switchboard No.1 1200A 120/208V, 3 phase 4 wire 60Hz. Each of the floors of the building is equipped with a lighting panel and receptacle panel. This allowed for easier coordination between the trades because only one 4 #500MCM-1#1/OGND-3-1/2"C feeder is supplied for each set of panel boards between floors.

Masonry/Precast Lintels

The all natural brick veneer is non-bearing will seamlessly blend into the neighboring buildings. The 4” brick veneer is a running bond. Windows will be double hung with4”x8”x4’-4” precast concrete lintels and 4”x4”x4’ window sill lintels to accent the windows. Concrete lintels and the brick veneer are attached with a steel L-angle that is fastened to the 8” concrete masonry units. The expansion bolts anchor the angles. Cmu that have anchors going intomortarjoint between them are grouted.The base of the building features a 70sf granite base at Mac Dougal Street. First through sixth floor features a brick facade. While, the sixth floor features 18” foot high terracotta cornice crown. Because the brick facade was laid in the winter temporary heat is needed for exterior masonry and building finishes. Swing scaffolding is used along the north, south, and east perimeter; while steel tubular masonry scaffolding is used for the west perimeter.

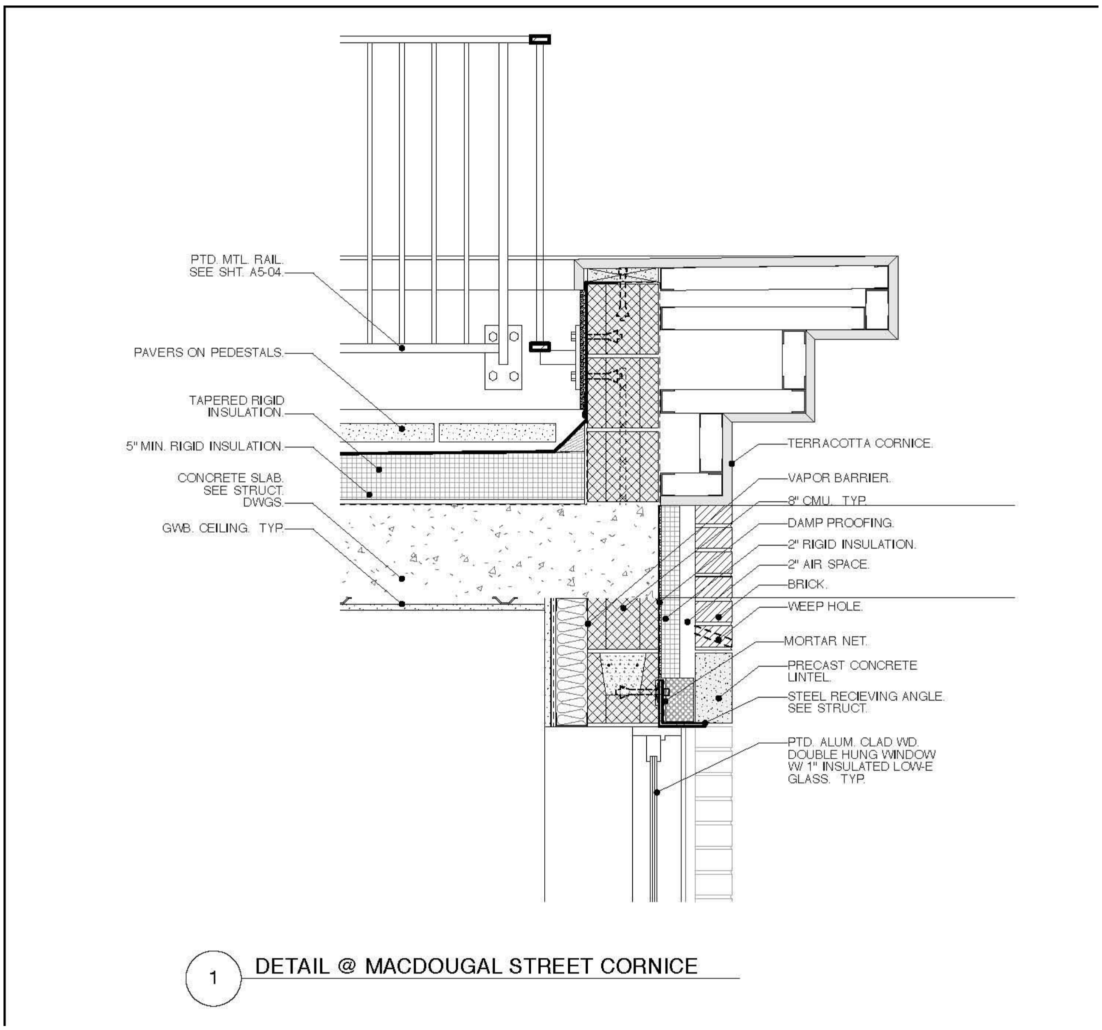


Figure 11: Shows the Lintel Connection to the 8” CMU

Curtain Wall

Three curtain wall slots were chosen to break up the brick façade to blend in with the surrounding townhouse buildings. The curtain wall system type of glazing is the Kawneer powder coated aluminum. This curtain wall configuration is dry glazed gaskets. The glass features fire rated ¾" 2 ply glass. There is 2 Layers of ½" fire rated gypsum board separating the curtain wall frame and metal stud which is mounted with a powder actuator fastener.

Figure 12: Shows the Three Curtain Walls Slots, Granite Base, Existing Wall to remain, and the Terracotta Cornice

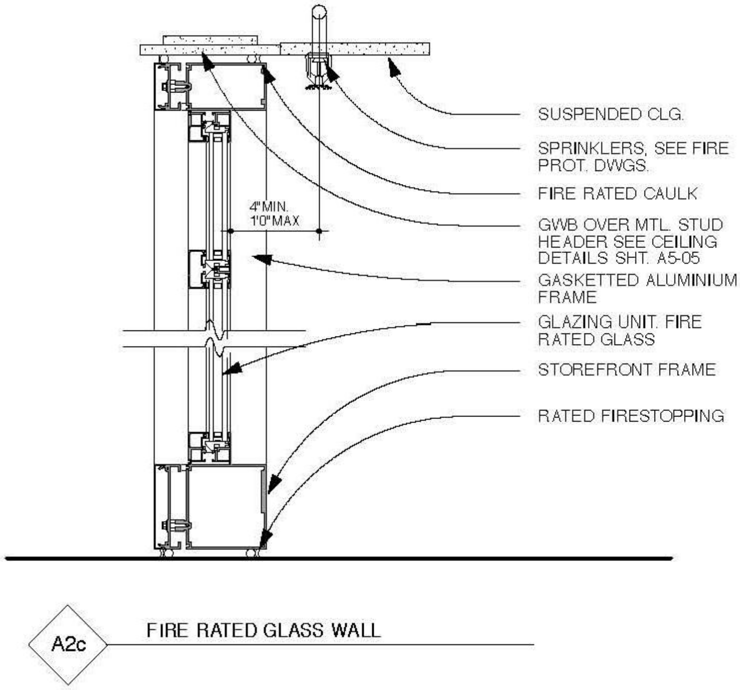


Figure 13: Shows a Typical Curtain Wall Connection

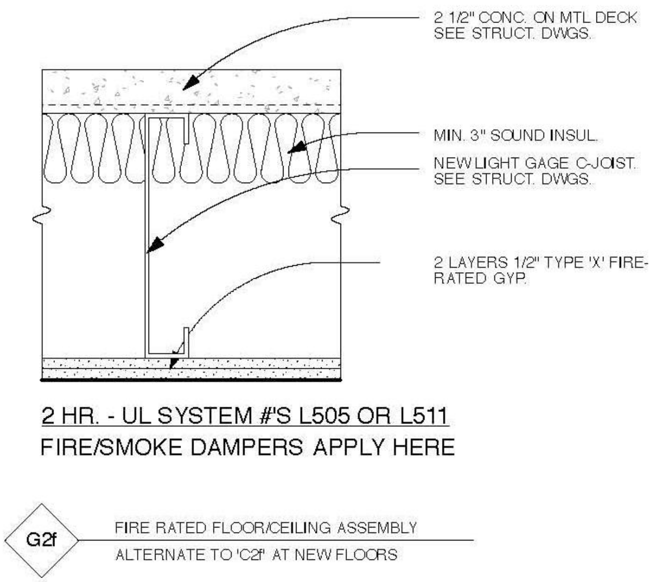


Figure 14: Illustrates the Connection Detail to the Concrete Slab

Support of Excavation

The site resides in a metropolitan area. There are no streams or natural water courses visible on premises. Neither are there any vaults located below the sidewalk level. The premise does not lie within any flood hazard area designated by the federal emergency management agency. The site will be dug down an additional 12 feet requiring sheeting at the west side, east side, and north wall. During the excavation stage under pinning was necessary for the existing apartments which are abut to the north and west wall in order to start foundation work. Also underpinning is required at the wall of the existing playhouse which will be the common wall for the office and play house. Piles were then drilled at the east property line to strengthen and stabilize existing soil and foundations of adjacent buildings. In addition to the piles drilled sheeting was installed. Then the 16 foot high construction fence was erected. Next the reinforced mat foundation slab is poured on top of the piles. Ground water is expected at 15' 8" therefore a dewatering system is used. De watering the pumping of water from below ground level is then utilized. Well points were installed and the dewatering system ran 24/7 for 22 weeks.

Figure 15: Display the Dewatering System

Sustainability

The Owner requires the Contractor to implement practices and procedures to meet the project's environmental performance goals, which include achieving LEED Platinum Certification. Specific project goals that may impact this area of work include: use of recycled-content materials; use of locally-manufactured materials; use of low-emitting materials; construction waste recycling; and the implementation of a construction indoor air quality management plan. The west side roof features two 5'x14' sky lights which will be used to day light the office suite below.

The Green roof not only adds aesthetic appeal to the building and reduces the amount of rain water runoff. The green roof is a 12" Intensive American Hydotech Lite Top. This type of roofing system was chosen to accommodate plants, shrubs, and trees. There are three sets of green roofs the second floor, the sixth floor, and roof.

The design and construction team has worked with Kinetix LEED AP team members to ensure that every sustainable alternative was addressed from start to finish. This pursuit of sustainable building was lead by the client's active role. The client recently completed a cogeneration plant which will provide heat and power to the site throughout the year. The owner also utilizes a wind power contract.

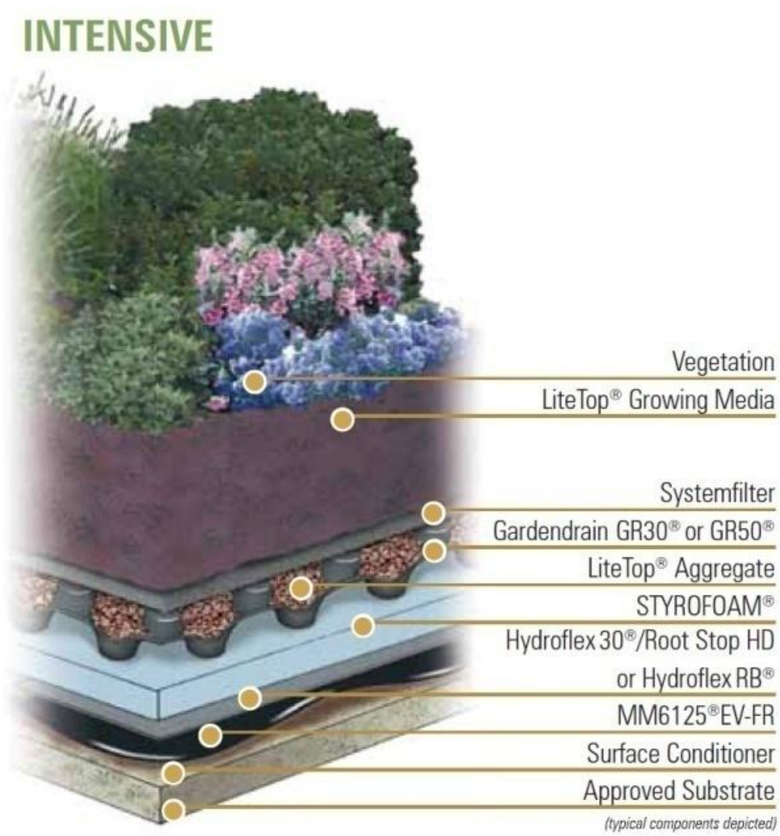


Figure 16: Demonstrates a Typical Green Roof Provided by Hydrotech

Project Cost Evaluation

While estimating through RS Means, careful considerations must be made to ensure the assumptions in the square foot estimate reflex the actual building. Due to the adjacent the structures underpinning requirements and structural bracing of the existing to remain brick wall the, a direct comparison of foundations can't be achieved. Another difference is historical requirements of the restoration of the existing doors, seats, walls, entrance canopy these must be considered separately as an allowance. The site preparation and Utilities is another thing that is not included in the comparison of the buildings. Green roofs are not included in the RS Means and D4 Estimates.

Therefore in order to consider theRS Means and D4 Estimates, additional assemblies would need to be added including: underpinning, shoring and bracing, allowances added, green roof, skylights, staging, curtain for theatre, permitting, insurance, swing scaffolding, temporary heat,

Careful measures were implemented in the RS Means estimate. Monitor speakers, surveillance cameras, intercom outlets, smoke-ceiling detectors, smoke duct detectors, auditorium seats, and elevators/elevator stops were added to the initial estimate. In order to assess the Theatre building systems separately another RS Means estimate was conducted.

New York City, Ny location factor and the project time factors were added to both the RS Means and D4 estimates to the current. Computer analysis is provided in the Appendix.

Detailed Structural Systems Estimate

Table 2: Shows the Summary of the Detailed Structural Estimate

Summary of Detailed Structural Estimate	
BEAMS	$ 45,754.77
STRUCTURAL STEEL	$ 50,650.78
COLUMNS	$ 309,425.00
COLUMNS (For BUTRICES TO EXISTING MASONRY WALL	$ 3,891.60
ELEVATED SLABS	$ 1,445,630.97
SLAB ON GRADE	$ 10,596.01
FOUNDATION MAT SLAB	$ 474,486.75
FOUNDATION WALLS	$ 205,286.79
FOUNDATION FOOTINGS	$ 30,129.12
FOUNDATIONS GRADE BEAMS	$ 19,414.15
Total	$ 2,595,265.94

A Revit Structures model was constructed to provide the quantity takeoffs. The model can give the construction team a very clear idea of the three dimensional properties of the structure. The columns takeoff of concrete does not include the quantity of concrete that pass through the slabs in monolithic columns. Also the concrete columns that pass through the foundation walls is included in the foundation walls' quantity of concrete and is not included in the columns' quantities; this is shown visually in Figure 6 the column schedule produced by Revit.

Exclusions and Assumptions:

- Stud rails
- Mechanical Shaft openings
- Underpinning with tiebacks of Adjacent and Existing Structure
- Tie backs
- Structural steel required to temporary brace existing masonry walls during construction
- Retaining walls
- Excavation costs
- Waterproofing membrane
- Concrete Stairwells
- Sleeves for conduct and water holes

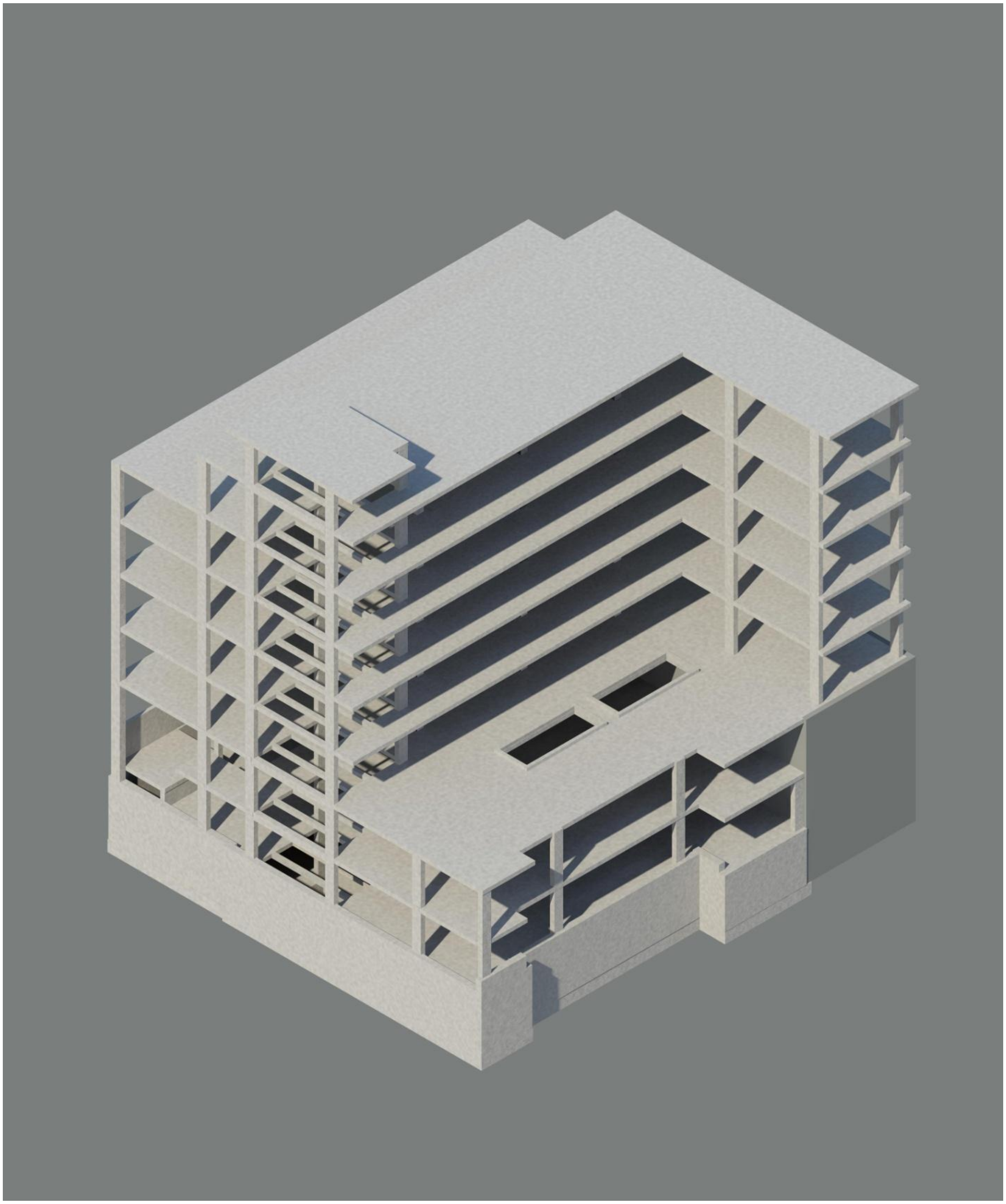


Figure 17: Shows the Three Dimensional Model of the Revit Structures Model

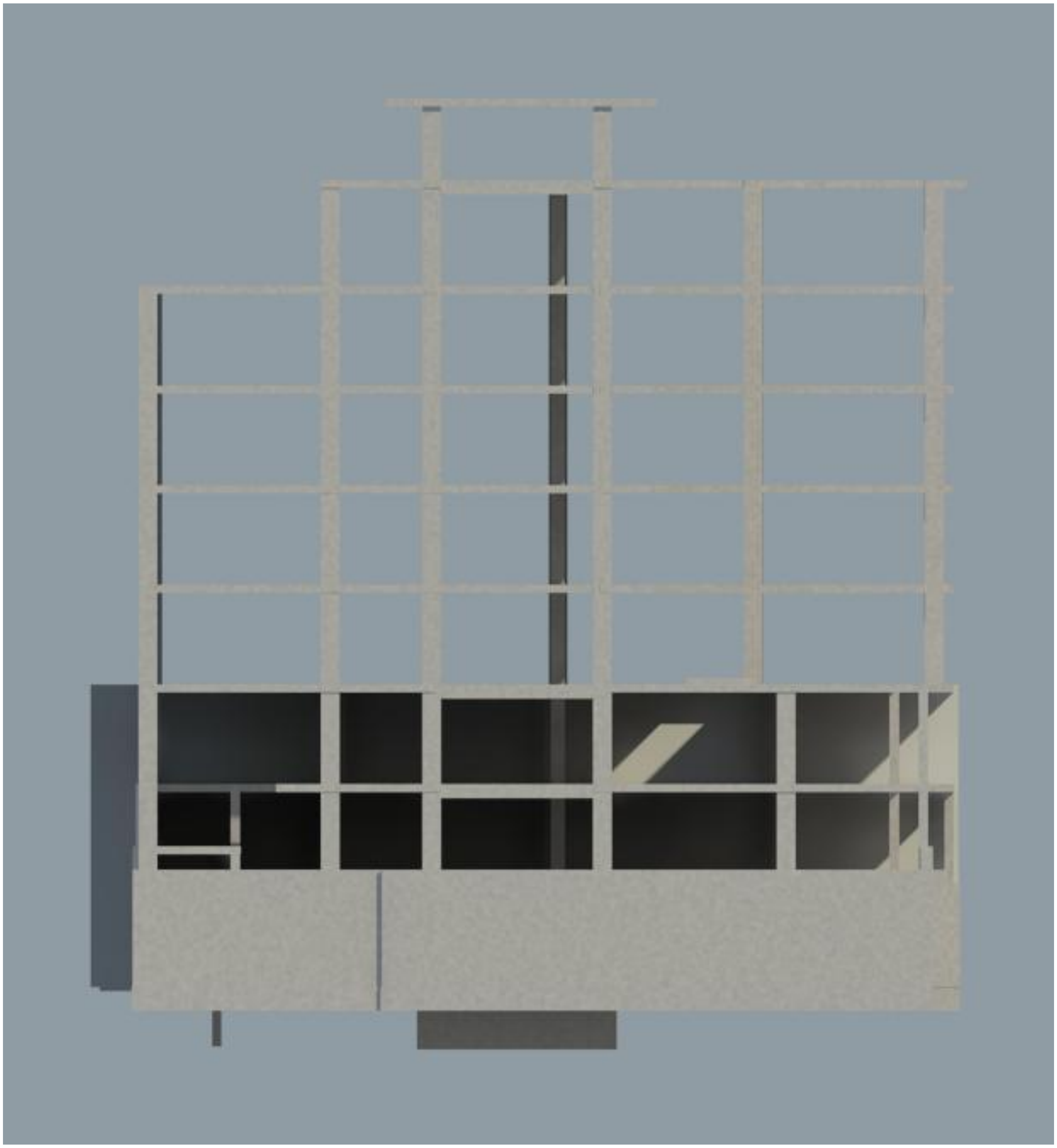


Figure 18: Shows the East Elevation of the Revit Structures Model

.General Conditions Estimate

Many of the typical trade requirements were excluded from the construction managers general conditions cost; these include maintenance of fence, roof protection at adjacent building to south of law school, crane, D.O.B./DOT Regulations, temporary heat, permit expediter, surveying, erosion control, temporary toilets, dumpsters, fire extinguishers, final cleaning, and trash chutes. RS Means was used for the billing rate of the project team. Some of the job descriptions were not found in RS Means, so the following assumptions were made.

Building Skanska Job No. Construction Cleaning					
All NJ local 593	Manhours	# Months	Total Hrs.	Rates	Cost
Labor foreman cost	160	8	1280	$87.00	$111,360.00
Labor Shop steward cost	160	8	1280	$85.00	$108,800.00
Laborer (3 men)	320	8	2260	$78.00	$176,280.00
				10% mark up	$40,000.00
				Total:	$436,440.00

Table 3: General Conditions Estimate

PRECONSTRCUTION & CONSTRCUTION

PROJECT MANAGEMENT MANPOWER/FORECAST

	Jul 2008	Aug 2008	Sep 2008	Oct 2008	Nov 2008	Dec 2008	Jan 2009	Feb 2009	Mar 2009	Apr 2009	May 2009	Jun 2009	July 2009	Aug 2009
			1	2	3	4	5	6	7	8	9	10	11	12
PROJECT MANAGEMENT														
1 PROJECT EXECUTIVE	0	4	4	4	16	16	16	16	16	16	16	16	16	16
2 PROJECT MANAGER	0	16	24	24	120	160	160	160	160	160	160	160	160	160
3 PROJECT ENGINEER			40	160	160	160	160	160	160	160	160	160	160	160
4 GENERAL SUPERINTENDENT			40	160	160	160	160	160	160	160	160	160	160	160
5 MEP SUPERINTENDENT														
6 ESTIMATING	0	40	40	100	140	40	8	8	8	160	40			
7 FIELD ADMINISTRATOR			0	0	20	20	160	160	160	160	160	160	160	160
8 SCHEDULING SERVICES			8	8	8	16	16	16	16	16	16	16	16	16
9 SAFETY DIRECTOR				16	16	16	16	16	16	16	16	16	16	16
10 ACCOUNTING/IT SERVICES				16	16	16	32	32	32	32	32	32	32	32
ESTIMATED MAN-HOURS PER MONTH	0	60	156	488	656	604	728	728	728	880	760	720	720	720

	Aug 2009	Sep 2009	Nov 2009	Dec 2010	Jan 2010	Feb 2010	Mar 2010	April 2010	May 2010	June 2010	July 2010	Aug 2010			Bare Labor	Total O&P	
	13	14	15	16	17	18	19	20	21	22	23	24	TOTAL HOURS	Weeks	BILLING RATE	BILLING RATE	STAFF COST
PROJECT MANAGEMENT																	
1 PROJECT EXECUTIVE	16	16	16	16	16	16	16	16	4	4	4		312	7.8	$2,100	$3,275	$25,545
2 PROJECT MANAGER	160	160	160	160	160	160	160	160	160	160	80	40	3344	83.6	$2,100	$3,275	$273,790
3 PROJECT ENGINEER	160	160	160	160	160	160	160	160	160	160	120	80	3600	90	$1,300	$2,025	$182,250
4 GENERAL SUPERINTENDENT	160	160	160	160	160	160	160	160	160	140	40	0	3420	85.5	$1,700	$2,650	$226,575
5 MEP SUPERINTENDENT	80	160	160	160	160	160	80						960	24	$1,950	$3,025	$72,600
6 ESTIMATING													584	14.6	$1,950	$3,025	$44,165
7 FIELD ADMINISTRATOR	160	160	160	160	160	160	160	160	160	160	160	80	3160	79	$1,300	$2,025	$159,975
8 SCHEDULING SERVICES	16	16	16	16	16	16	16	16	16	0	0	0	312	7.8	$1,600	$2,500	$19,500
9 SAFETY DIRECTOR	16	16	16	16	16	16	16	16	16	8	0	0	328	8.2	$1,600	$2,500	$20,500
10 ACCOUNTING/IT SERVICES	32	32	32	32	32	32	32	32	32	32	32	10	666	16.65	$1,125	$1,750	$29,138
ESTIMATED MAN-HOURS PER MONTH	800	880	880	880	880	880	800	720	708	664	436	210					
																Preconstruction & CM Services:	$1,054,038
																General Conditions:	$649,981
																Total CM Services:	$1,704,019
																Total Cost per Month:	$77,455

Table 4: General Conditions Estimate

Item	Unit Cost	Units month	Quantity	Units	Total	Total cost per mo.	Comments
General Conditions							
Trailer Cost	$0	lump sum	1	# months	$0	$0	Used Owner Facility adjacent Building
Trailer Infrastructure	$0	lump sum	1	# months	$0	$0	Used Owner Facility adjacent Building
Temporary Power	$1,657	lump sum	1	# months	$1,657	$75	200 Amp Underground feed
Computer Hardware	$35,000	lump sum	1	# months	$35,000	$1,591	Server/Computers/Printer/Scanner
Temporary Heat	$408,800	allow	0	# months	$0	$0	In Trades Budget for Masonry
Temporary Heat	$98,500	allow	0	# months	$0	$0	In Trades Budget for Building Finishes
Temporary toilets	$0		22	# months	$0	$0	In Trades Budget
Temporary Fence	$33.49	lf	100	lf	$3,349	$152	Plywood, painted 4"x4" frame, 8' high
Teporary Fence	$5.30	lf	120	lf	$636	$29	Rented Chain Link, 6ft high
Sidewalk bridge	$201.02	lf	100	lf	$20,102	$914	Heavy duty steel posts & beams, including parapet protection & waterproofing
Small tools	$125	month	22		$2,750	$125	
Telephone Services	$245	month	22	# months	$5,397	$245	Telephone Bill; avg.bill/month incl. longdist.
Telephone Equipment	$0	month	22	# months	$0	$0	By Owner
Field Office Furniture	$650	month	22	# months	$14,300	$650	Furniture for 6 people
Computer Software	$750	month	22	# months	$16,500	$750	Software(P3, Prolog, Suretrack)
T1 Conductivity	$1,000	month	22	# months	$22,000	$1,000	Internet capability
Copy/Fax Machine	$555	month	22	# months	$12,210	$555	Rental
Business Expense	$125	month	22	# months	$2,750	$125	Misc. Business expense
Field Office Misc.	$150	month	22	# months	$3,300	$150	
Clerical Supplies	$470	month	22	# months	$10,340	$470	
Printing/Drawings Repro	$800	month	22	# months	$17,600	$800	
Mail and Fedex	$1,000	month	22	# months	$22,000	$1,000	
OSHA prot. Supplies	$175	month	22	# months	$3,850	$175	
Dumpsters(field office)	$0	month	22	# months	$0	$0	In Trades Budget
Progress Photos	$0	month	22	# months	$0	$0	By Owner
Project Signs	$250	month	22	# months	$5,500	$250	
EDP	$650	month	22	# months	$14,300	$650	
Trade labor	$0	month	22	# months	$0	$0	In Trades Budget
Teamster	$0	month	22	# months	$0	$0	In Trades Budget
Operating Engineer	$0	month	10	# months	$0	$0	In Trades Budget
Traffic Control	$0	month	16	# months	$0	$0	In Trades Budget
Dumpsters	$4,000	month	0	# months	$0	$0	In Trades Budget
Construction Cleaning	$13,638.75	month	32	# months	$436,440.00	$13,638.75	Includes Foreman and 3 Labors
				Total:	**$649,981**		
			Cost per month:		**$21,679**		

Table 5: General Conditions Estimate

Client Information

The building is the final building in the Law School's master plan. In addition to the new Provincetown Playhouse, the building will house the Law School's new and existing Research Centers which outgrown their current space and are awaiting a permanent home. The conversion of this building into an academic one is important as one of the only available academic sites for the Law School. Previously 133-139 MacDougal was a residential building with some office space as well as the home of the Provincetown Playhouse. The Playhouse is a working theatre for the client's Steinhardt music and performing arts department.

The owner chose to fast track the project to accommodate the move-in date of July 1, 2010. An early start of demolition phase and excavation has been planned while designs were being finalized. This approach enabled the construction manager to value engineer and schedule the project.Safety, coordination and logistical issues in an active and operating campus located in the urban area will be a key issue in the successful implementation of this Project. Skanska, the construction manager, has hired a full time Project Manager, full time Project Engineer and full time Project Superintendent along with the assistance of a Safety Manager assigned to the Project to ensure the safety of the students, faculty, and surrounding community.

To fulfill the initiative in the community to preserve the playhouse many measures are being taken to preserve its intrinsic features.The main criterion for owner satisfaction of quality is to conserve the physical space of the Playhouse Theatre including itsfour walls, doors, and seats. The new building is of low-scale with a new façade only a few feet higher than the current building height and is designed and detailed to be harmonious with the existing streetscape

Local Conditions

The preferred method of construction is concrete in the NYC area, because of the lack of space for steel shake out. The allowable work hours are 7:00am-6:00pm Monday through Friday. Skanska , aware of the LEED certification, contracted off-site construction waste recycling.

Note that the Project Datum Elevation 0.0 feet corresponds to the sidewalk grade at 139 MacDougal Street. The subsurface investigation consisted of seven geotechnical borings and ten test pits. The general subsurface profile consists of a layer of uncontrolled fill material underlain by natural fine sand, a layer of silt and clay, decomposed rock, and bedrock. From these findings the Langan's engineers decided on the mat slab foundation type. The historical topographic Atlas of the City of New York (Viele, 1865) indicates that a former water course Minetta Creek, passed diagonally in the northeast-southwest direction beneath the site. The silt and clay layer above the bedrock is likely associated with this former stream. Ground water is expected at 15' 8" and the lowest site elevation is 23' below grade; therefore a dewatering system was used.

Located near Washington Square Park in Greenwich Village, the site is accessible from 6th Avenue, Broadway, and West 3rd and 4th Streets. Parking is available at w 3rd Street for a discounted price by the client.

Figure18: Illustrates the Vicinity of Discounted Parking Colored in Red

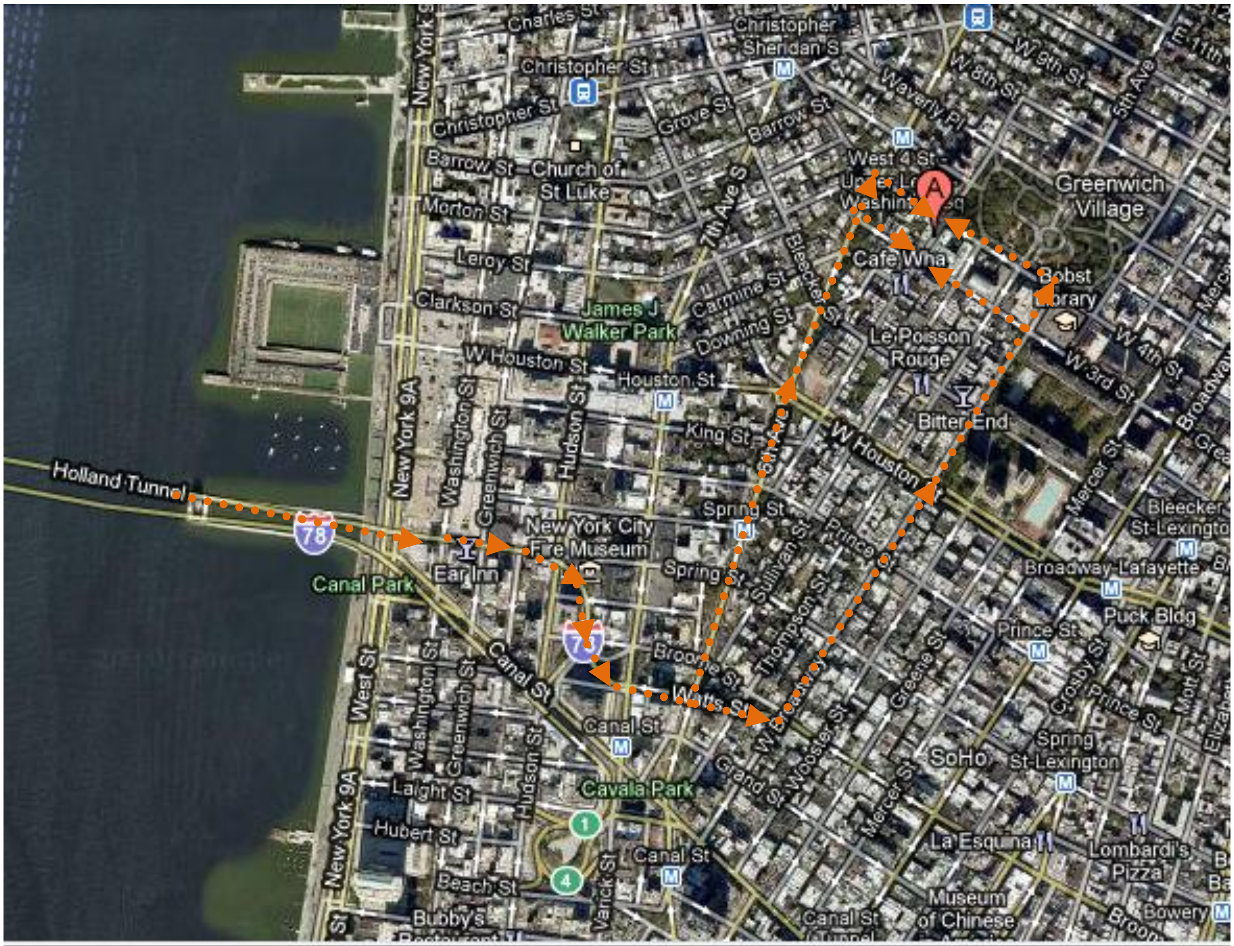
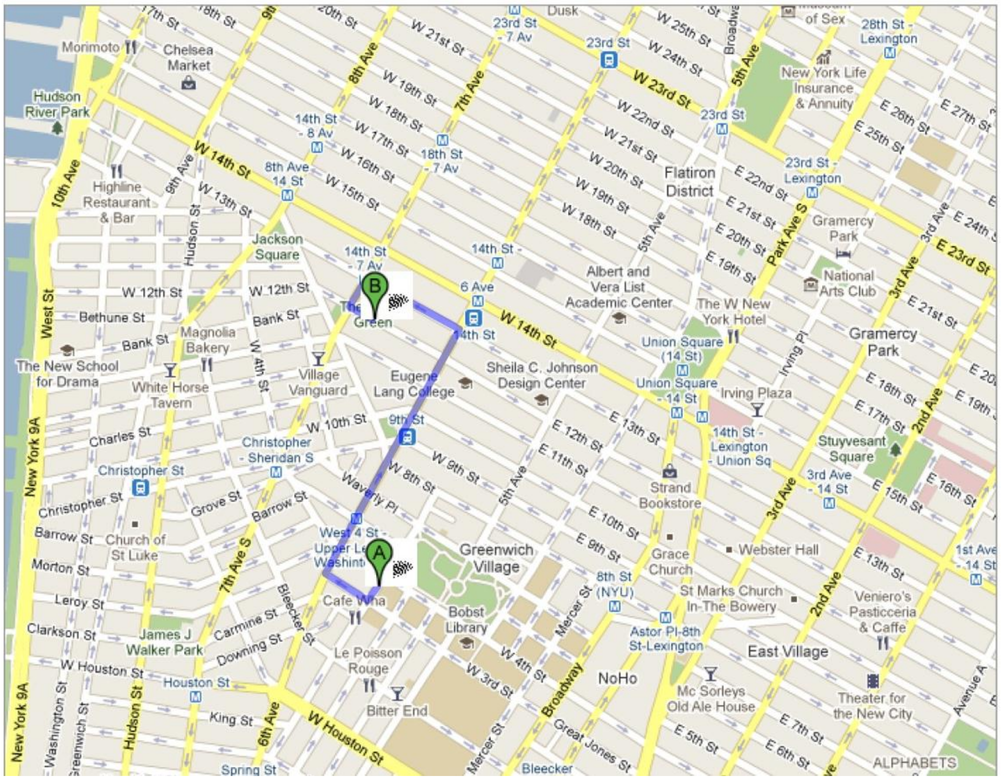


Figure 19: Shows the Traffic Route In and Out of New York City, NY from Google Maps

Google maps

Directions to Saint Vincents Catholic Medical Centers of New York: For Information On Additional Services
170 West 12th Street, New York, NY 10011 - (212) 604-7000
0.8 mi – about **3 mins**



133 MacDougal St, New York, NY 10012

1.	Head **southwest** on **MacDougal St** toward **W 3rd St**	go 141 ft total 141 ft
2.	Take the 1st **right** onto **W 3rd St**	go 427 ft total 0.1 mi
3.	Turn **right** at **6th Ave/Avenue of the Americas** About 1 min	go 0.4 mi total 0.6 mi
4.	Turn **left** at **W 13th St** About 1 min	go 0.2 mi total 0.7 mi
5.	Take the 1st **left** onto **7th Ave**	go 272 ft total 0.8 mi
6.	Take the 1st **left** onto **W 12th St** Destination will be on the right	go 220 ft total 0.8 mi

Saint Vincents Catholic Medical Centers of New York: For Information On Additional Services
170 West 12th Street, New York, NY 10011 - (212) 604-7000

Figure 20: Shows the Directions to the Closest Hospital in Case of an Medical Emergency

Project Delivery System

The construction project is a fast-tracked project with construction management. This arrangement allows phasing because the design and construction people are able to get together early and develop the necessary coordination schedules. The construction manager was brought in at the inception of the project.

The contract type is a typical Architectural engineering contract with the owner. There is only a communication relationship between the contractor and the architecture engineer. The owner hired both the design firms and the construction manager firm early in the preconstruction phase of the project. Skanska was brought in to work with the designers in the design selection, as well as overseeing the construction phase. This type of delivery method is program management delivery method; although, Skanska holds the contracts with subcontractors and suppliers.

The major advantages of the program management delivery method are open communication, cost savings, and shortened schedule. This type of contract enabled excellent communication to be established early in the design and build process among the project team and continues through the completion of the project.

This method was chosen in order to accelerate the schedule. By choosing this type of construction method the excavation phase and demolition was enabled to start before the actual construction documents were finished. This also helped to give the owner price checks along the way. The construction management company Skanska hascontributed feasibility, constructability, and cost studies throughout the design phases.

Subguard is utilized for subcontractor bonds. This type of bonding is far superior to the traditional performance and payment bonds for the experienced construction manager. Subguard brings cost savings to the construction manager. Subguard is initiated at the onset of sub contractor default; unlike traditional bonds which can take months to come into effect. This puts the Skanska in the position to enact a remedy for the problem and Subguard pays the costs. The construction manager takes on higher risks including: rental agreements, bodily injury claims, and purchase orders. Therefore, Skanska implements extensive procurement and purchasing prequalification. In addition, Skanska implements its Injury Free Environment program to ensure the New York and OSHA safety rules are withheld.

The project has been contracted in a phase procurement manner. The bid package 1 is footings/foundations and interior U/G utilities-MEP, superstructure concrete, and site work/perimeter utilities. Bid package 2 is the long lead equipment including air handling units, elevators, substation, and skylights. Bid package 3 is the building shell package. Bid package 4 is the MEP system fit-out. Bid package 5 is the A/E office fit-out.

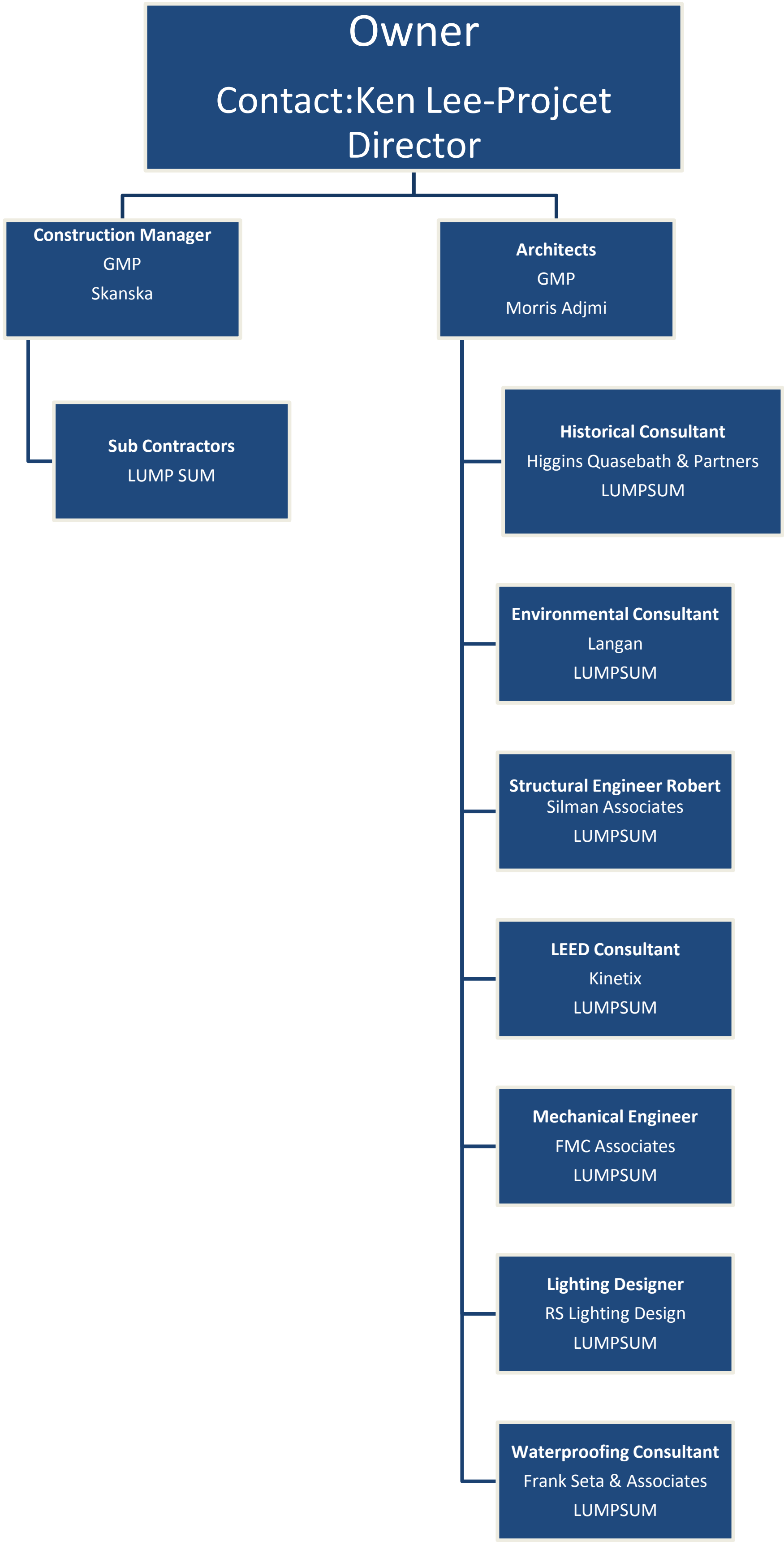


Figure 21: Shows the Project Team and Contract Types

Staffing Plan

Construction management services will be provided by Skanska USA Building Inc. and will also provide expertise related to the commissioning and qualification of the facility and is illustrated in Figure 23. The position descriptions are summarized in the Figure 24 due to the various tasks of the project team.

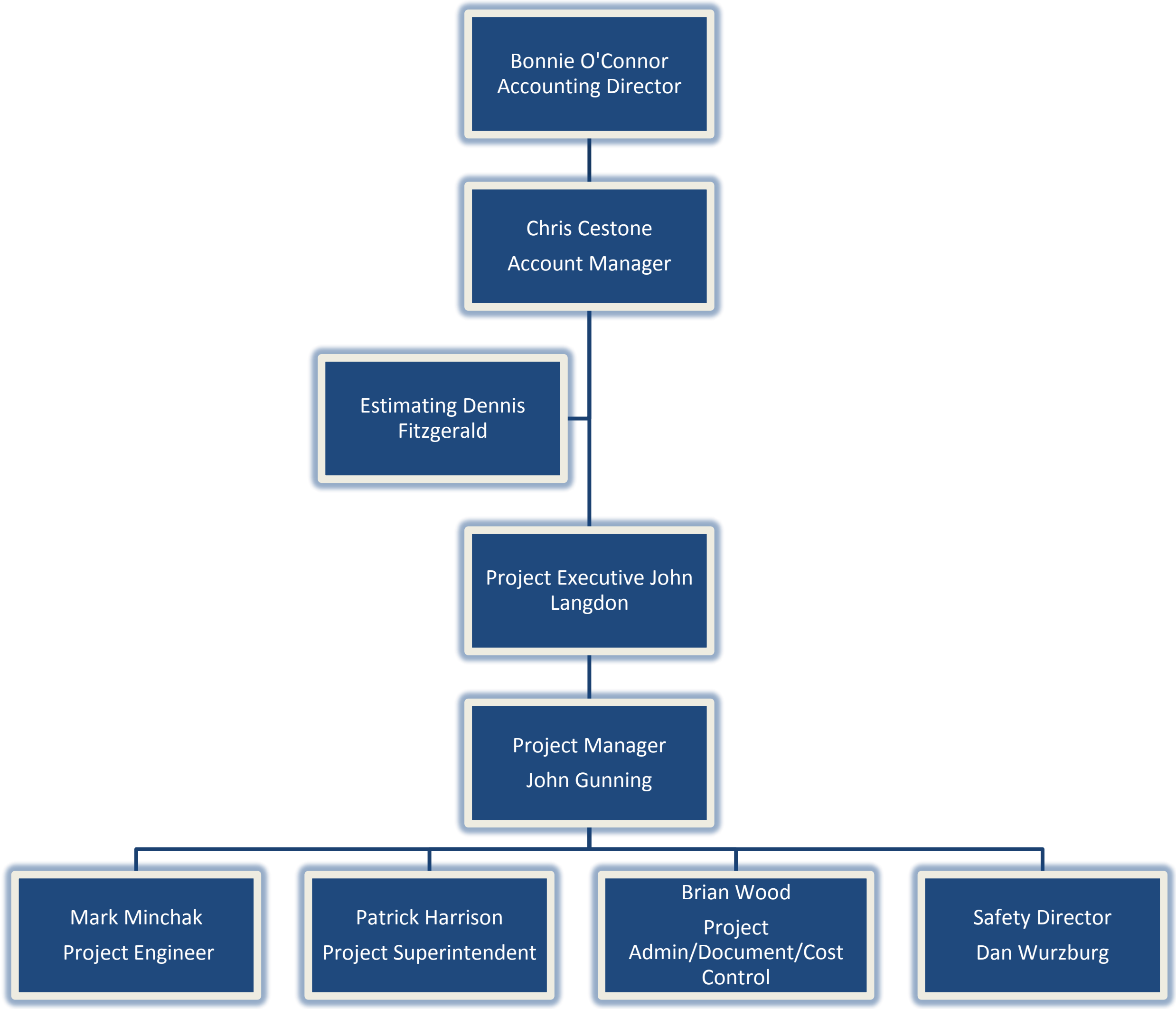


Figure 22: Show Staffing Plan for the Construction Manager Skanska

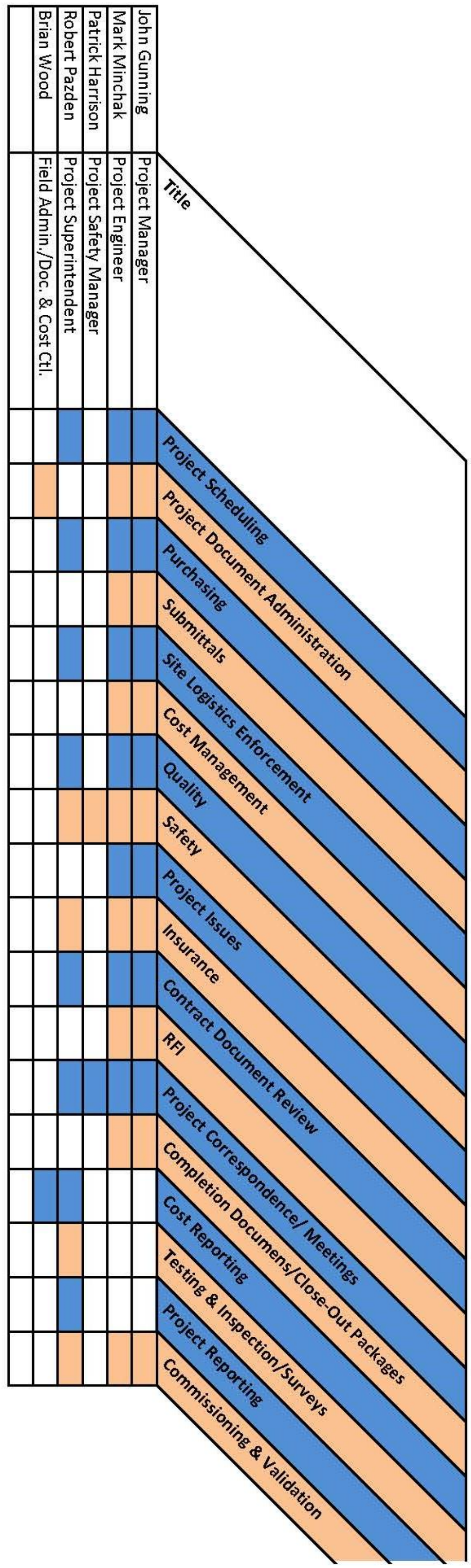


Figure23: Briefly Describes the Structure of the Project Management and Supervision Staff

Appendix A: Structural Estimate

Depth (in)	Type	Level	Perimeter ft	Area sf	Volume cy	Volume cy	Reinforcing	ton/cy	ton
		Matt Slab, SOG, Elevated Floor Material Takeoff							
5	SOG	CELLAR FLOOR	42.60	65	27.28	1.01	6x6-W2.0xW2.0W.W.F.	N/A	N/A
30	Mat Slab	CELLAR FLOOR	63.82	225	562.11	20.82	#9 @ 8" Each Way (Top & Bottom)	0.107	2.222
30	Mat Slab	CELLAR FLOOR	376.25	6033	15082.25	558.60	#9 @ 8" Each Way (Top & Bottom)	0.107	59.631
8	Mat Slab	THEATER BASEMENT FLOOR	28.38	50.00	33.33	1.23	#5 @12" (Top & Bottom)	0.109	0.134
5	SOG	THEATER BASEMENT FLOOR	218.83	1992	830.08	30.74	6x6-W2.0xW2.0W.W.F.	0.095	0.117
10	Elevated	BASEMENT FLOOR	391.59	5629	4691.20	173.75	#6 @ 12" OC Each Way (Top & Bottom)	N/A	N/A
10	Elevated	ENTRY @ 135 MACDOUGAL	49.67	153	127.90	4.74	#6 @ 12" OC Each Way (Top & Bottom)	0.095	0.449
10	Elevated	ENTRY @ 135 MACDOUGAL	112.48	765	637.71	23.62	#6 @ 12" OC Each Way (Top & Bottom)	0.095	2.238
10	Elevated	FIRST FLOOR	374.98	5198	4331.75	160.44	#6 @ 12" OC Each Way (Top & Bottom)	0.095	15.201
10	Elevated	SECOND FLOOR	496.61	7481	6234.58	230.91	#6 @ 12" OC Each Way (Top & Bottom)	0.095	21.879
10	Elevated	THIRD FLOOR	399.95	5617	4680.85	173.36	#6 @ 12" OC Each Way (Top & Bottom)	0.095	16.426
10	Elevated	FOURTH FLOOR	399.95	5617	4680.85	173.36	#6 @ 12" OC Each Way (Top & Bottom)	0.095	16.426
10	Elevated	FIFTH FLOOR	399.95	5617	4680.85	173.36	#6 @ 12" OC Each Way (Top & Bottom)	0.095	16.426
10	Elevated	SIXTH FLOOR	399.95	5617	4680.85	173.36	#6 @ 12" OC Each Way (Top & Bottom)	0.095	16.426
10	Elevated	TO ROOF STRUCTURE	365.04	3818	3181.54	117.83	#6 @ 12" OC Each Way (Top & Bottom)	0.095	11.165
10	Elevated	TO BULK HEAD	94.5	492	409.99	15.18	#6 @ 12" OC Each Way (Top & Bottom)	0.095	1.439
			TOTAL SLAB CONCRETE:	54369	54873	2032			180.180

Table 2: Shows the Mat Slab, Slab on Grade, and Elevated Floor Material Takeoff

Type	Size	Length ft	Volume cf	Volume cy	Forming sfca
		Concrete Structural Framing Schedule			
Concrete-Rectangular Beam	10 x 10	16.32	11.34	0.42	40.80
Concrete-Rectangular Beam	10 x 10	16.32	11.34	0.42	40.80
Concrete-Rectangular Beam	10 x 10	16.32	11.34	0.42	40.80
Concrete-Rectangular Beam	10 x 10	16.32	11.34	0.42	40.80
Concrete-Rectangular Beam	10 x 10	16.51	11.47	0.42	41.28
Concrete-Rectangular Beam	10 x 10	16.51	11.47	0.42	41.28
Concrete-Rectangular Beam	10 x 10	16.55	11.50	0.43	41.38
Concrete-Rectangular Beam	10 x 10	16.55	11.50	0.43	41.38
Concrete-Rectangular Beam	10 x 10	16.55	11.50	0.43	41.38
Concrete-Rectangular Beam	10 x 10	16.55	11.50	0.43	41.38
Concrete-Rectangular Beam	10 x 10	17.29	11.49	0.43	43.23
Concrete-Rectangular Beam	10 x 10	17.29	11.49	0.43	43.23
Concrete-Rectangular Beam	10 x 10	17.38	12.07	0.45	43.45
Concrete-Rectangular Beam	10 x 10	17.38	12.07	0.45	43.45
Concrete-Rectangular Beam	10 x 10	17.41	12.09	0.45	43.53
Concrete-Rectangular Beam	12 x 16	15.82	21.09	0.78	58.01
Concrete-Rectangular Beam	12 x 16	15.82	21.09	0.78	58.01
Concrete-Rectangular Beam	12 x 16	15.82	21.09	0.78	58.01
Concrete-Rectangular Beam	12 x 16	15.82	21.09	0.78	58.01
Concrete-Rectangular Beam	12 x 18	16.29	24.44	0.91	65.16
Concrete-Rectangular Beam	12 x 18	16.29	24.44	0.91	65.16
Concrete-Rectangular Beam	12 x 18	16.42	24.45	0.91	65.68
Concrete-Rectangular Beam	12 x 18	17.46	26.19	0.97	69.84
Concrete-Rectangular Beam	36 x 32	21.22	169.76	6.29	176.83
Concrete-Rectangular Beam	42 x 32	21.4	199.7333	7.40	178.33
	Concrete Framing Member:		26.922 cy		

Table 3: Shows the Concrete Beam Schedule

Type Footing	Type Rein.	Length (ft)	Quantity Bar/beam	Quantity Beams	Wt./lf lbs/ft	Wt. lbs.	Wt. Ton	Total wt. Ton	Volume Concr.(cy)	ton/cy
CONCRETE FRAMING BEAM REINFORCING										
BM-1 (10"x10")	#5	17	3	6	1.043	319.158	0.159579			
BM-1 (10"x10")	#5	17	3	6	1.043	319.158	0.159579			
BM-1 (10"x10")	#4	2	17	6	0.668	136.272	0.068136	0.387294	2.623457	0.147627
BM-1 (10"x10")	#5	16	3	13	1.043	650.832	0.325416			
BM-1 (10"x10")	#5	16	3	13	1.043	650.832	0.325416			
BM-1 (10"x10")	#4	2	16	13	0.668	277.888	0.138944	0.789776	5.349794	0.147627
BM-1 (10"x10")	#5	15	3	4	1.043	187.74	0.09387			
BM-1 (10"x10")	#5	15	3	4	1.043	187.74	0.09387			
BM-1 (10"x10")	#4	2	15	4	0.668	80.16	0.04008	0.22782	1.54321	0.147627
BM-1 (10"x10")	#5	21	3	2	1.043	131.418	0.065709			
BM-1 (10"x10")	#5	21	3	2	1.043	131.418	0.065709			
BM-1 (10"x10")	#4	2	21	2	0.668	56.112	0.028056	0.159474	1.080247	0.147627
BM-2 (12"x16")	#7	15	3	4	2.044	367.92	0.18396			
BM-2 (12"x16")	#7	15	3	4	2.044	367.92	0.18396			
BM-2 (12"x16")	#4	4	15	4	0.688	165.12	0.08256	0.45048	3.124889	0.144159
BM-3 (12"x18")	#7	16	3	3	2.044	294.336	0.147168			
BM-3 (12"x18")	#7	16	3	3	2.044	294.336	0.147168			
BM-3 (12"x18")	#4	4.5	16	3	0.688	148.608	0.074304	0.36864	2.715556	0.135751
BM-3 (12"x18")	#7	17	3	1	2.044	104.244	0.052122			
BM-3 (12"x18")	#7	17	3	1	2.044	104.244	0.052122			
BM-3 (12"x18")	#4	4.5	17.00	1	0.688	52.632	0.026316	0.13056	0.97	0.134598
BM-4(36"x32")	#8	21	10	1	2.044	429.24	0.21462			
BM-4(36"x32")	#6	21	8	1	2.044	343.392	0.171696			
BM-4(36"x32")	#4	11	42	1	0.688	317.856	0.158928	0.545244	6.287407	0.08672
BM-5(42"x32")	#9	21	10	1	3.4	714	0.357			
BM-5(42"x32")	#6	21	8	1	1.502	252.336	0.126168			
BM-5(42"x32")	#4	12	42	1	0.668	336.672	0.168336	0.651504	7.407407	0.087953
TOTAL CONCRETE FRAME BEAM REINFORCING:						7421.584	3.71079			

Table 4: Shows the Concrete Beam Reinforcement

Steel Structural Framing Schedule					
Type	Size	Length ft	Weight lbs./lf	Weight lbs.	Weight ton
C-Channel	C10X20	21.77	20.00	435.40	0.2177
C-Channel	C10X20	21.77	20.00	435.40	0.2177
L-Angle	L6X4X5/16	21.77	10.30	224.23	0.11
L-Angle	L6X4X5/16	21.77	10.30	224.23	0.11
L-Angle	L6X6X5/16	24.79	12.50	309.88	0.15
L-Angle	L6X6X5/16	7.07	12.50	88.38	0.04
L-Angle	L6X6X5/16	15.08	12.50	188.50	0.09
L-Angle	L6X6X5/16	16.67	12.50	208.38	0.10
L-Angle	L6X6X5/16	11.99	12.50	149.88	0.07
LL-Double Angle	2L6X6X5/8	9.21	48.60	447.61	0.22
LL-Double Angle	2L6X6X5/8	9.21	48.60	447.61	0.22
LL-Double Angle	2L6X6X5/8	9.21	48.60	447.61	0.22
LL-Double Angle	2L6X6X5/8	9.21	48.60	447.61	0.22
LL-Double Angle	2L6X6X5/8	9.21	48.60	447.61	0.22
LL-Double Angle	2L6X6X5/8	9.21	48.60	447.61	0.22
LL-Double Angle	2L6X6X5/8	9.21	48.60	447.61	0.22
LL-Double Angle	2L6X6X5/8	9.21	48.60	447.61	0.22
LL-Double Angle	2L6X6X5/8	9.21	48.60	447.61	0.22
W-Wide Flange	W8X10	17.41	10.00	174.10	0.09
W-Wide Flange	W10X19	6.72	19.00	127.68	0.06
W-Wide Flange	W10X19	6.6	19.00	125.40	0.06
W-Wide Flange	W10X19	7.07	19.00	134.33	0.07
W-Wide Flange	W10X19	7.05	19.00	133.95	0.07
W-Wide Flange	W10X19	7.14	19.00	135.66	0.07
W-Wide Flange	W10X19	7.14	19.00	135.66	0.07
W-Wide Flange	W10X19	7.14	19.00	135.66	0.07
W-Wide Flange	W10X19	7.14	19.00	135.66	0.07
W-Wide Flange	W10X19	6.97	19.00	132.43	0.07
		Steel Framing Members:	3.831623 ton		

Table 5: Shows the Concrete Structural Framing Schedule

CONCRETE COLUMNS					
Type	Size in	Length ft	Surface Area sf	Material: Volume cf	Volume cy
Concrete-Rectangular-Column	12" x 12"	21.75	72	16.92	0.63
Concrete-Rectangular-Column	12" x 24"	21.75	112.00	26.50	0.98
Concrete-Rectangular-Column	12" x 24"	32.42	154.00	35.38	1.31
Concrete-Rectangular-Column	12" x 24"	32.42	179.00	46.58	1.73
Concrete-Rectangular-Column	12" x 24"	32.42	180.00	47.48	1.76
Concrete-Rectangular-Column	12" x 24"	32.42	178.00	48.54	1.80
Concrete-Rectangular-Column	12" x 24"	43.08	229.00	57.39	2.13
Concrete-Rectangular-Column	12" x 24"	43.08	229.00	57.39	2.13
Concrete-Rectangular-Column	12" x 24"	43.08	229.00	57.39	2.13
Concrete-Rectangular-Column	12" x 24"	43.08	229.00	57.39	2.13
Concrete-Rectangular-Column	12" x 24"	8.32	49.00	14.97	0.55
Concrete-Rectangular-Column	12" x 24"	8.32	49.00	14.97	0.55
Concrete-Rectangular-Column	12" x 24"	43.08	180.00	56.00	2.07
Concrete-Rectangular-Column	12" x 24"	8.32	49.00	14.97	0.55
Concrete-Rectangular-Column	12" x 24"	36.32	215.00	67.64	2.51
Concrete-Rectangular-Column	12" x 24"	36.32	215.00	67.64	2.51
Concrete-Rectangular-Column	12" x 24"	43.08	229.00	57.39	2.13
Concrete-Rectangular-Column	12" x 24"	43.08	229.00	57.39	2.13
Concrete-Rectangular-Column	12" x 24"	43.08	229.00	57.39	2.13
Concrete-Rectangular-Column	12" x 24"	54.00	332.00	99.89	3.70
Concrete-Rectangular-Column	12" x 24"	54.00	319.00	99.67	3.69
Concrete-Rectangular-Column	12" x 24"	54.00	332.00	99.89	3.70
Concrete-Rectangular-Column	12" x 24"	54.00	319.00	99.67	3.69
Concrete-Rectangular-Column	12" x 24"	54.00	319.00	99.67	3.69
Concrete-Rectangular-Column	12" x 24"	42.67	266.00	79.30	2.94
Concrete-Rectangular-Column	12" x 24"	52.08	313.00	97.80	3.62
Concrete-Rectangular-Column	12" x 24"	52.08	309.00	95.88	3.55
Concrete-Rectangular-Column	12" x 24"	52.08	313.00	95.96	3.55
Concrete-Rectangular-Column	12" x 24"	52.08	308.00	95.83	3.55
Concrete-Rectangular-Column	12" x 24"	43.33	256.00	80.00	2.96
Concrete-Rectangular-Column	12" x 24"	43.33	256.00	80.00	2.96
Concrete-Rectangular-Column	12" x 24"	32.00	189.00	59.00	2.19
Concrete-Rectangular-Column	12" x 24"	32.00	189.00	59.00	2.19
Concrete-Rectangular-Column	12" x 24"	32.00	189.00	59.00	2.19
Concrete-Rectangular-Column	12" x 24"	32.00	189.00	59.00	2.19
Concrete-Rectangular-Column	16" x 24"	64.42	414	129.55	4.80
Concrete-Rectangular-Column	16" x 48"	25.65	273.6	136.80	5.07
Concrete-Rectangular-Column	16" x 48"	25.65	273.6	136.80	5.07

Table 6: Shows the Concrete Column Schedule

CONCRETE COLUMNS Type	Size in	Length ft	Surface Area sf	Material: Volume cf	Volume cy
Concrete-Rectangular-Column	18" x 18"	32.42	193	67.31	2.49
Concrete-Rectangular-Column	18" x 18"	32.42	193	67.31	2.49
Concrete-Rectangular-Column	18" x 18"	43.08	257	89.44	3.31
Concrete-Rectangular-Column	18" x 18"	43.08	257	89.44	3.31
Concrete-Rectangular-Column	18" x 18"	43.08	257	89.44	3.31
Concrete-Rectangular-Column	18" x 18"	43.33	258	90.00	3.33
Concrete-Rectangular-Column	18" x 18"	43.33	258	90.00	3.33
Concrete-Rectangular-Column	18" x 18"	54	322	112.13	4.15
Concrete-Rectangular-Column	18" x 18"	43.08	257	89.44	3.31
Concrete-Rectangular-Column	18" x 18"	43.33	258	90.00	3.33
Concrete-Rectangular-Column	18" x 18"	43.33	258	90.00	3.33
Concrete-Rectangular-Column	18" x 18"	54	322	112.13	4.15
Concrete-Rectangular-Column	18" x 36"	25.65	232	111.69	4.14
Concrete-Rectangular-Column	18" x 36"	25.65	232	111.69	4.14
Concrete-Rectangular-Column	18" x 36"	25.65	232	111.69	4.14
Concrete-Rectangular-Column	18" x 36"	32.42	296	134.63	4.99
Concrete-Rectangular-Column	18" x 36"	25.65	232	111.69	4.14
Concrete-Rectangular-Column	18" x 36"	25.65	232	111.69	4.14
Concrete-Rectangular-Column	18" x 36"	32.42	296	134.63	4.99
Concrete-Rectangular-Column	18" x 36"	32.42	296	134.63	4.99
TOTAL CONCRETE COLUMNS:			**172.63 cy**		
TOTAL CONCRETE COLUMNS:			**13732.2 sf**		

Table 7: Shows the Concrete Column Schedule

FOUNDATION WALL CONCRETE								
Type of Wall	Type of Concrete	Length (ft)	Width (ft)	Area (sf)	Volume (cf)	Volume (cy)	ton/cy	ton
Exterior - 8" Concrete	CIP	17.67	0.67	12	8.15	0.30	0.107	0.032
Exterior - 8" Concrete	CIP	6.85	0.67	5	3.05	0.11	0.107	0.012
Exterior - 8" Concrete	CIP	17.67	0.67	12	7.85	0.29	0.107	0.031
Exterior - 8" Concrete	CIP	6.85	0.67	4	2.75	0.10	0.107	0.011
Exterior - 8" Concrete	CIP	6.83	0.67	5	3.33	0.12	0.107	0.013
Exterior - 8" Concrete	CIP	17.67	0.67	12	7.85	0.29	0.107	0.031
Exterior - 8" Concrete	CIP	6.83	0.67	5	3.04	0.11	0.107	0.012
Exterior - 8" Concrete	CIP	17.67	0.67	11	7.56	0.28	0.107	0.030
Foundation - 8" Concrete	CIP	70.63	0.67	438	311.74	11.55	0.107	1.235
Foundation - 1-'4" Concrete	CIP	18.03	1.33	201	267.94	9.92	0.107	1.062
Foundation - 1-'4" Concrete	CIP	6.67	1.33	76	100.67	3.73	0.107	0.399
Foundation - 1-'4" Concrete	CIP	2.87	1.33	53	70.54	2.61	0.107	0.280
Foundation - 1-'4" Concrete	CIP	10.28	1.33	155	206.67	7.65	0.107	0.819
Foundation - 1-'4" Concrete	CIP	57.71	1.33	709	945.85	35.03	0.107	3.748
Foundation - 1-'4" Concrete	CIP	0.58	1.33	24	32.16	1.19	0.107	0.127
Foundation - 1-'4" Concrete	CIP	26.71	1.33	336	448.11	16.60	0.107	1.776
Foundation - 1-'4" Concrete	CIP	42.37	1.33	516	688.50	25.50	0.107	2.729
Foundation - 1-'4" Concrete	CIP	70.63	1.33	1048	1397.20	51.75	0.107	5.537
Foundation - 2' Concrete	CIP	19.41	2.00	68	135.62	5.02	0.107	0.537
Foundation - 2' Concrete	CIP	8.50	2.00	27	53.83	1.99	0.107	0.213
Foundation - 2' Concrete	CIP	19.41	2.00	61	122.95	4.55	0.107	0.487
Foundation - 2' Concrete	CIP	8.50	2.00	21	41.17	1.52	0.107	0.163
Interior - 12" Concrete	CIP	7.31	1.00	127	127.37	4.72	0.107	0.505
Interior - 12" Concrete	CIP	16.50	1.00	91	90.37	3.35	0.107	0.358
Interior - 12" Concrete	CIP	13.44	1.00	53	53.10	1.97	0.107	0.210
Interior - 12" Concrete	CIP	10.33	1.00	37	36.66	1.36	0.107	0.145
Interior- 14" Concrete	CIP	16.50	1.17	91	106.13	3.93	0.107	0.421
	TOTAL FOUNDATION WALL CONCRETE:			**4198**	**5280.16**	**195.5615**		**20.92508**

Table 8: Shows the Foundation Wall Schedule

FOOTING CONCRETE								
Type	Width (ft)	Depth (ft)	Length (ft)	Quantity (Each)	Volume (cf)	Volume (cy)	Perimeter Form (ft)	Forms SFCA
F4.0	4	1	4	1	16.00	0.59	8	32.00
F6.5	6.5	2.33	6.5	1	98.58	3.65	13.00	84.50
F9.5	9.5	3.17	9.5	2	571.58	21.17	19	180.50
F7.5'x 24.5'	7.5	2.67	24.5	1	490.00	18.15	15	367.50
F9.5'x24.5'	9.5	3.17	24.5	1	737.04	27.30	19	465.50
				TOTAL FOOTING CONCRETE:	**1913.21**	**70.86**		

Table 9: Shows the Concrete Footing Schedule

FOOTING REINFORCING						
Type Footing	Type Rein.	Length (ft)	Quantity (Each)	Wt./lf lbs/ft	Wt. lbs.	Wt. Ton
F4.0	#5	4	4	1.043	16.688	0.00834
	#5	4	4	1.043	16.688	0.00834
F6.5	#6	6.5	8	1.502	78.104	0.03905
	#6	6.5	8	1.502	78.104	0.03905
F9.5	#9	9.5	18	3.4	581.4	0.29070
	#9	9.5	18	3.4	581.4	0.29070
F7.5'x 24.5'	#10	10	24.5	4.303	1054.235	0.52712
	#7	8	24.5	2.044	400.624	0.20031
	#7	24	7.5	2.044	367.92	0.18396
F9.5'x24.5'	#11	14	24.5	5.313	1822.359	0.91118
	#9	9	24.5	3.4	749.7	0.37485
	#9	24	9.5	3.4	775.2	0.38760
			TOTAL FOOTING REINFORCING:		**6522.422**	**3.26121**

Table 10: Shows the Concrete Footing Reinforcement

Type	Width (ft)	Depth (ft)	Length (ft)	Quantity (Each)	Volume (cf)	Volume (cy)	Perimeter Form (ft)	Forms SFCA
TIE BEAM CONCRETE								
TB-1	3	3	15.75	2	283.50	10.50	6.00	94.50
TB-2	2	2	8.33	1	33.33	1.23	4.00	33.33
TB-3	2.5	2.67	24.00	2	320.00	11.85	5.33	128.00
TB-4	2.5	2	17.50	1	87.50	3.24	4.00	70.00
TB-5	2	1.5	17.50	1	52.50	1.94	3.00	52.50
TB-6	3.33	2.5	25.00	1	208.33	7.72	5.00	125.00
			TOTAL TIE BEAM CONCRETE:		**985.17**	**36.49**		

Table 9: Shows the Concrete Tie Beam Schedule

Type Footing	Type Rein.	Length (ft)	Quantity (Each)	Wt./lf lbs/ft	Wt. lbs.	Wt. Ton
TIE BEAM REINFORCING						
TB-1	#10	15.75	14	4.303	948.8115	0.47441
	#6	15.75	8	1.502	189.252	0.09463
	# 4	5.5	16	0.668	58.784	0.02939
TB-2	#10	8.33	6	4.303	215.0639	0.10753
	#6	8.33	6	1.502	75.06996	0.03753
	# 4	1.67	9	0.668	10.02	0.00501
TB-3	#10	24	8	4.303	826.176	0.41309
	#6	24	8	1.502	288.384	0.14419
	# 4	4.75	24	0.668	76.152	0.03808
TB-4	#10	17.5	7	4.303	527.1175	0.26356
	#6	17.5	5	1.502	131.425	0.06571
	# 4	4.75	24	0.668	76.152	0.03808
TB-5	#6	17.5	4	1.502	105.14	0.05257
	#6	17.5	4	1.502	105.14	0.05257
	# 4	2.92	24	0.668	46.76	0.02338
TB-6	#10	25	14	4.303	1506.05	0.75303
	#6	25	8	1.502	300.4	0.15020
	# 4	5.33	24	0.668	85.504	0.04275
		TOTAL TIE BEAM REINFORCING:			**5571.402**	**2.78570**

Table 10: Shows the Concrete Tie Beam Reinforcement

Appendix B: RS Means Structural Estimate

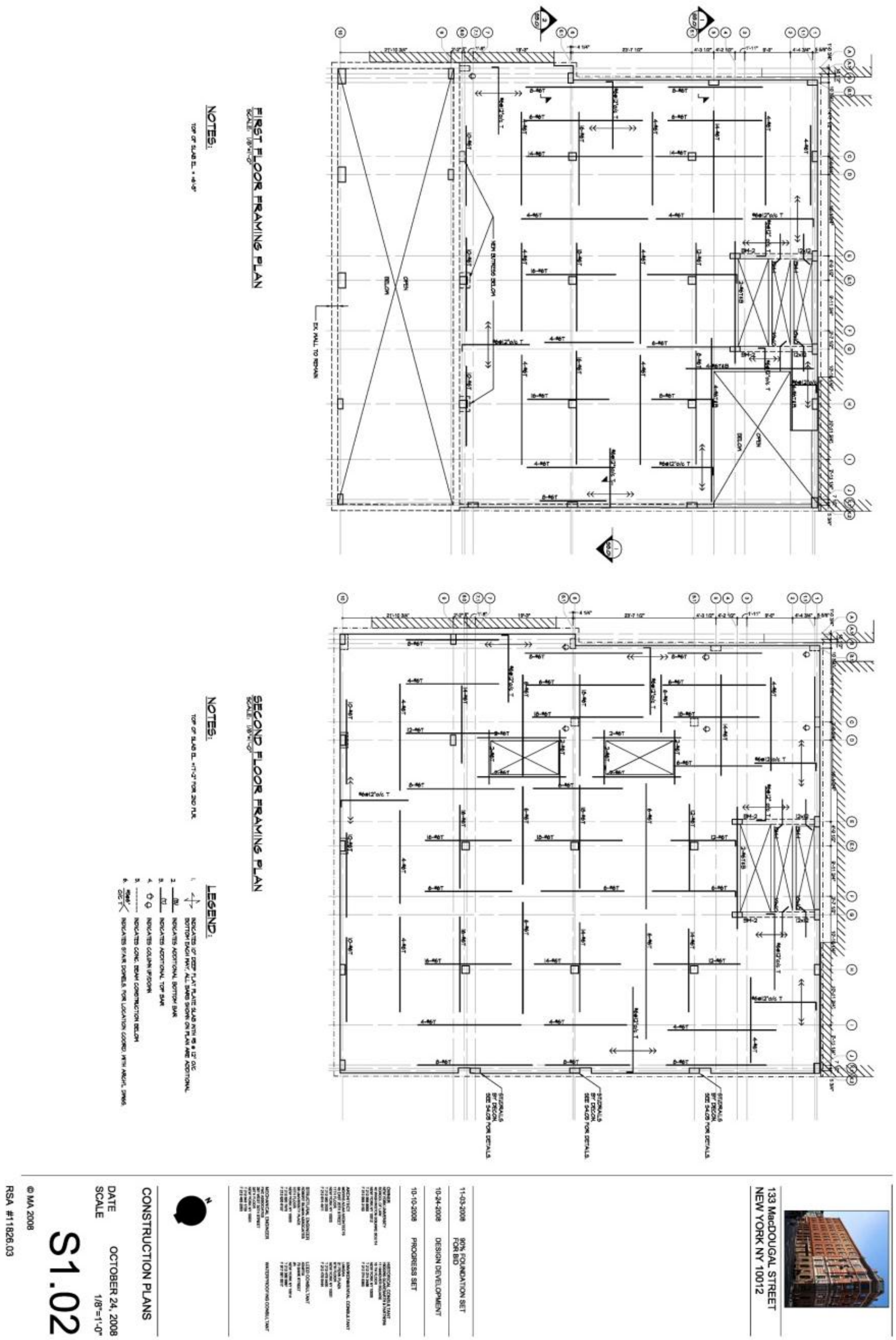
Luke Gray
NYC New York 10012
Data Release : Year 2008 Quarter 1
Labor Type: Standard Union

Unit Cost Estimate

Quantity	LineNumber	Source	SubContr	Description	Crew	Daily Output	Labor Hours	Unit	Mat. O&P	Labor O&P	Equip. O&P	Total O&P	Ext. Mat. O&P	Ext. Labor O&P	Ext. Equip. O&P	Ext. Total O&P
BEAMS				**$ 45,754.77**												
1126	031113202050			C.I.P. concrete forms, beams and girders, interior, plywood, 12" wide, 2 use, includes shoring, erecting, bracing, stripping and cleaning	C2	340	0.14	SFCA	$ 2.52	$ 15.68	$ -	$ 18.20	$ 2,837.52	$ 17,655.68	$ -	$ 20,493.20
335.2	031113202550			C.I.P. concrete forms, beams and girders, interior, plywood, 24" wide, 2 use, includes shoring, erecting, bracing, stripping and cleaning	C2	365	0.132	SFCA	$ 1.88	$ 14.62	$ -	$ 16.50	$ 630.18	$ 4,900.62	$ -	$ 5,530.80
26.922	033105700050			Structural concrete, placing, beam, small, elevated, pumped, includes vibrating, excludes material	C20	60	1.067	C.Y.	$ -	$ 93.95	$ 16.54	$ 110.49	$ -	$ 2,529.32	$ 445.29	$ 2,974.61
26.922	33105350400			Structural concrete, ready mix, normal weight, 5000 psi, includes local aggregate, sand, portland cement and water, delivered, excludes all additives and treatments				C.Y.	$ 129.72	$ -	$ -	$ 129.72	$ 3,492.32	$ -	$ -	$ 3,492.32
2.514044	032110600100			Reinforcing steel, in place, beams and girders, #3 to #7, A615, grade 60, incl labor for accessories, excl material for accessories	4 Rodm	1.6	20	Ton	$ 1,164.40	$ 2,770.60	$ -	$ 3,935.00	$ 2,927.35	$ 6,965.41	$ -	$ 9,892.76
1.196748	032110600150			Reinforcing steel, in place, beams and girders, #8 to # 18, A615, grade 60, incl labor for accessories, excl material for accessories	4 Rodm	2.7	11.852	Ton	$ 1,164.40	$ 1,652.47	$ -	$ 2,816.87	$ 1,393.49	$ 1,977.59	$ -	$ 3,371.08
STRUCTURAL STEEL				**$ 50,650.78**												
870.8	051223400600			Channel framing, structural steel, 8" and larger, field fabricated, incl cutting & welding	E3	500	0.048	Lb.	$ 0.80	$ 5.69	$ 0.34	$ 6.83	$ 696.64	$ 4,954.85	$ 296.07	$ 5,947.56
5422	051223400400			Angle framing, structural steel, 4" and larger, field fabricated, incl cutting & welding	E3	440	0.055	Lb.	$ 0.77	$ 6.47	$ 0.38	$ 7.62	$ 4,174.94	$ 35,080.34	$ 2,060.36	$ 41,315.64
17.5	051223750300			Structural steel member, 100-ton project, 1 to 2 story building, W8x10, A992 steel, shop fabricated, incl shop primer, bolted connections	E2	600	0.093	L.F.	$ 14.64	$ 10.15	$ 3.33	$ 28.12	$ 256.20	$ 177.63	$ 58.28	$ 492.10
63	051223750700			Structural steel member, 100-ton project, 1 to 2 story building, W10x22, A992 steel, shop fabricated, incl shop primer, bolted connections	E2	600	0.093	L.F.	$ 32.48	$ 10.15	$ 3.33	$ 45.96	$ 2,046.24	$ 639.45	$ 209.79	$ 2,895.48
COLUMNS				$ 309,425.00												
158.5	033053400920			Structural concrete, in place, column, square, avg reinforcing, 24" x 24", includes forms(4 uses), reinforcing steel, and finishing	C14A	17.71	11.293	C.Y.	$ 486.45	$ 1,194.08	$ 54.57	$ 1,735.10	$ 77,102.33	$ 189,261.68	$ 8,649.35	$ 275,013.35
15	033053400820			Structural concrete, in place, column, square, avg reinforcing, 16" x 16", includes forms(4 uses), reinforcing steel, and finishing	C14A	12.57	15.911	C.Y.	$ 540.50	$ 1,676.98	$ 76.63	$ 2,294.11	$ 8,107.50	$ 25,154.70	$ 1,149.45	$ 34,411.65
COLUMNS (For BUTRICES TO EXISTING MASONRY WALL				$ 3,891.60												
120	036305101530			Chemical anchoring, for fastener 3/4" diam x 6" embedment, incl epoxy cartridge, excl layout, drilling & fastener	2 Skwk	72	0.222	Ea.	$ 7.20	$ 25.23	$ -	$ 32.43	$ 864.00	$ 3,027.60	$ -	$ 3,891.60
ELEVATED SLABS				$ 1,445,630.97												
1420	033105350400			Structural concrete, ready mix, normal weight, 5000 psi, includes local aggregate, sand, portland cement and water, delivered, excludes all additives and treatments				C.Y.	$ 129.72	$ -	$ -	$ 129.72	$ 184,202.40	$ -	$ -	$ 184,202.40
1420	033105701500			Structural concrete, placing, elevated slab, pumped, 6" to 10" thick, includes vibrating, excludes material	C20	160	0.4	C.Y.	$ -	$ 35.12	$ 6.21	$ 41.33	$ -	$ 49,870.40	$ 8,818.20	$ 58,688.60
46004	031113351150			C.I.P. concrete forms, elevated slab, flat plate, plywood, to 15' high, 4 use, includes shoring, erecting, bracing, stripping and cleaning	C2	560	0.09	S.F.	$ 1.73	$ 9.52	$ -	$ 11.25	$ 79,586.92	$ 437,958.08	$ -	$ 517,545.00
2904	031113357080			C.I.P. concrete forms, elevated slab, edge forms, 7" to 12" high, 2 use, includes shoring, erecting, bracing, stripping and cleaning	C1	198	0.162	SFCA	$ 0.65	$ 17.51	$ -	$ 18.16	$ 1,887.71	$ 50,851.96	$ -	$ 52,739.67
3485	031113358000			C.I.P. concrete forms, elevated slab, perimeter deck and rail, straight, includes shoring, erecting, bracing, stripping and cleaning	C1	90	0.36	L.F.	$ 16.29	$ 38.48	$ -	$ 54.77	$ 56,770.65	$ 134,102.80	$ -	$ 190,873.45
46004	033529300350			Concrete finishing, floors, power screed, bull float, machine float & steel trowel (ride-on)	C10E	4000	0.006	S.F.	$ -	$ 0.54	$ 0.07	$ 0.61	$ -	$ 24,842.16	$ 3,220.28	$ 28,062.44
134.538	032110600400			Reinforcing steel, in place, elevated slabs, #4 to #7, A615, grade 60, incl labor for accessories, excl material for accessories	4 Rodm	2.9	11.034	Ton	$ 1,249.60	$ 1,543.62	$ -	$ 2,793.22	$ 168,118.93	$ 207,675.86	$ -	$ 375,794.79
134.538	032110602200			Reinforcing steel, crane cost for handling, minimum, add	C5	135	0.415	Ton	$ -	$ 55.41	$ 7.43	$ 62.84	$ -	$ 7,454.76	$ 999.62	$ 8,454.38
134.538	032110602000			Reinforcing steel, unload and sort, add to base	C5	100	0.56	Ton	$ -	$ 74.21	$ 10.04	$ 84.25	$ -	$ 9,984.08	$ 1,350.76	$ 11,334.84
460	033923230200			Curing, burlap/poly blanket, 2 ply	2 Clab	70	0.229	C.S.F.	$ 20.11	$ 18.88	$ -	$ 38.99	$ 9,250.60	$ 8,684.80	$ -	$ 17,935.40
SLAB ON GRADE				$ 10,596.01												
32	033105350400			Structural concrete, ready mix, normal weight, 5000 psi, includes local aggregate, sand, portland cement and water, delivered, excludes all additives and treatments				C.Y.	$ 129.72	$ -	$ -	$ 129.72	$ 4,151.04	$ -	$ -	$ 4,151.04
32	033105701500			Structural concrete, placing, elevated slab, pumped, 6" to 10" thick, includes vibrating, excludes material	C20	160	0.4	C.Y.	$ -	$ 35.12	$ 6.21	$ 41.33	$ -	$ 1,123.84	$ 198.72	$ 1,322.56
109.2	031113653060			C.I.P. concrete forms, slab on grade, edge, wood, over 12", 4 use, includes erecting, bracing, stripping and cleaning	C1	350	0.09	SFCA	$ 0.88	$ 9.91	$ -	$ 10.79	$ 96.07	$ 1,081.84	$ -	$ 1,177.91
20.57	032205500200			Welded wire fabric, sheets, 6 x 6 - W2.1 x W2.1 (8 x 8) 30 lb. per C.S.F., A185	2 Rodm	31	0.516	C.S.F.	$ 19.54	$ 72.23	$ -	$ 91.77	$ 401.94	$ 1,485.77	$ -	$ 1,887.71
2057	033529300350			Concrete finishing, floors, power screed, bull float, machine float & steel trowel (ride-on)	C10E	4000	0.006	S.F.	$ -	$ 0.54	$ 0.07	$ 0.61	$ -	$ 1,110.78	$ 143.99	$ 1,254.77
20.57	033923230200			Curing, burlap/poly blanket, 2 ply	2 Clab	70	0.229	C.S.F.	$ 20.11	$ 18.88	$ -	$ 38.99	$ 413.66	$ 388.36	$ -	$ 802.02
FOUNDATION MAT SLAB				$ 474,486.75												
1172.5	031113550050			C.I.P. concrete forms, mat foundation, plywood, 2 use, includes erecting, bracing, stripping and cleaning	C2	310	0.15	SFCA	$ 1.31	$ 17.22	$ -	$ 18.53	$ 1,535.98	$ 20,190.45	$ -	$ 21,726.43
581	033105702950			Structural concrete, placing, foundation mat, pumped, over 20 C.Y., includes vibrating, excludes material	C20	400	0.16	C.Y.	$ -	$ 14.05	$ 2.48	$ 16.53	$ -	$ 8,163.05	$ 1,440.88	$ 9,603.93

581	033105350400			Structural concrete, ready mix, normal weight, 5000 psi, includes local aggregate, sand, portland cement and water, delivered, excludes all additives and treatments				C.Y.	$ 129.72	$ -	$ -	$ 129.72	$ 75,367.32	$ -	$ -	$ 75,367.32
63.08	033923230200			Curing, burlap/poly blanket, 2 ply	2 Clab	70	0.229	C.S.F.	$ 20.11	$ 18.88	$ -	$ 38.99	$ 1,268.54	$ 1,190.95	$ -	$ 2,459.49
62	032110601100			Reinforcing steel, in place, typical, average, 50 to 100 ton job, #3 to #7, A615, grade 60, incl labor for accessories, excl material for accessories	4 Rodm	2.2	14.545	Ton	$ 1,164.40	$ 2,028.48	$ -	$ 3,192.88	$ 72,192.80	$ 125,765.76	$ -	$ 197,958.56
62	032110601110			Reinforcing steel, in place, typical, average, 50 to 100 ton job, #8 to #18, A615, grade 60, incl labor for accessories, excl material for accessories	4 Rodm	3.1	10.323	Ton	$ 1,192.80	$ 1,444.67	$ -	$ 2,637.47	$ 73,953.60	$ 89,569.54	$ -	$ 163,523.14
6308	033529300350			Concrete finishing, floors, power screed, bull float, machine float & steel trowel (ride-on)	C10E	4000	0.006	S.F.	$ -	$ 0.54	$ 0.07	$ 0.61	$ -	$ 3,406.32	$ 441.56	$ 3,847.88
FOUNDATION WALLS				$ 205,286.79												
100	031505953050			Form oil, coverage varies greatly, maximum, includes material only				Gal.	$ 12.30	$ -	$ -	$ 12.30	$ 1,230.00	$ -	$ -	$ 1,230.00
3.134	033105704950			Structural concrete, placing, walls, pumped, 8" thick, includes vibrating, excludes material	C20	100	0.64	C.Y.	$ -	$ 56.19	$ 9.93	$ 66.12	$ -	$ 176.10	$ 31.12	$ 207.22
11.4	033105705100			Structural concrete, placing, walls, pumped, 12" thick, includes vibrating, excludes material	C20	110	0.582	C.Y.	$ -	$ 50.92	$ 9.06	$ 59.98	$ -	$ 580.49	$ 103.28	$ 683.77
171	033105705350			Structural concrete, placing, walls, pumped, 15" thick, includes vibrating, excludes material	C20	120	0.533	C.Y.	$ -	$ 46.53	$ 8.30	$ 54.83	$ -	$ 7,956.63	$ 1,419.30	$ 9,375.93
8396	031113859260			C.I.P. concrete forms, walls, steel framed plywood, over 8' to 16' high, based on 100 uses of purchased forms, 4 uses of bracing lumber, includes erecting, bracing, stripping and cleaning	C2	450	0.107	SFCA	$ 0.44	$ 11.83	$ -	$ 12.27	$ 3,694.24	$ 99,324.68	$ -	$ 103,018.92
186	033105350400			Structural concrete, ready mix, normal weight, 5000 psi, includes local aggregate, sand, portland cement and water, delivered, excludes all additives and treatments				C.Y.	$ 129.72	$ -	$ -	$ 129.72	$ 24,127.92	$ -	$ -	$ 24,127.92
8396	033529600020			Concrete finishing, walls, includes breaking ties and patching voids	1 Cefi	540	0.015	S.F.	$ 0.03	$ 1.40	$ -	$ 1.43	$ 251.88	$ 11,754.40	$ -	$ 12,006.28
21	032110600700			Reinforcing steel, in place, walls, #3 to #7, A615, grade 60, incl labor for accessories, excl material for accessories	4 Rodm	3	10.667	Ton	$ 1,107.60	$ 1,494.15	$ -	$ 2,601.75	$ 23,259.60	$ 31,377.15	$ -	$ 54,636.75
FOUNDATION FOOTINGS				$ 30,129.12												
1130	031113450050			C.I.P. concrete forms, footing, continuous wall, plywood, 2 use, includes erecting, bracing, stripping and cleaning	C1	440	0.07	SFCA	$ 3.52	$ 7.87	$ -	$ 11.39	$ 3,977.60	$ 8,893.10	$ -	$ 12,870.70
69	031113451500			C.I.P. concrete forms, footing, keyway, tapered wood, 2" x 4", 4 use, includes erecting, bracing, stripping and cleaning	CARP	530	0.02	L.F.	$ 0.23	$ 1.71	$ -	$ 1.94	$ 15.87	$ 117.99	$ -	$ 133.86
71	033105350400			Structural concrete, ready mix, normal weight, 5000 psi, includes local aggregate, sand, portland cement and water, delivered, excludes all additives and treatments				C.Y.	$ 129.72	$ -	$ -	$ 129.72	$ 9,210.12	$ -	$ -	$ 9,210.12
0.479	032110600500			Reinforcing steel, in place, footings, #4 to #7, A615, grade 60, incl labor for accessories, excl material for accessories	4 Rodm	2.1	15.238	Ton	$ 1,107.60	$ 2,127.43	$ -	$ 3,235.03	$ 530.61	$ 1,019.17	$ -	$ 1,549.77
2.782	032110600550			Reinforcing steel, in place, footings, #8 to #18, A615, grade 60, incl labor for accessories, excl material for accessories	4 Rodm	3.6	8.889	Ton	$ 1,050.80	$ 1,236.88	$ -	$ 2,287.68	$ 2,923.48	$ 3,441.19	$ -	$ 6,364.67
FOUNDATIONS GRADE BEAMS				$ 19,414.15												
504	031113500050			C.I.P. concrete forms, grade beam, plywood, 2 use, includes erecting, bracing, stripping and cleaning	C2	580	0.08	SFCA	$ 1.70	$ 9.20	$ -	$ 10.90	$ 856.80	$ 4,636.80	$ -	$ 5,493.60
36.5	033105703250			Structural concrete, placing, grade beam, pumped, includes vibrating, excludes material	C20	180	0.356	C.Y.	$ -	$ 31.17	$ 5.51	$ 36.68	$ -	$ 1,137.71	$ 201.12	$ 1,338.82
36.5	033105350400			Structural concrete, ready mix, normal weight, 5000 psi, includes local aggregate, sand, portland cement and water, delivered, excludes all additives and treatments				C.Y.	$ 129.72	$ -	$ -	$ 129.72	$ 4,734.78	$ -	$ -	$ 4,734.78
2.7857	032110600150			Reinforcing steel, in place, beams and girders, #8 to # 18, A615, grade 60, incl labor for accessories, excl material for accessories	4 Rodm	2.7	11.852	Ton	$ 1,164.40	$ 1,652.47	$ -	$ 2,816.87	$ 3,243.67	$ 4,603.29	$ -	$ 7,846.95
Total													**$ 911,783.44**	**$ 1,652,245.13**	**$ 31,237.42**	**$ 2,595,265.94**

Appendix C: Flat Plate Structural Floor Plan



Appendix D: Actual Project Cost

Total Project cost	%	Total Cost	Cost/SF
			55,130
Site Development			
Site Preparation	0.17%	$45,240	$0.82
Utilities	3.23%	$846,633	$15.36
Site Development Total:	3.40%	$891,873	$16.18
Building			
Demolition	3.58%	$939,500	$17.04
Foundation	14.85%	$3,895,572	$70.66
Cast In Place Concrete Structure	16.43%	$4,310,000	$78.18
Thermal and Moisture Protection	1.58%	$414,540	$7.52
Exterior Wall	9.51%	$2,494,380	$45.25
Interior Partitions and Finishes	7.55%	$1,979,160	$35.90
Interior Finishes	4.04%	$1,059,522	$19.22
Soffits at Office Ceilings	0.29%	$76,032	$1.38
Specialties	2.42%	$634,796	$11.51
Vertical Transportation	2.69%	$704,500	$12.78
Plumbing	2.04%	$535,951	$9.72
Fire Protection	2.23%	$586,213	$10.63
H.V.A.C.	10.83%	$2,839,736	$51.51
Electrical	10.59%	$2,777,906	$50.39
Total Building Cost:	88.63%	$23,247,808	$421.69
Trade Requirements			
Trade Requirements	6.39%	$1,674,992	$30.38
Trade Requirements Total:	6.39%	$1,674,992	$30.38
Allowances			
Allowances	1.58%	$415,000	$7.53
Allowances Total:	1.58%	$415,000	$7.53
Site, Building, Trade Requirements and Allowances Cost:	100.00%	**$26,229,673**	**$475.78**
Total Cost minus site:		**$25,337,800**	**$459.60**
Contractor Fees (General Conditions,Overhead,Profit:)	6.60%	**$1,731,544**	**$31.41**
Architectural Fees:	7.00%	**$1,836,077**	**$33.30**
Total Project Cost:		**$29,797,294**	**$540.49**

Appendix E: D4 Estimated Software Cost

D4Cost Southern Arkansas University Adjusted

Sunday, October 3, 2010 — **Statement of Probable Cost** — Page 1

Southen Arkansas University Adjuste - Aug 2010 - NY - N.Y.C.

Prepared By:	**Cromwell Architects Engineers** **101 Spring Street** **Little Rock, AR 72201** **Fax:**	Prepared For:	, **Fax:**
Building Sq. Size:	**55130**	Site Sq. Size:	**170000**
Bid Date:	**1/1/1992**	Building use:	**Educational**
No. of floors:	**3**	Foundation:	**MAT**
No. of buildings:	**1**	Exterior Walls:	**MAS**
Project Height:	**70**	Interior Walls:	**GYP**
1st Floor Height:	**14**	Roof Type:	**BIT**
1st Floor Size:	**15789**	Floor Type:	**VCT**
		Project Type:	**NEW**

Division		Percent	Sq. Cost	Amount
00	**Bidding Requirements**	**6.50**	**13.74**	**757,354**
	Bonds & Certificates	1.10	2.32	127,909
	General Conditions	5.40	11.42	629,445
01	**General Requirements**	**0.47**	**0.99**	**54,314**
	Constr. Fac. & Temp. Controls	0.47	0.99	54,314
03	**Concrete**	**6.15**	**13.00**	**716,836**
	Cast-In-Place	2.77	5.86	322,878
	Curing	0.07	0.14	7,966
	Formwork	1.47	3.10	170,908
	Precast	1.01	2.13	117,300
	Reinforcement	0.84	1.77	97,783
04	**Masonry**	**13.11**	**27.72**	**1,527,979**
	Unit	13.11	27.72	1,527,979
05	**Metals**	**12.33**	**26.06**	**1,436,786**
	Decking	1.76	3.73	205,669
	Joists	3.73	7.88	434,512
	Structural Framing	6.84	14.45	796,605
06	**Wood & Plastics**	**3.14**	**6.64**	**366,196**
	Finish Carpentry	1.86	3.94	217,256
	Rough Carpentry	1.28	2.70	148,940
07	**Thermal & Moisture Protection**	**5.24**	**11.08**	**610,674**
	Dampproofing	0.16	0.34	18,829
	Exterior Wall Assemblies	0.32	0.67	36,934
	Fireproofing	2.17	4.60	253,465
	Firestopping	0.17	0.35	19,553
	Insulation	0.24	0.51	28,243
	Membrane Roofing	1.96	4.14	228,303
	Skylights	0.22	0.46	25,347
08	**Doors & Windows**	**4.25**	**8.99**	**495,419**
	Glazing	2.67	5.65	311,726
	Hardware	0.75	1.58	87,348
	Metal Doors & Frames	0.83	1.75	96,346
09	**Finishes**	**12.03**	**25.44**	**1,402,383**
	Acoustical Treatment	1.31	2.76	152,133
	Carpet	1.09	2.31	127,182
	Gypsum Board	1.99	4.21	232,011
	Metal Support Systems	2.52	5.33	293,940
	Painting	1.37	2.89	159,364
	Resilient Flooring	1.71	3.61	199,151
	Tile	0.80	1.70	93,764
	Wall Coverings	1.24	2.63	144,837
10	**Specialties**	**0.86**	**1.81**	**100,003**
	Louvers & Vents	0.10	0.20	11,247
	Toilet & Bath Accessories	0.37	0.79	43,451

	Visual Display Board	0.33	0.69	38,020
	Wall & Corner Guards	0.06	0.13	7,285
14	**Conveying Systems**	**0.92**	**1.95**	**107,491**
	Elevators	0.92	1.95	107,491
15	**Mechanical**	**22.74**	**48.07**	**2,649,924**
	Air Distribution	1.30	2.76	152,079
	Controls	2.61	5.52	304,158
	Fire Protection	1.51	3.19	176,079
	HVAC	13.49	28.51	1,571,832
	Insulation	1.18	2.50	137,595
	Plumbing	2.42	5.11	281,973
	Testing, Adjusting & Balancing	0.22	0.48	26,208
16	**Electrical**	**12.26**	**25.91**	**1,428,457**
	Communications	0.78	1.64	90,523
	Lighting	2.24	4.73	260,707
	Service & Distribution	9.04	19.11	1,053,691
	Special Systems	0.20	0.43	23,536
Total Building Costs		**100.00**	**211.39**	**11,653,816**
02	**Site Work**	**100.00**	**5.93**	**1,007,707**
	Demolition	19.10	1.13	192,516
	Earthwork	21.01	1.25	211,706
	Landscaping	11.14	0.66	112,301
	Paving & Surfacing	8.28	0.49	83,423
	Peparation	15.86	0.94	159,823
	Sewerage & Drainage	14.65	0.87	147,595
	Water Distribution	9.96	0.59	100,342
Total Non-Building Costs		**100.00**	**5.93**	**1,007,707**
Total Project Costs		**--**	**--**	**12,661,523**

D4Cost American Music Theatre Adjusted

Sunday, October 3, 2010

Statement of Probable Cost

Page 1

American Music Theatre Adjusted - Aug 2010 - NY - N.Y.C.

Prepared By:	Cornerstone Design Architects 320 Granite Run Drive Lancaster, PA 17604-3310 Fax:	Prepared For:	, Fax:
Building Sq. Size:	**55294**	Site Sq. Size:	**116270**
Bid Date:	**8/1/1996**	Building use:	**Recreational**
No. of floors:	**2**	Foundation:	**CMU**
No. of buildings:	**1**	Exterior Walls:	**MAS**
Project Height:	**64**	Interior Walls:	**DRY**
1st Floor Height:	**16**	Roof Type:	**MEM**
1st Floor Size:	**31900**	Floor Type:	**CAR**
		Project Type:	**NEW**

Division		Percent	Sq. Cost	Amount
00	**Bidding Requirements**	**0.18**	**0.68**	**37,593**
	Bonds & Certificates	0.18	0.68	37,593
01	**General Requirements**	**7.22**	**27.16**	**1,501,536**
	Constr. Fac. & Temp. Controls	0.93	3.51	194,028
	Contract Closeout	0.12	0.44	24,254
	Coordination	0.29	1.10	60,634
	Faciltiy Startup/Commissioning	0.17	0.66	36,380
	Field Engineering	0.24	0.90	49,720
	Identification Systems	0.02	0.07	3,881
	Maintenance	0.05	0.18	9,701
	Material & Equipment	1.05	3.95	218,282
	Project Development & Mgt.	1.98	7.46	412,310
	Project Meetings	0.12	0.44	24,254
	Quality Control	0.20	0.75	41,231
	Regulatory Requirements	0.19	0.70	38,806
	Supervision	1.87	7.02	388,057
03	**Concrete**	**3.60**	**13.55**	**749,434**
	Cast-In-Place	3.09	11.62	642,719
	Precast	0.51	1.93	106,716
04	**Masonry**	**6.07**	**22.81**	**1,261,184**
	Masonry	6.07	22.81	1,261,184
05	**Metals**	**12.34**	**46.41**	**2,566,024**
	Metals	12.34	46.41	2,566,024
06	**Wood & Plastics**	**6.71**	**25.22**	**1,394,578**
	Wood & Plastics	6.71	25.22	1,394,578
07	**Thermal & Moisture Protection**	**7.40**	**27.81**	**1,537,674**
	EIFS	1.11	4.17	230,409
	Joint Sealers	0.16	0.59	32,742
	Manufactured Roofing & Siding	1.16	4.36	241,323
	Membrane Roofing	4.72	17.76	982,268
	Waterproofing	0.24	0.92	50,932
08	**Doors & Windows**	**2.16**	**8.11**	**448,690**
	Doors & Windows	2.16	8.11	448,690
09	**Finishes**	**11.43**	**42.99**	**2,376,847**
	Acoustical Treatment	0.59	2.24	123,693
	Carpet	1.77	6.67	368,654
	Gypsum Board	6.42	24.12	1,333,944
	Metal Support Systems	0.00	0.00	0
	Painting	2.01	7.54	417,161
	Special Ceiling Surfaces	0.00	0.00	0
	Tile	0.64	2.41	133,394
	Wall Covering	0.00	0.00	0
10	**Specialties**	**0.46**	**1.72**	**95,316**
	Fire Protection	0.05	0.20	10,914

D4Cost American Music Theatre Adjusted

	Identifying Devices	0.10	0.39	21,828
	Telephone	0.02	0.08	4,366
	Toilet & Bath Accessories	0.28	1.05	58,208
11	**Equipment**	**17.51**	**65.85**	**3,641,176**
	Theatre & Stage	17.51	65.85	3,641,176
14	**Conveying Systems**	**0.95**	**3.57**	**197,666**
	Elevators	0.82	3.07	169,775
	Lifts	0.13	0.50	27,892
15	**Mechanical**	**13.00**	**48.86**	**2,701,844**
	Fire Protection	0.98	3.68	203,730
	HVAC	9.27	34.87	1,928,156
	Plumbing	2.74	10.31	569,958
16	**Electrical**	**10.97**	**41.23**	**2,279,832**
	Electrical	10.97	41.23	2,279,832
Total Building Costs		**100.00**	**375.98**	**20,789,396**
02	**Site Work**	**100.00**	**35.46**	**4,123,101**
	Site Work	100.00	35.46	4,123,101
Total Non-Building Costs		**100.00**	**35.46**	**4,123,101**
Total Project Costs		**--**	**--**	**24,912,497**

Appendix F: RS Means Cost Works Data

RSMeans Office Building

Square Foot Cost Estimate Report

Estimate Name:	Untitled

Building Type:	**Office, 5-10 Story with Face Brick with Concrete Block Back-up / R/Conc. Frame**
Location:	NEW YORK, NY
Stories Count (L.F.):	**8.00**
Stories Height	**12.00**
Floor Area (S.F.):	**80,000.00**
LaborType	**Union**
Basement Included:	No
Data Release:	**Year 2010 Quarter 3**
Cost Per Square Foot	**$221.43**
Total Building Cost	**$17,714,000**

Costs are derived from a building model with basic components. Scope differences and market conditions can cause costs to vary significantly.

		% of Total	Cost Per SF	Cost
A Substructure		**2.6%**	**4.28**	**$342,000**
A1010	**Standard Foundations**		**2.58**	**$206,000**
	Strip footing, concrete, reinforced, load 11.1 KLF, soil bearing capacity 6 KSF, 12" deep x 24" wide			
	Spread footings, 3000 PSI concrete, load 800K, soil bearing capacity 6 KSF, 12' - 0" square x 37" deep			
A1030	**Slab on Grade**		**0.87**	**$69,500**
	Slab on grade, 4" thick, non industrial, reinforced			
A2010	**Basement Excavation**		**0.07**	**$5,500**
	Excavate and fill, 10,000 SF, 4' deep, sand gravel, or common earth, on site storage			
A2020	**Basement Walls**		**0.76**	**$61,000**
	Foundation wall, CIP, 4' wall height, direct chute, .148 CY/LF, 7.2 PLF, 12" thick			
B Shell		**31.6%**	**52.28**	**$4,182,500**
B1010	**Floor Construction**		**24.74**	**$1,979,000**
	Cast-in-place concrete column, 20" square, tied, 800K load, 12' story height, 394 lbs/LF, 6000PSI			
	Cast-in-place concrete column, 20" square, tied, 900K load, 12' story height, 394 lbs/LF, 6000PSI			
	Cast-in-place concrete column, 20", square, tied, minimum reinforcing, 500K load, 10'-14' story height, 375 lbs/LF, 4(			
	Flat plate, concrete, 9" slab, 20" column, 20'x25' bay, 75 PSF superimposed load, 188 PSF total load			
B1020	**Roof Construction**		**2.51**	**$200,500**
	Floor, concrete, beam and slab, 20'x25' bay, 40 PSF superimposed load, 18" deep beam, 8.5" slab, 146 PSF total lo			
B2010	**Exterior Walls**		**18.99**	**$1,519,500**
	Brick wall, composite double wythe, standard face/CMU back-up, 8" thick, perlite core fill			
B2020	**Exterior Windows**		**4.76**	**$380,500**
	Windows, aluminum, sliding, insulated glass, 5' x 3'			
B2030	**Exterior Doors**		**0.32**	**$25,500**
	Door, aluminum & glass, with transom, narrow stile, double door, hardware, 6'-0" x 10'-0" opening			
	Door, steel 18 gauge, hollow metal, 1 door with frame, no label, 3'-0" x 7'-0" opening			
B3010	**Roof Coverings**		**0.97**	**$77,500**
	Roofing, asphalt flood coat, gravel, base sheet, 3 plies 15# asphalt felt, mopped			
	Insulation, rigid, roof deck, composite with 2" EPS, 1" perlite			

RSMeans Office Building

		% of Total	Cost Per SF	Cost
	Roof edges, aluminum, duranodic, .050" thick, 6" face			
	Flashing, aluminum, no backing sides, .019"			
C Interiors		**19.5%**	**32.28**	**$2,582,500**
C1010	**Partitions**		**4.97**	**$397,500**
	Metal partition, 5/8" water resistant gypsum board face, no base layer, 3-5/8" @ 24" OC framing ,same opposite face			
	1/2" fire ratedgypsum board, taped & finished, painted on metal furring			
C1020	**Interior Doors**		**2.98**	**$238,000**
	Door, single leaf, kd steel frame, hollow metal, commercial quality, flush, 3'-0" x 7'-0" x 1-3/8"			
C1030	**Fittings**		**0.89**	**$71,000**
	Toilet partitions, cubicles, ceiling hung, plastic laminate			
C2010	**Stair Construction**		**3.02**	**$242,000**
	Stairs, steel, cement filled metal pan & picket rail, 16 risers, with landing			
C3010	**Wall Finishes**		**1.39**	**$111,000**
	Painting, interior on plaster and drywall, walls & ceilings, roller work, primer & 2 coats			
	Vinyl wall covering, fabric back, medium weight			
C3020	**Floor Finishes**		**9.04**	**$723,000**
	Carpet, tufted, nylon, roll goods, 12' wide, 36 oz			
	Carpet, padding, add to above, minimum			
	Vinyl, composition tile, maximum			
	Tile, ceramic natural clay			
C3030	**Ceiling Finishes**		**10.00**	**$800,000**
	Acoustic ceilings, 3/4"mineral fiber, 12" x 12" tile, concealed 2" bar & channel grid, suspended support			
D Services		**46.3%**	**76.71**	**$6,137,000**
D1010	**Elevators and Lifts**		**17.08**	**$1,366,000**
	Traction, geared passenger, 3500 lb, 8 floors, 12' story height, 2 car group, 200 FPM			
D2010	**Plumbing Fixtures**		**2.88**	**$230,000**
	Water closet, vitreous china, bowl only with flush valve, wall hung			
	Urinal, vitreous china, wall hung			
	Lavatory w/trim, vanity top, PE on CI, 20" x 18"			
	Service sink w/trim, PE on CI,wall hung w/rim guard, 24" x 20"			
	Water cooler, electric, wall hung, 8.2 GPH			
	Water cooler, electric, wall hung, wheelchair type, 7.5 GPH			
D2020	**Domestic Water Distribution**		**0.56**	**$45,000**
	Gas fired water heater, commercial, 100< F rise, 200 MBH input, 192 GPH			
D2040	**Rain Water Drainage**		**0.34**	**$27,500**
	Roof drain, CI, soil,single hub, 5" diam, 10' high			
	Roof drain, CI, soil,single hub, 5" diam, for each additional foot add			
D3050	**Terminal & Package Units**		**21.19**	**$1,695,500**
	Rooftop, multizone, air conditioner, offices, 25,000 SF, 79.16 ton			
D4010	**Sprinklers**		**3.93**	**$314,500**
	Wet pipe sprinkler systems, steel, light hazard, 1 floor, 10,000 SF			
	Wet pipe sprinkler systems, steel, light hazard, each additional floor, 10,000 SF			
	Standard High Rise Accessory Package 8 story			
D4020	**Standpipes**		**1.14**	**$91,500**
	Wet standpipe risers, class III, steel, black, sch 40, 4" diam pipe, 1 floor			
	Wet standpipe risers, class III, steel, black, sch 40, 4" diam pipe, additional floors			
	Fire pump, electric, with controller, 5" pump, 100 HP, 1000 GPM			
	Fire pump, electric, for jockey pump system, add			
D5010	**Electrical Service/Distribution**		**2.46**	**$197,000**
	Service installation, includes breakers, metering, 20' conduit & wire, 3 phase, 4 wire, 120/208 V, 1600 A			

2

RSMeans Office Building

		% of Total	Cost Per SF	Cost
	Feeder installation 600 V, including RGS conduit and XHHW wire, 60 A			
	Feeder installation 600 V, including RGS conduit and XHHW wire, 200 A			
	Feeder installation 600 V, including RGS conduit and XHHW wire, 1600 A			
	Switchgear installation, incl switchboard, panels & circuit breaker, 1600 A			
D5020	**Lighting and Branch Wiring**		**17.71**	**$1,417,000**
	Receptacles incl plate, box, conduit, wire, 16.5 per 1000 SF, 2.0 W per SF, with transformer			
	Miscellaneous power, 1.2 watts			
	Central air conditioning power, 4 watts			
	Motor installation, three phase, 460 V, 15 HP motor size			
	Motor feeder systems, three phase, feed to 200 V 5 HP, 230 V 7.5 HP, 460 V 15 HP, 575 V 20 HP			
	Motor connections, three phase, 200/230/460/575 V, up to 5 HP			
	Motor connections, three phase, 200/230/460/575 V, up to 100 HP			
	Fluorescent fixtures recess mounted in ceiling, 1.6 watt per SF, 40 FC, 10 fixtures @32watt per 1000 SF			
D5030	**Communications and Security**		**8.12**	**$650,000**
	Telephone wiring for offices & laboratories, 8 jacks/MSF			
	Communication and alarm systems, fire detection, addressable, 100 detectors, includes outlets, boxes, conduit and			
	Fire alarm command center, addressable with voice, excl. wire & conduit			
	Internet wiring, 8 data/voice outlets per 1000 S.F.			
D5090	**Other Electrical Systems**		**1.29**	**$103,000**
	Generator sets, w/battery, charger, muffler and transfer switch, diesel engine with fuel tank, 100 kW			
	Uninterruptible power supply with standard battery pack, 15 kVA/12.75 kW			
E Equipment & Furnishings		**0.0%**	**0.00**	**$0**
E1090	**Other Equipment**		**0.00**	**$0**
F Special Construction		**0.0%**	**0.00**	**$0**
G Building Sitework		**0.0%**	**0.00**	**$0**
Sub Total		**100%**	**$165.55**	**$13,244,000**
Contractor's Overhead & Profit		**25.0%**	**$41.39**	**$3,311,000**
Architectural Fees		**7.0%**	**$14.49**	**$1,159,000**
User Fees		**0.0%**	**$0.00**	**$0**
Total Building Cost			**$221.43**	**$17,714,000**

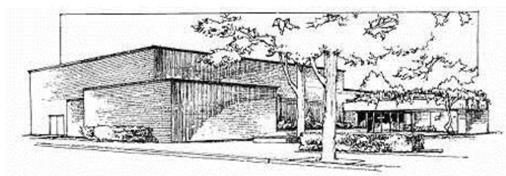
3

RSMeans Auditorium

Square Foot Cost Estimate Report

Estimate Name: **Untitled**

Building Type:	**Auditorium with Face Brick with Concrete Block Back-up / Bearing Wall**
Location:	NEW YORK, NY
Stories Count (L.F.):	**2.00**
Stories Height	**16.00**
Floor Area (S.F.):	**3,944.00**
LaborType	**Union**
Basement Included:	No
Data Release:	**Year 2010 Quarter 3**
Cost Per Square Foot	**$457.28**
Total Building Cost	**$1,803,500**



Costs are derived from a building model with basic components. Scope differences and market conditions can cause costs to vary significantly.
Parameters are not within the ranges recommended byRSMeans.

		% of Total	Cost Per SF	Cost
A Substructure		7.3%	24.85	$98,000
A1010	**Standard Foundations**		6.85	$27,000
	Strip footing, concrete, reinforced, load 6.8 KLF, soil bearing capacity 3 KSF, 12" deep x 32" wide			
	spread footings, 3000 PSI concrete, load 50K, soil bearing capacity 6 KSF, 3' - 0" square x 12" deep			
	Spread footings, 3000 PSI concrete, load 100K, soil bearing capacity 6 KSF, 4' - 6" square x 15" deep			
A1030	**Slab on Grade**		4.06	$16,000
	Slab on grade, 6" thick, non industrial, reinforced			
A2010	**Basement Excavation**		0.13	$500
	Excavate and fill, 30,000 SF, 4' deep, sand, gravel, or common earth, on site storage			
A2020	**Basement Walls**		13.82	$54,500
	Foundation wall, CIP, 4' wall height, direct chute, .197 CY/LF, 9.44 PLF, 16" thick			
B Shell		56.3%	192.44	$759,000
B1010	**Floor Construction**		2.79	$11,000
	Steel column, W8, 100 KIPS, 20' unsupported height, 40 PLF			
	Floor, concrete, slab form, open web bar joist @ 2' OC, on bearing wall, 30' span, 24.5" deep, 125 PSF superimpose			
B1020	**Roof Construction**		4.82	$19,000
	Roof, steel joists, 1.5" 22 ga metal deck, on bearing walls, 30' bay, 23.5" deep, 40 PSF superimposed load, 60 PSF t			
	Roof, steel joists, 1.5" 22 ga metal deck, on bearing walls, 100' bay, 57.5" deep, 40 PSF superimposed load, 65 PSF			
	Roof joist, light gauge, 12 ga			
	Roof joist, light gauge, 14 ga			
B2010	**Exterior Walls**		134.51	$530,500
	Brick wall, composite double wythe, standard face/CMU back-up, 8" thick, perlite core fill			
B2020	**Exterior Windows**		38.79	$153,000
	Aluminum flush tube frame, for insulating glass, 2" x 4-1/2", 5'x20' opening,3 intermediate horizontals			
	Glazing panel, plate glass, 1/4" thick, tempered			
B2030	**Exterior Doors**		2.41	$9,500
	Door, aluminum & glass, without transom, narrow stile, double door, hardware, 6'-0" x 7'-0" opening			
	Door, steel 18 gauge, hollow metal, 2 doors with frame, no label, 6'-0" x 7'-0" opening			

1

RSMeans Auditorium

		% of Total	Cost Per SF	Cost
B3010	**Roof Coverings**		8.87	$35,000
	Roofing, asphalt flood coat, gravel, base sheet, 3 plies 15# asphalt felt, mopped			
	Insulation, rigid, roof deck, composite with 2" EPS, 1" perlite			
	Roof edges, aluminum, duranodic, .050" thick, 6" face			
	Flashing, aluminum, no backing sides, .019"			
	Gravel stop, aluminum, extruded, 4", mill finish, .050" thick			
B3020	**Roof Openings**		0.25	$1,000
	Roof hatch, with curb, 1" fiberglass insulation, 2'-6" x 3'-0", aluminum			
C Interiors		13.6%	46.40	$183,000
C1010	**Partitions**		5.58	$22,000
	Concrere block (CMU) partition, light weight, hollow, 6" thick, no finish			
C1020	**Interior Doors**		2.92	$11,500
	Door, single leaf, kd steel frame, hollow metal, commercial quality, flush, 3'-0" x 7'-0" x 1-3/8"			
C2010	**Stair Construction**		2.16	$8,500
	Stairs, steel, cement filled metal pan & picket rail, 20 risers, with landing			
C3010	**Wall Finishes**		18.64	$73,500
	2 coats paint on masonry with block filler			
	Painting, masonry or concrete, latex, brushwork, primer & 2 coats			
	Painting, masonry or concrete, latex, brushwork, addition for block filler			
	Wall coatings, epoxy coatings, maximum			
C3020	**Floor Finishes**		11.41	$45,000
	Carpet, tufted, nylon, roll goods, 12' wide, 36 oz			
	Carpet, padding, add to above, maximum			
	Vinyl tile, maximum			
	Add for sleepers on concrete, treated, 24" OC, 1"x2"			
	Underlayment, plywood, 5/8" thick			
C3030	**Ceiling Finishes**		5.70	$22,500
	Acoustic ceilings, 3/4" fiberglass board, 24" x 48" tile, tee grid, suspended support			
D Services		20.4%	69.85	$275,500
D1010	**Elevators and Lifts**		4.06	$16,000
	Hydraulic passenger elevator, 4500 lb., 2 floor, 125 FPM			
D2010	**Plumbing Fixtures**		6.09	$24,000
	Water closet, vitreous china, bowl only with flush valve, wall hung			
	Urinal, vitreous china, stall type			
	Lavatory w/trim, wall hung, PE on CI, 18" x 15"			
	Service sink w/trim, PE on CI, corner floor, 28" x 28", w/rim guard			
	Shower, stall, fiberglass 1 piece, three walls, 36" square			
	Water cooler, electric, wall hung, wheelchair type, 7.5 GPH			
D2020	**Domestic Water Distribution**		2.79	$11,000
	Gas fired water heater, commercial, 100< F rise, 75.5 MBH input, 63 GPH			
D2040	**Rain Water Drainage**		8.37	$33,000
	Roof drain, DWV PVC, 4" diam, diam, 10' high			
	Roof drain, DWV PVC, 4" diam, for each additional foot add			
D3050	**Terminal & Package Units**		16.73	$66,000
	Rooftop, single zone, air conditioner, restaurants, 10,000 SF, 50.00 ton			
D4010	**Sprinklers**		4.44	$17,500
	Wet pipe sprinkler systems, steel, light hazard, 1 floor, 10,000 SF			
D5010	**Electrical Service/Distribution**		3.04	$12,000
	Service installation, includes breakers, metering, 20' conduit & wire, 3 phase, 4 wire, 120/208 V, 800 A			
	Feeder installation 600 V, including RGS conduit and XHHW wire, 800 A			

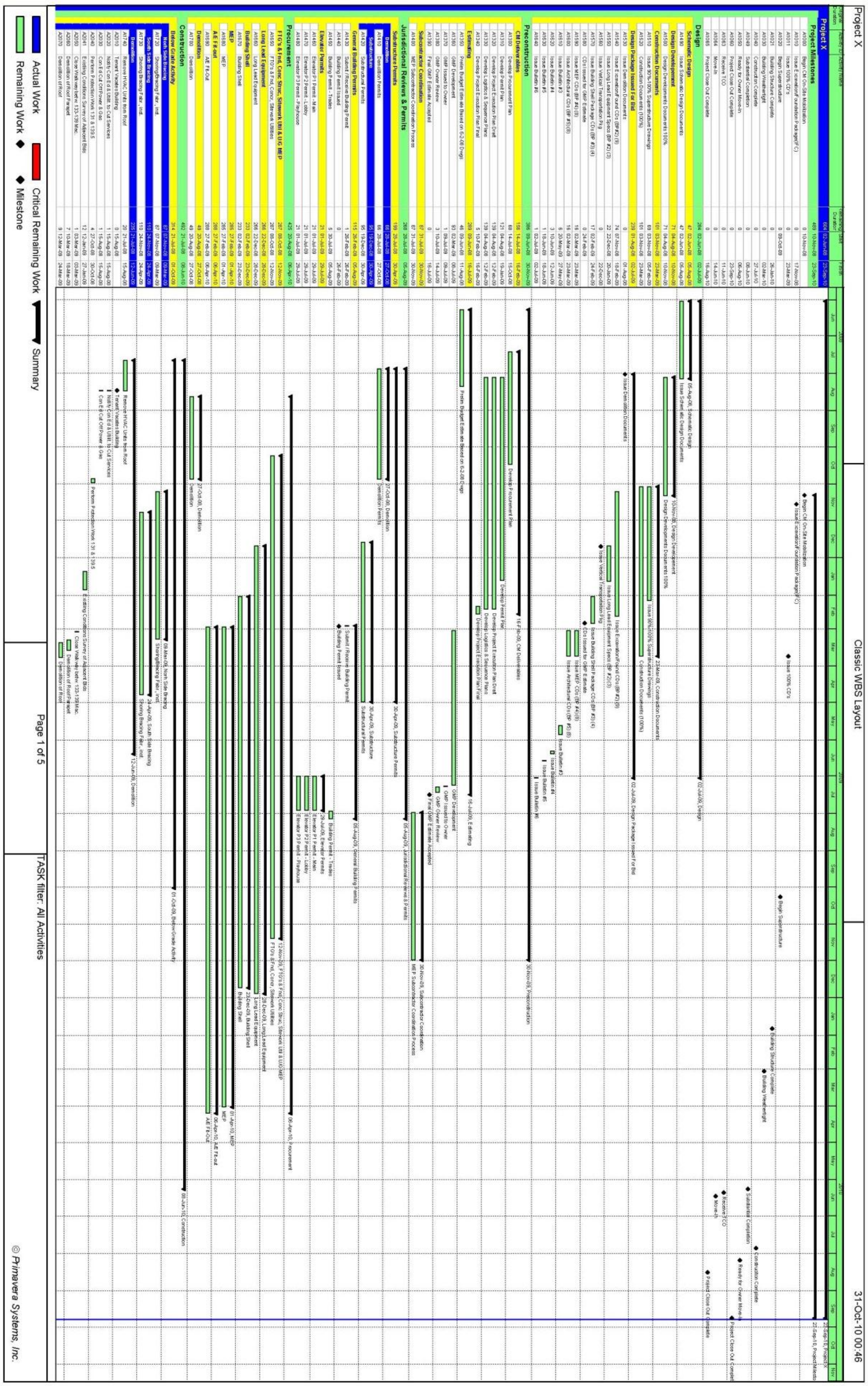
2

RSMeans Auditorium

		% of Total	Cost Per SF	Cost
	Switchgear installation, incl switchboard, panels & circuit breaker, 800 A			
D5020	**Lighting and Branch Wiring**		17.88	$70,500
	Receptacles incl plate, box, conduit, wire, 8 per 1000 SF, .9 watts per SF			
	Wall switches, 2.0 per 1000 SF			
	Miscellaneous power, 1 watt			
	Central air conditioning power, 3 watts			
	Motor installation, three phase, 200 V, 15 HP motor size			
	Motor feeder systems, three phase, feed to 200 V 15 HP, 230 V 15 HP, 460 V 40 HP, 575 V 50 HP			
	Fluorescent fixtures recess mounted in ceiling, 3 watt per SF, 60 FC, 15 fixtures @40 watt per 1000 SF			
D5030	**Communications and Security**		4.94	$19,500
	Communication and alarm systems, includes outlets, boxes, conduit and wire, sound systems, 30 outlets			
	Communication and alarm systems, fire detection, non-addressable, 25 detectors, includes outlets, boxes, conduit a			
D5090	**Other Electrical Systems**		1.52	$6,000
	Generator sets, w/battery, charger, muffler and transfer switch, gas/gasoline operated, 3 phase, 4 wire, 277/480 V, 1			
E Equipment & Furnishings		2.5%	8.37	$33,000
E1090	**Other Equipment**		8.37	$33,000
	102 - Auditorium chair, fully upholstered, spring seat			
F Special Construction		0.0%	0.00	$0
G Building Sitework		0.0%	0.00	$0
Sub Total		100%	$341.91	$1,348,500
Contractor's Overhead & Profit		25.0%	$85.45	$337,000
Architectural Fees		7.0%	$29.92	$118,000
User Fees		0.0%	$0.00	$0
Total Building Cost			**$457.28**	**$1,803,500**

3

Appendix G: Detailed Project Schedule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Page 1 of 5
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Remaining Work
Critical Remaining Work
Milestone
Summary
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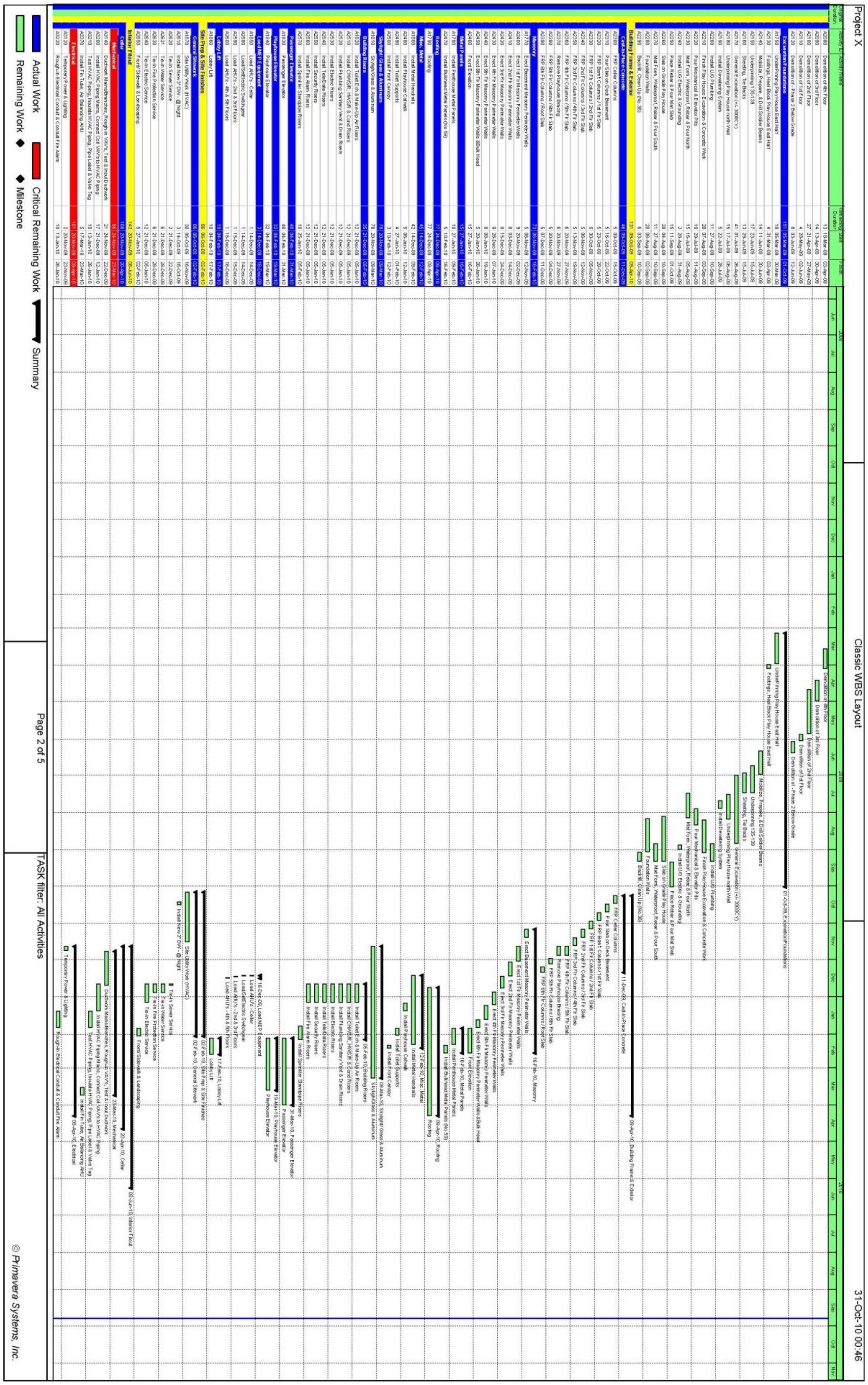

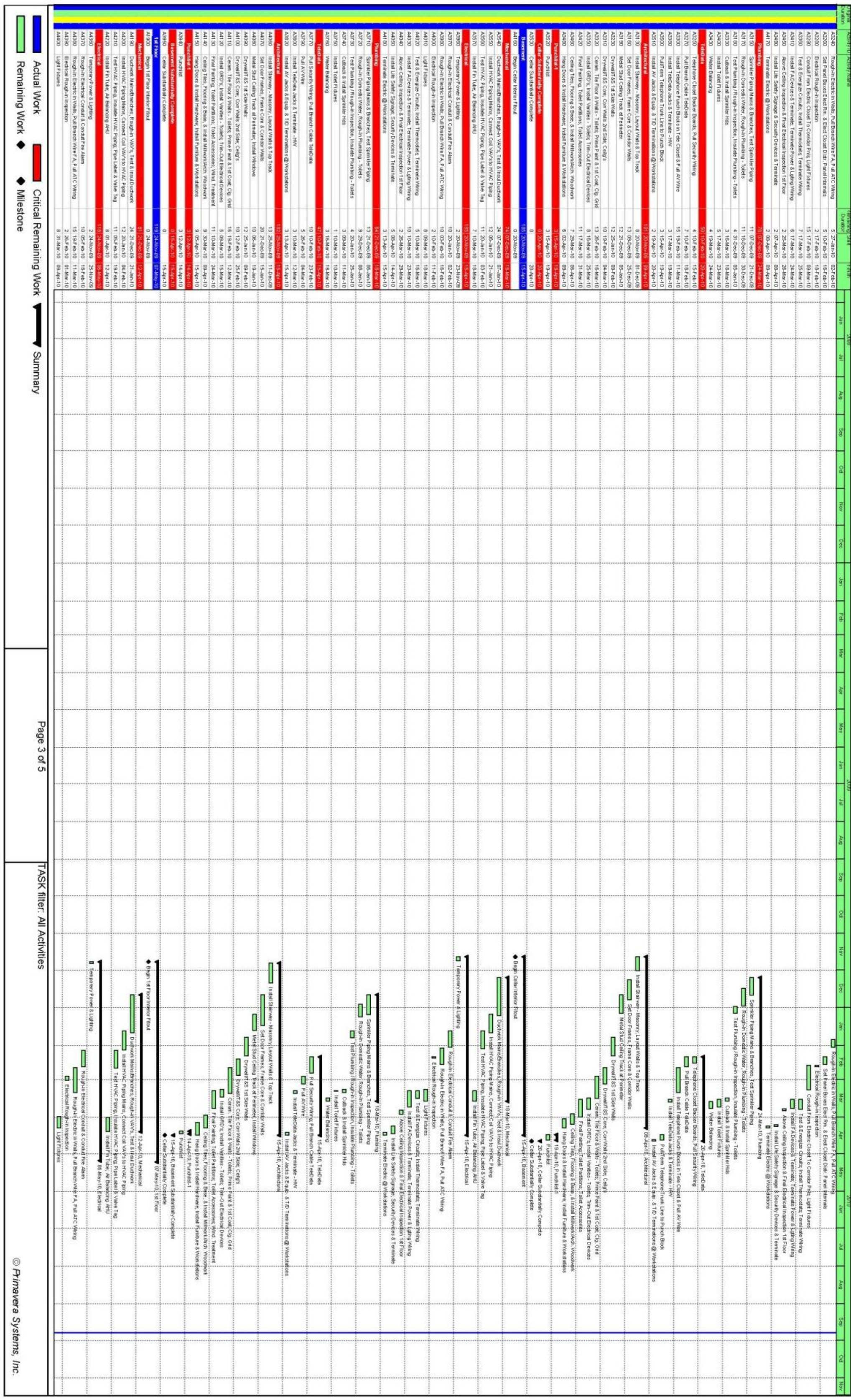
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Actual Work
Remaining Work
Critical Remaining Work
Milestone
Summary
Page 3 of 5
TASK filter: All Activities
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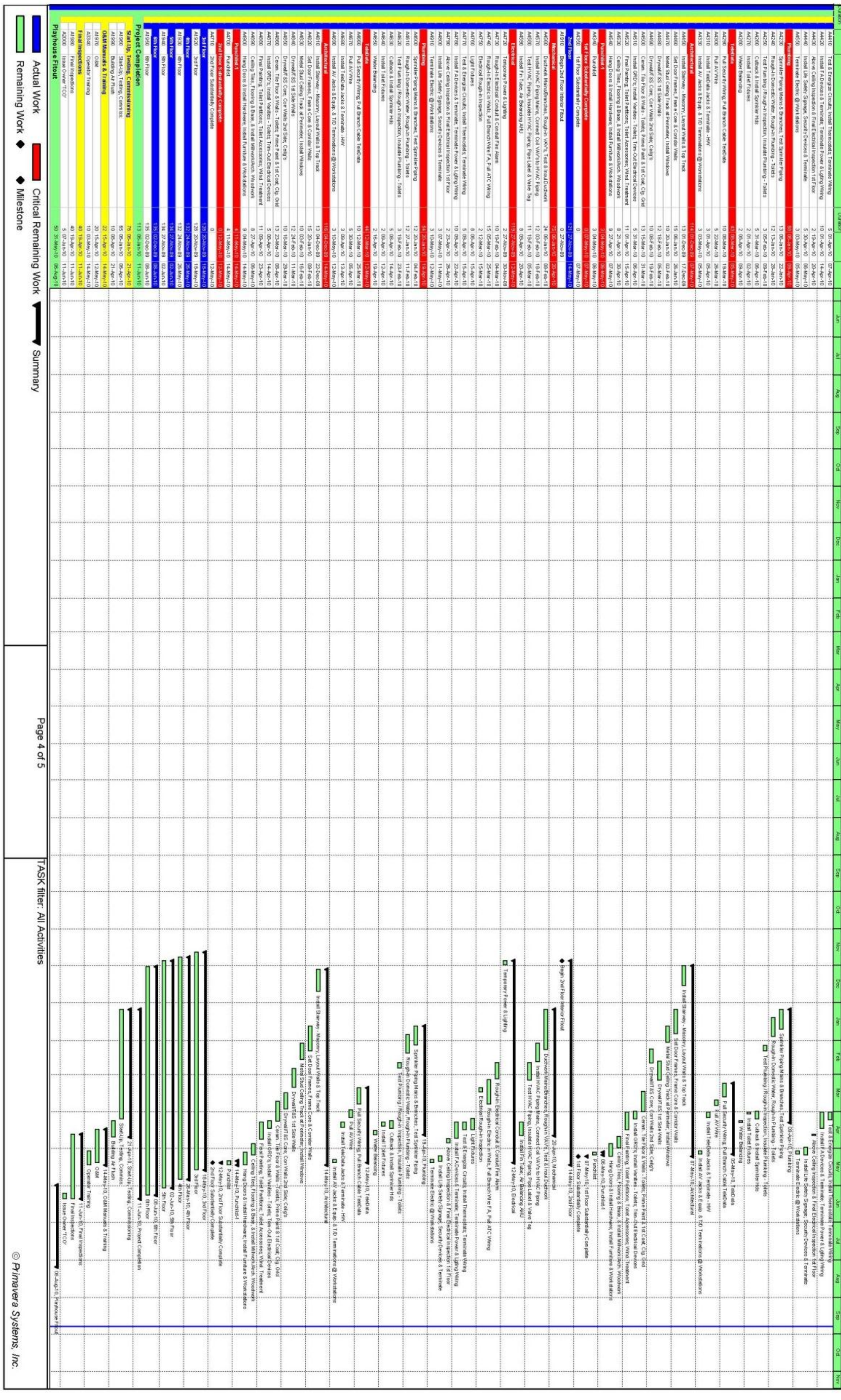
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Remaining Work
Critical Remaining Work
Milestone
Summary
Page 4 of 5
TASK filter: All Activities
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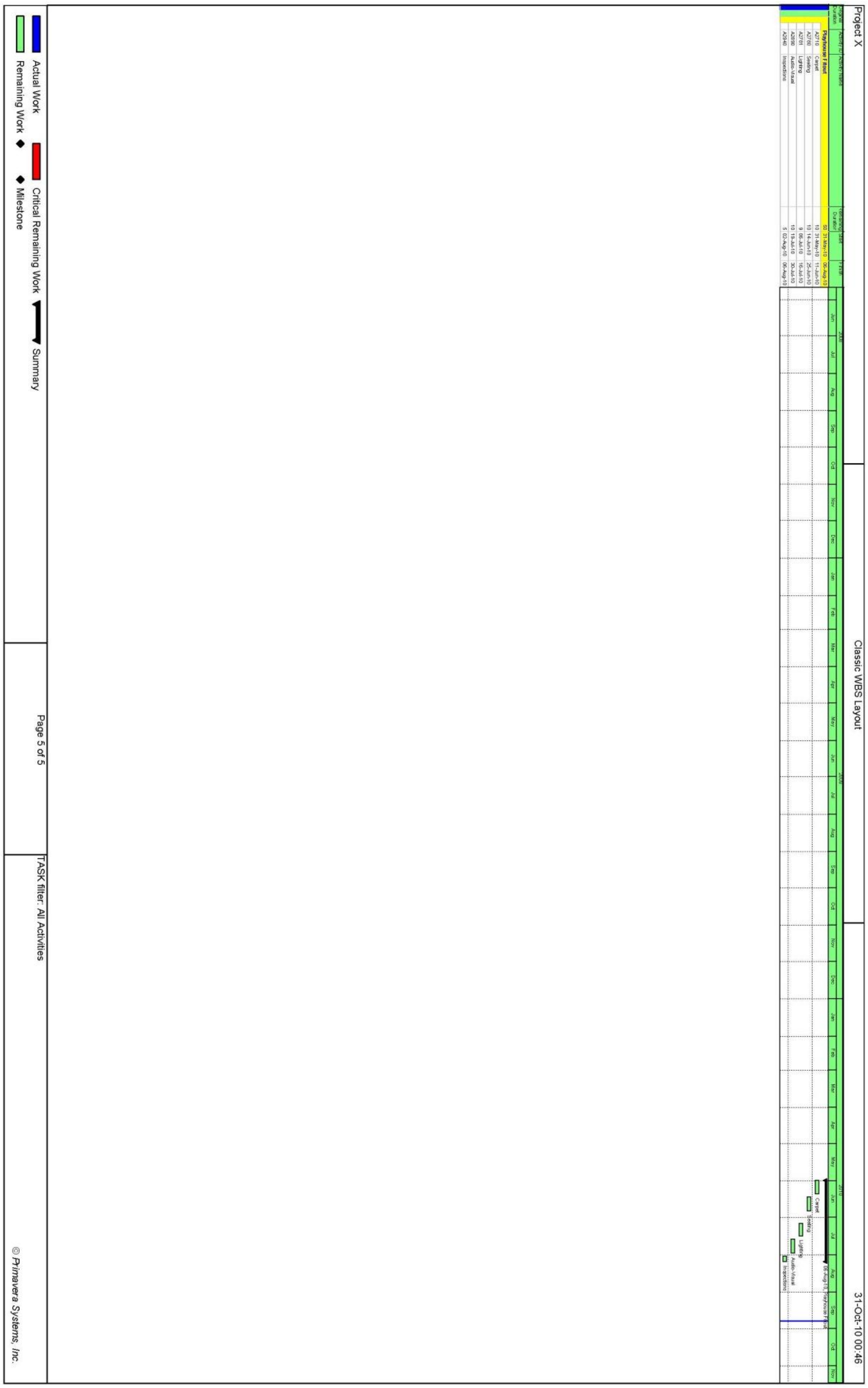
Project X
Classic WBS Layout
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Carpet
Seating
Lighting
Audio-Visual
Inspections
Actual Work
Remaining Work
Critical Remaining Work
Milestone
Summary
Page 5 of 5
TASK filter: All Activities
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III. Analysis 1: Alternative Structural Bracing for the Playhouse

Background

One of the constructability challenges was preserving the existing playhouse's walls. The demolition of the existing 33,000SF building, located in New York City, consists of four separate townhouses that were merged together during the 1940's. Although only the theatre's 1869 square feet, which are located on the basement and ground floor level, will be preserved. The exterior masonry walls are 17 feet above grade and 10 feet of foundation walls below grade. The existing building is compiled of brick and mortar, which has been primarily demolished by excavators. The playhouse was demolished by hand. The building has a historical and cultural significance. The Provincetown players, an amateur group of writers and artist, performed in the theatre during the early part of the 20th century. Eugene O'Neill and Susan Glaspell, helped to expand the little theatre movement in America, and set a new course for American theatre in the Modern period. The playhouse houses a 4,400SF playhouse on the ground and basement levels that is scheduled to remain. As part of the project, the interior walls of the theatre will be demolished and rebuilt. The playhouse portion of the building is located at the southern end of the site's 8,430 SF footprint. Four exterior walls of the original theatre that is located on the basement and ground floor level will remain.

The project team has done the following to preserve the historical significance of the theatre: The owner has preserved the exact volume and footprint of the playhouse theatre. The owner has preserved and restored the 1940's playhouse façade. The owner has integrated relevant historical features and pieces of the existing theatre. The original storefront height of the previous building was six stories above grade. In order to keep the original height of the building the owner built the same amount of stories in the front façade. The owner has built a smaller building than allowed by zoning. Thenew construction is low-scale, contextual, brick building for law faculty and student research.

As part of the project the existing theatre walls had to remain in place. The foundation walls had to be underpinned. Four stories of existing building had to be removed and the theatre walls had to be temporary braced. The new footings were installed while temporary bracing was in place. The new cast-in-place concrete superstructure had to be framed and poured around bracing.

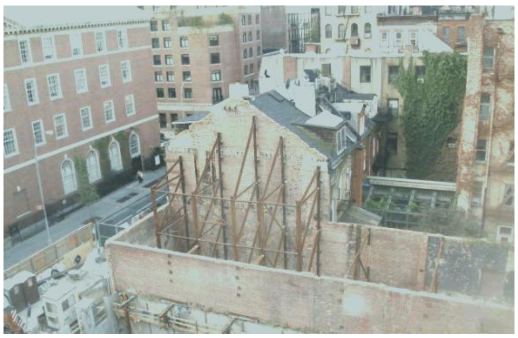


Figure 24: Shows Temporary Structural Steel Bracing

Figure 25: Shows an Up-close View of the Structural Steel Bracing

Opportunity for Improvement

The new structure's lateral resisting system will be a concrete moment frame with butrices running along the masonry wall. A temporary steel frame was used to preserve the existing theatre walls and the adjacent building. This made construction activity very difficult due to the structural bracing. The steel bracing was anchored to the adjacent building's masonry wall. Double angle steel wielded together was used for vertical members and round hollow structural sections (HSS) steel tubing was used for the lateral members as shown in Figures 26 and 27. One lane of traffic was closed during construction to allow for a crawler crane to be used.

Potential Solution

A potential solution is a structural system for the theatre that would serve as a permanent structural system in conjunction with the demolition phase. The bracing's cost and schedule will be compared with the existing system. Restructuring the building will involve replacing the internal load bearing structural elements while leaving the façade. The goal is to devise a permanent feature that stabilizes lateral rigidity to sustain the live and dead loads of the new structure. The positioning of the bracing needs to be carefully considered to avoid obstructions to the four stories of demolition work. The new footings, which is cast-in-place matt slab, are to be installed while temporary bracing is in place.

Research/Analysis Steps (B1=Breadth 1, CM = Construction Management Analysis)

1) Identify the purpose of the temporary bracing used for construction. Is it for ensuring safety, repair, strengthening, or restructuring? – CM – B1
2) Find three feasible alternatives to the method chosen for the theatre. CM –B1

  a) The first alternative is executing the office building demolition and construction, then doing the theatre after the cast-in-place superstructure and buttresses to stabilize the wall between the theatre and the office building.

  b) The second alternative I will study is diving H-piles next to the historical walls, then attaching the masonry to the façade with anchors going through the mortar in the masonry on the outside of the wall.

  c) The third alternative is bracing the facade along the perimeter using a flying box shoring that extends across the sides of the building on the east side to provide in-plane stability to the walls during reconstruction. The box girder flying shoring requires a central support prop or tower. This support needs to have a temporary foundation to take the loads which it will carry.

d) The fourth method is strapping the façade with structural steel to prevent spread from wind forces by using horizontal or inclined steel sections fixed as straps around the perimeter of the building.

e) The fifth alternative I will study involves bracing the structure on theeast and west sides on the exterior of the building. The south masonry walls could be attached to the adjacent structure.

f) The sixth method strengthening the existing masonry is to improve the structural performance to enable the building to fulfill its new functional requirements.

3) Discuss the design criteria for the structural system with the structural engineer and the construction manager. CM –B1

4) Decide on one alternative method based on conceptual constructability, cost, and schedule. CM – B1

5) Create a Revit model of the existing concrete structure. – CM – B1

6) Model the temporary steel structure in order to develop a cost of the original temporary steel. – CM –B2

7) Calculate the construction live, wind and seismic loads on the existing masonry wall.-B1

8) Perform hand calculation for preliminary design of the temporary steel structure.-B1

9) Model the chosen option in Revit and perform a structural analysis to verify hand calculations.-B1

10) Evaluate how the altered temporary will affect site logistics, MEP, and the new concrete flat plate system. Also special attention will need to be paid to the steel angles attached to the historical masonry wall for the new concrete floor attachment to the masonry. -CM

11) Update schedule with alternate structural bracing. Determine if there was a significant schedule reduction.-CM

12) Perform a quantity takeoff and estimate of the proposed structural system.-CM

13) Compare the two structural systems (the original and the alternative) based on cost, schedule, and obstruction of other trades productivity. CM

a) Labor costs from local union

b) Initial costs from steel manufacture

Tools & Resources

- Revit Structures
- Bently RAM Elements (this will be used as an alternate if Revit Structures can’t be used for analysis)
- RS Means Cost Data

Resources

AISC Steel Manual

Expected Outcomes

The alternative structural lateral bracing will result in a less congested site. The alternative bracing will potentially serve to reduce the amount of temporary shoring for the cast-in-place floor slabs above the theatre. This will provide the site with a safer and more productive working environment.

Course Reference

AE 308: Introduction to Structural Analysis
AE 401: Design of Steel and Wood Structures for Buildings
AE 430: Indeterminate Structures
AE 475: Building Construction Engineering
AE 472: Building Construction Planning and Management

Interoperability

Today, one of the challenges of BIM is the exchange of information between the different software programs. The two most popular software companies are Autodesk and Bentley. Autodesk makes Revit, which is mostly used by architects. Bentley makes RAM Elements, which is used by structural engineers. A general understanding of the interoperability requirements of the software is needed before starting the design process.

Autodesk Structural Engineering Partner Program is intended to establish a frame work for participating software analysis partners collaborate with Autodesk in delivering solution for the field of Structural Engineering. The application and exchange of data between Revit and the structural program is the primary goal of this partnership. The round-trip integration is Autodesk's description of this information exchange workflow. All data that is available in Autodesk Revit Structure and supported by the structural application must be interchangeable. This minimizes the amount of data that needs to be manually created in the structural application. Additionally, the integration should be done in such a way so data added in the application is not lost when the Revit Model is updated. The external software must be devised to ensure that model data, created or changed in the structural design application or in Autodesk Revit Structure can be reflected in each other. The user must have the option of creating the original model data in either program and passing it into the other. For instance, the model can be started in RAM program and sent into Autodesk Revit Structure (through the application) or vice versa. Another requirement is that the minimum Data imported and exported. (Autodesk)

In all cases changes and deletions of structural elements in one application must be updated in the other when the models are synchronized. Physical material properties including steel, concrete, and wood must be able to be transferred to both applications. Column, beam, joist, and brace section properties must be able to be interlink between applications. The material cross section properties that must be interlinked include W and C steel section, concrete rectangle, concrete round and square, and wood. Also slab, wall, and foundation properties must be interchangeable. Lastly, load cases and load combinations must be interchangeable. (Autodesk)

Revit Structures →RAM Elements→ RAM Masonry model

Initially the Project X structural model was created in Revit Structures. Next, the model was exported to the RAM Elements. The load cases, load combinations, material properties were defined. The steel members will be analyzed, designed, and optimized. Then, the structural model's steel connections can be detailed for fabrication;although for this structural analysis the connections will not be considered. Lastly the RAM Elements model will be exported into Revit Structures. This exchange of information is made possible through the use of the plug-in for Revit Structures, made by Bentley, to import and export files to RAM Elements. Bentley provides this link to allow the transfer of information from the architect to the engineer.

Bentley's Integrated Structural Modeling methodology maximizes the interoperability of structural information among different specialized applications. Learn more about these key products, supported by **Integrated Structural Modeling** from the following links:

- Structural Synchronizer V8i / English
- ISM Revit Plugin V8i / English
- Structural Dashboard V8i / English
- RAM Structural System - Revit Link / English
- IModel Plugin for Revit V8i / English
- RAM Elements V8*i*
- RAM Concept V8*i*
- Structural Modeler V8*i*

Process

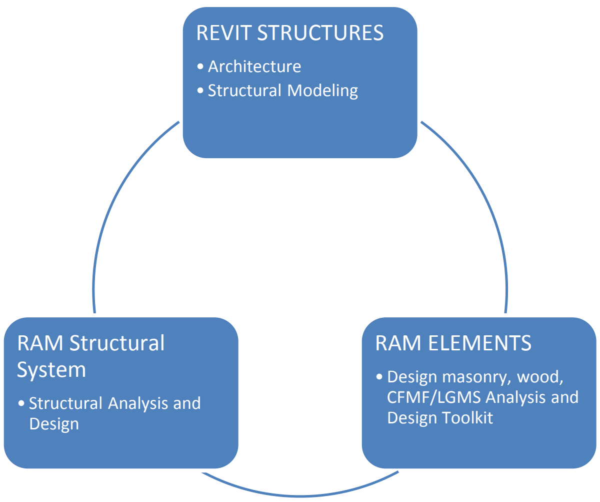


Figure 26: Shows the information work flow of the structural information.

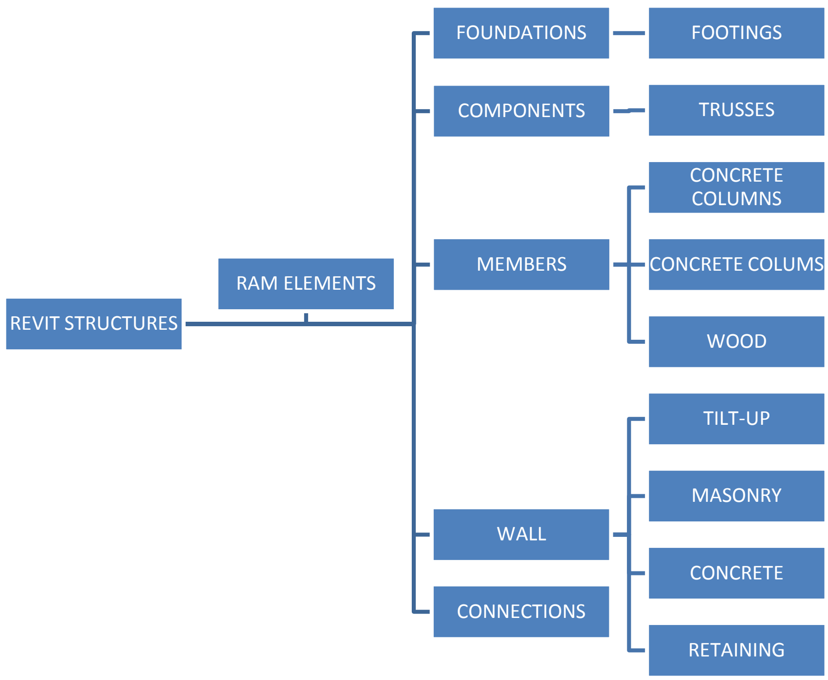


Figure26: Shows the Bentley Structural System overview

Structural Analysis

The new building will serve the community as a playhouse, office support space, as well as university office space. The temporary bracing for the theatre was redesigning, which is 89' x 21' x 27'. The bracing of the temporary bracing of the adjacent building will remain the same. The bracing of the theatre masonry walls will be redesigned.

The redesigned steel bracing will serve two purposes first it will reduce the flexural moment secondly; it will reduce the unbraced length of the masonry wall. The design criterion was to reduce the construction site congestion. Also, the temporary bracing cannot interfere with the new structural columns.When modeling a steel frame, the member restraints of the steel members are modeled as moment frames. Additional boundary restraints are required between the steel members and the masonry wall shell. These boundary restraints are assigned in RAM Elements by using FEM (Finite Element Model). At intermediate points the shell and steel members were divided to resemble the steel connection to the masonry wall.

One of the most important factors of the structural bracing is the sequence of the demolition. The demolition began from the roof and worked its way down the building, floor by floor toward the cellar. Demolition per floor started from the interior center and continued toward the exterior of the building. The demolition stopped at the concrete slab level where the holes were made in the slab above the theatre which is the first floor. Next the temporary steel bracing will be erected. The slab acting as the rigid diaphragm will be removed. Finally, the new foundation and substructure will be constructed.

Loads/Load Combinations

Since the temporary bracing is only functioning during before construction the self weight of the masonry walls and the wind forces were only considered. The wind forces were only analyzed, instead of considering seismic loads, for the redesign of the temporary bracing. The wind loads were calculated using Equation 1 per ASCE 7-05 Section 6.5.15, *Wind Loads on Other Structures*, because this was determined to be the worst case. The masonry walls above grade are only 17 feet in height, therefore q_z was constant equal to 15.519. The wind load calculations can be found in Appendix H.1.

$$F=q_z G C_f A_f (lb)(N)=0.0171ksf \qquad \text{Eq. 1}$$

Also, the self-weight of the masonry walls was considered for the design. The self weight of the unreinforced masonry wall with Type M mortar was calculated to be 1999.5plf. Next, the ASCE 7-05 Serviceability and LRFD load combinations were applied to the building's masonry walls.The controlling load combination was D_3=1.2DL+1.6W

Table 6: shows the Loads applied to the building before the building was constructed.

Load conditions

Cases:

Num	ID	Description	Category
1	DL	Dead Load	DL
2	SW	Self Weight	DL
3	W	Wind loads other structures	WIND

Table 7: shows the ASCE 7-05 Serviceability and LRFD

Combinations:

Formula: D1 = 1.4DL+1.4SW

Num	ID	DL	SW	W	Type
1	D1	1.4	1.4	0	Design
2	D2	1.2	1.2	0.8	Design
3	D3	1.2	1.2	1.6	Design
4	D4	0.9	0.9	1.6	Design
5	S1	1	1	0	Service
6	S2	1	1	1	Service
7	S3	0.6	0.6	1	Service

Shell properties RAM elements

Shells are fixed to the nodes and it is not possible to release end fixity as with other members. In the Ram elements model, the shells and walls share coincident nodes. The walls perpendicular to each other will act as rigidity elements to one another. This means that moments will transfer across the corner. This is of course possible and acceptable, because the wall is detailed with temporary steel in the corners. The rigid floor diaphragms of the floor stabilize the structure after the new slab is constructed. The shells are modeled at the centerline. The steel members end fixity to the masonry was determined to be rigid connected.

RAM Elements performs a finite element (FEM) analysis and forces are distributed through the structure based on the stiffness matrix. Therefore in order to run the structural analysis all section properties and all material properties must be defined. An analysis can be performed in the RAM Elements according to one of the following three methods: static linear-elastic analysis, static nonlinear- elastic analysis, or eigen value analysis. Static nonlinear is usually used with nonlinear members, such as tension or compression only members, or with a P-delta analysis.

Element Properties

The next step was to define the shell member properties and steel member properties. Then the steel member shapes. The type of brick used by the existing masonry wall to remain is 3-5/8” x 2-1/4”x 8” kiln burned i.e. red brick with 3/8” mortar joints stacked in a common bond configuration.

Properties of Brick Masonry					
Poison's Ratio	1.15				
Unit Weight	0.0729	Lb/in3			
Coeff. Of thermal expansion	0.45x10-5	1/F			
(Es) modulus of elasticity	1050000	psi	700*1500	assume F'm=1500	
(Es) Steel Elasticity Modulus	29000000	psi			
(f'm) Ultimate compressive Stress	1500	psi			
(Fs) Allowable steel stress	24000	psi			
(Fy) Longitudinal reinforcement yield stress	60000	psi			

Table 8: Masonry Wall Properties

Profile	Length	N° of pieces
	[ft]	
L 3X3X3_16	6.37	7
L 4X4X3_8	14.64	9
L 4X4X3_8	4.24	9
L 4X4X3_8	8.5	9
L 5X5X5_16	14.64	1
L 5X5X5_16	4.24	1
L 5X5X5_16	8.5	1
MC 6X12	17.33	6
MC 6X12	2.89	36
W 6X8.5	10.95	10
Total N° of pieces		89

Table 9: Steel member takeoff done in RAM Elements.

BearingWall Design

The wall is divided into horizontal and vertical strips and each segment is designed based on the envelope of positive and negative forces at the top and bottom, as well as the maximum value from the governing load combination.

For unreinforced walls the following design checks are done:

- Combined compressive stress
- Flexural tension
- Axial tension
- Shear

Computer Analysis

The structural model was created with the model by applying the lateral wind loads and self-weight loads. The wind load was calculated to be 17.1 psf by ASCE 7-05 Section 6.515, *Design of Wind Loads on other Structures.* The applied loads are shown on Figure 30. The original lateral bracing was an X-brace frame. Then the model was analyzed in the RAM elements software. The model was model as pinned along the base of the supported by the foundation wall. The flexural moment of the wall without bracing was analyzed to be 3.91kip*ft/ft. The rupture moment was calculated to be 0.88kip*ft/ft. Therefore structural bracing was determined to be required.

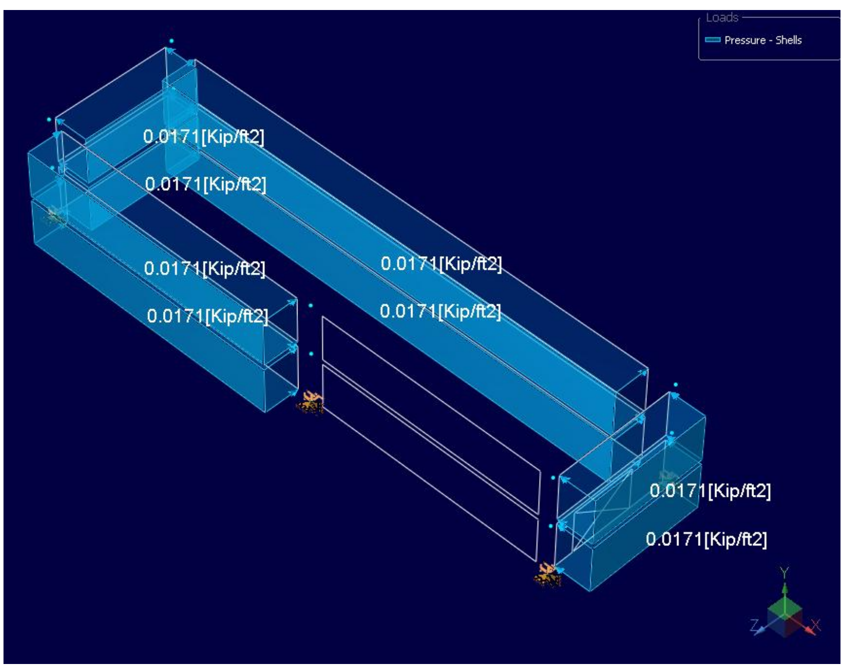


Figure27: shows the lateral forces applied on the face of the shell element

Determining Structural Bracing

The original four walls of the theatre will remain will the interior has been totally reconstructed. This is described as restructuring and represents the most extensive form of repair or reconstruction. Close attention was made to the sequence of the construction, because of the need to restrain the façade at all times and to ensure that any temporary work does not obstruct permanent installation.The first step is to construct the footing for the new columns. The steel frame used to support the façade will be constructed before demolition as part of the final works. Angles will be used to temporarily brace the frame to reduce the unbraced lengths of the frames columns. The floor beams can be installed immediately above the existing floor level. The connection of the columns to the façade will be angle sections welded either side of the column and bolted into the façade using epoxy resin anchors. The next phase is the demolition of the internal components of the building. The demolition will be less obstructed since the frame does not have interior columns within. Since the internal perimeter bay which provided the temporary works is part of the final frame structure. The cost of constructing the additional buttrices will be avoided.

Steel work offers unique advantages of prefabricated, dry construction, speed and ease of installation, immediate load carrying resistance, and high strength to weight ratio. The goal of this redesign is to find an alternative method of bracing the structure which minimizes construction work interference thereby increasing productivity. The need to refurbishment was considered as part of the original design. Steel is ideal for this refurbishment because of the space requirements on the site which are very restricted and congested.

The site logistics require the structural steel members to be as small as possible in order to allow for the steel to be taken apart by with the crawler cranethat is on site after the surrounding structure is in place. As in all design of temporary bracing work it is important to ensure that they do not obstruct the new foundation. In attempting to do an external bracing on end walls the long span of 88’9” moment is not reduced. Therefore, the design of partially internal and external was determined as the only probable method of reducing the moments of the long span. The columns could have been designed as composite columns. Thus allowing the columns and beams to be members of the permanent structure however due to time limitations the gravity loads of the new concrete structure was not consider for this thesis.

Proposed Alternative Bracing

The new structural frame as shown in Figure 31 reduces the site congestion. The proposed structural bracing reduced the maximum moment to 0.80kip*ft/ft, which is less then design moment 0.88kip*ft/ft; therefore it is a viable alternative.

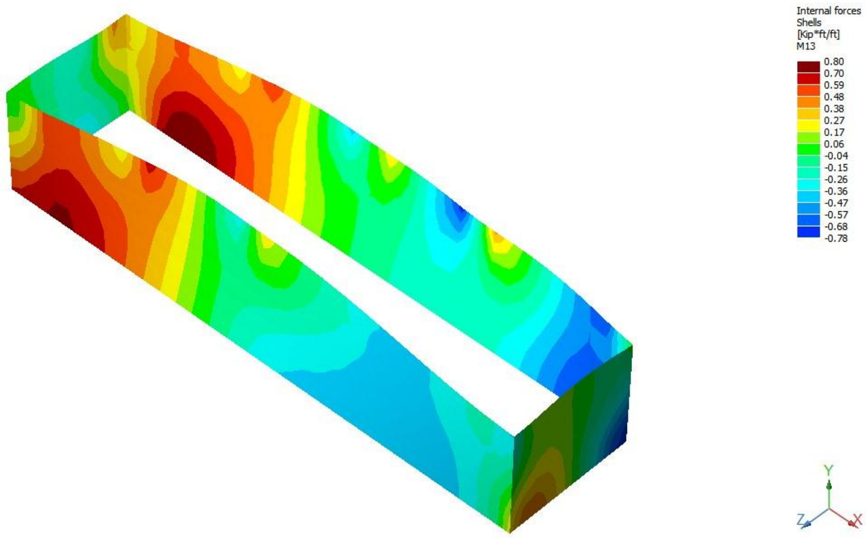


Figure 28: Shows the flexural moment with structural steel bracing along the shells local X-axis.

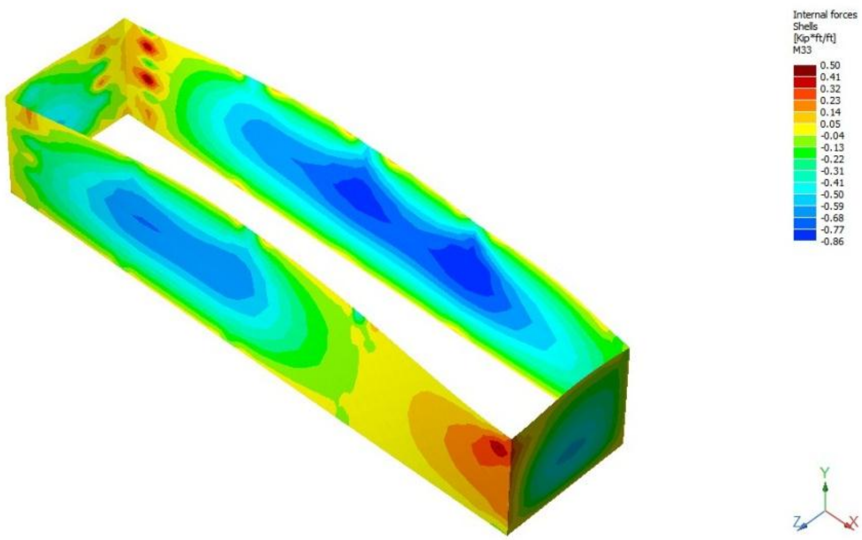


Figure29: Shows the moment with steel structural bracing along the shells local Z-axis.

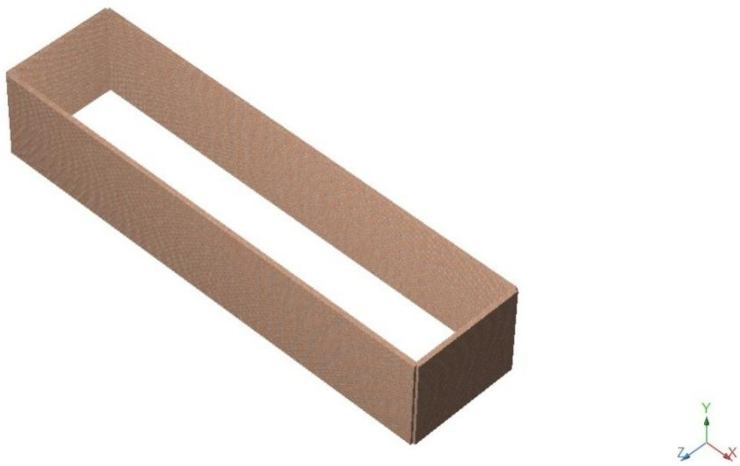


Figure30: Shows the rendering of the masonry wall in RAM Elements.

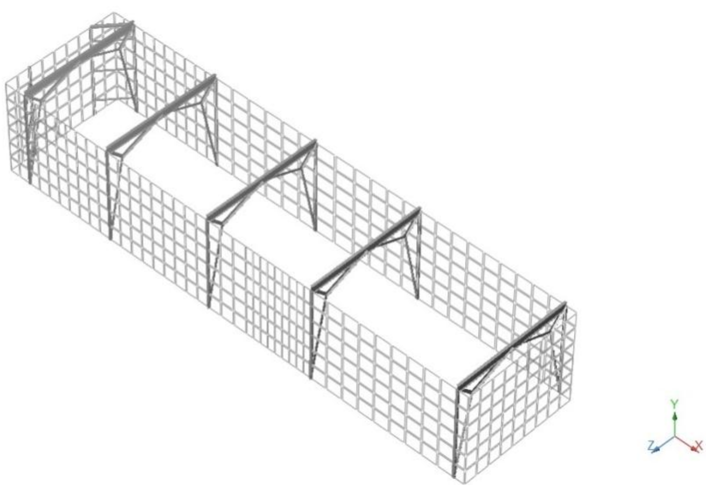


Figure31: Show the masonry wall with the steel rendered

Serviceability

The first design consideration is serviceability, as defined in IBC and ASCE 7, in Section 1604.3, *Serviceability.Structural systems and Members* were designed to have adequate stiffness to limit deflections and lateral drift. The maximum deflection of the masonry wall was 0.33 inches. The displacement was designed for L/240 for exterior walls with flexible finishes since there are no finishes that are applied to the masonry wall. The allowable deflectionis L/240 and is equals to 17ft/240=0.07083ft, which is 0.85inches. Therefore, the masonry wall meets the serviceability requirement.

Cost and Schedule Comparison

The cost of the x bracing and proposed lattice frame is within one hundred dollars of each other. The schedule of the proposed lattice bracing was determined to be an additional 6 days. The schedule can be reduced to only an additionalthree days to the original schedule by adding another crew to the angle framing construction. This is possible, because the light weight angles would not require a crane to construct. The primary advantage of using the W6x9 is that it can serve as the temporary shoring for the flat plate slab.

Table 10: Project X's Masonry Temporary Bracing

Project X's Masonry Wall Temporary Bracing															
Description	Quantity	Lb/ft	Quantity	Units	Crew	Daily Output	Labor Hours	Bare Material	Bare Labor	Equip-ment	Total	Total Incl O&P	Total	Duration	Duration Days
Steel Pipe, extra strong, no concrete 3" diameter x 12'-0"			8	Ea.	E2	60	0.933	135	39	26	200	245	$1,960	7.5	0.9
Steel Pipe, extra strong, no concrete 4" diameter			40	Ea.	E2	58	0.9660	198.0000	40.5000	27.0000	26.5000	317.5000	$12,700	38.6	4.8
Angle Framing , shop Fabricated, WT6x17.5	96	17.5	1680	Lb.	E3	440	0.055	0.81	3.95	0.29	5.05	8.18	$13,742	92.4	11.6
L 5x 5/16" x 6'			96	L.F.	E4	250	0.128	17.6	5.55	0.53	23.68	29.98	$2,878	12.3	1.5
Steel Knife Plate 3/8"			50	S.F.	E2	350	0.008	16.85	5.6		16.85	18.5	$925	0.4	0.1
												Total Cost	$32,205	151.2	18.9

Table11: Project X's Proposed Masonry Wall Temporary Bracing

Project X's Proposed Masonry Wall Temporary Bracing															
Description	Quantity	Lb/ft	Quantity	Units	Crew	Daily Output	Labor Hours	Bare Material	Bare Labor	Equip-ment	Total	Total Incl O&P	Total	Duration Hours	Duration Days
Angle Framing, shop fabricated, L3" x 3" x 3/8"	44.6	7.17	319.782	Lb.	E3	440	0.055	0.81	3.95	0.29	5.05	8.18	$2,616	17.6	2.2
Angle Framing , shop Fabricated, L4" x 4" x 3/8"	246.42	9.72	2395.2024	Lb.	E3	440	0.055	0.81	3.95	0.29	5.05	8.18	$19,593	131.7	16.5
Angle Framing , shop Fabricated, L5" x 5" x 5/16"	27.38	10.4	284.752	Lb.	E3	440	0.055	0.81	3.95	0.29	5.05	8.18	$2,329	15.7	2.0
Shop fabricated W6 x9			109.5	LF	E-2	600	0.093	14.85	4.06	2.9	21.81	26.5	$2,902	10.2	1.3
Channel MC6 x 12"			208	LF	E4	225	0.125	12.15	5.45	0.52	18.12	23.82	$4,955	26.0	3.3
												Total Cost	$32,394	201.2	25.1

Design Limitations

RAM's Masonry Module analyzes the masonry wall. Since shells created in RAM Element cannot vary thickness and material type. The foundation walls of the existing structure were considered to be unstable thus addition shoring was required. Therefore the masonry walls above the foundation level are only considered for the analysis.

- The height of the shells defines the height of the stories in the wall module. Note that if the last level shell is less or equal to 4ft height, it will be considered as a parapet.
- Shells must be part of a vertical and rectangular wall. Better results are obtained if the complete wall is selected instead of wall segments.
- Only the selected vertical members are transferred as columns.
- Columns must have uniform cross section and material from the bottom to top and they only may have a rotation of 90, 180, 270 degrees.
- All restraints or springs at the base of the wall must be the same.
- Masonry wall module receives up to 10 levels.
- The masonry wall module may receive flanges, but only when loads are not transferred (un-analyzed model) because the loads implicitly consider the effect of the flanges. Note any change inside the wall modules will not be transferred back to the RAM Elements model.
- Forces are transferred to the masonry wall module when the model is analyzed. RAM Elements transfers the resultant forces that act externally to the wall. If the model is not analyzed only the geometry is transferred.

Making changes to properties that have been imported from RAM Elements will compromise the accuracy of the imported forces. The following field should not be modified within the RAM Masonry Module:

- Geometry: Level restraints will be set to none for an imported analyzed wall. The level restraints are taken into consideration by the forces that are imported.
- Rigidity Elements: Columns will be read in for design and optimization. Flanges will be read in if the wall that is being imported is not analyzed. For an analyzed wall, the rigidity due to the flanges is taken into consideration by the forces that are imported.
- Loads: The loads that are imported from RAM Elements can be found in the Global forces folder. All input data can be modified in the detailer, but modifications made in the detailer will not be reflected back in the model of the main program. It is suggested that all the input data be applied prior to invoking the detailer.
- All shells in a RAM Elements model participate in the lateral force resisting system. There is no concept of gravity shells (walls) in RAM Elements.
- RAM does not have ACI 530 Seismic requirements preloaded in the load combinations. This load case must be manually entered into model by generating a new load combination.

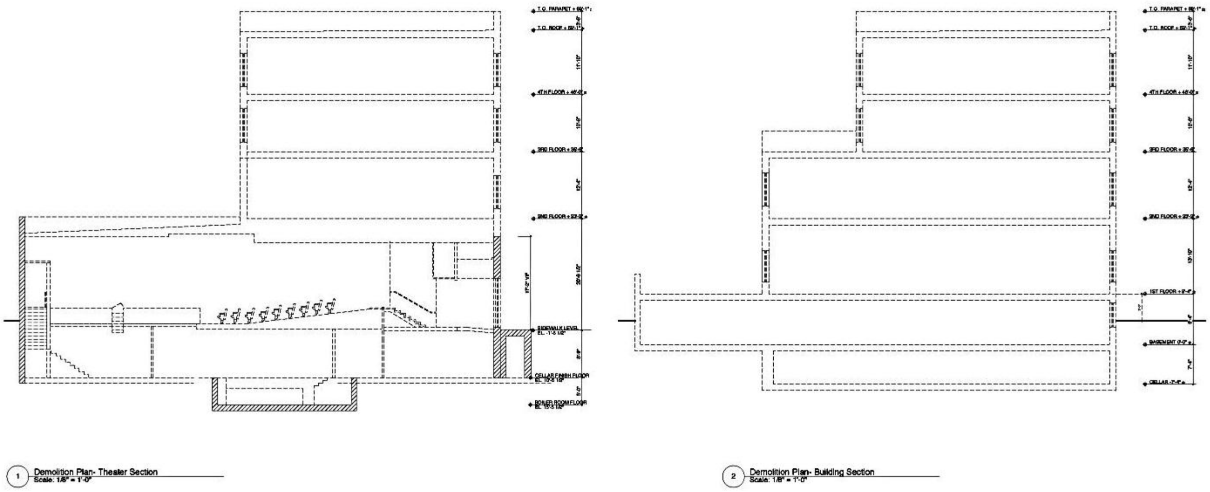


Figure32: Shows the building section of the theatre prior to demolition.

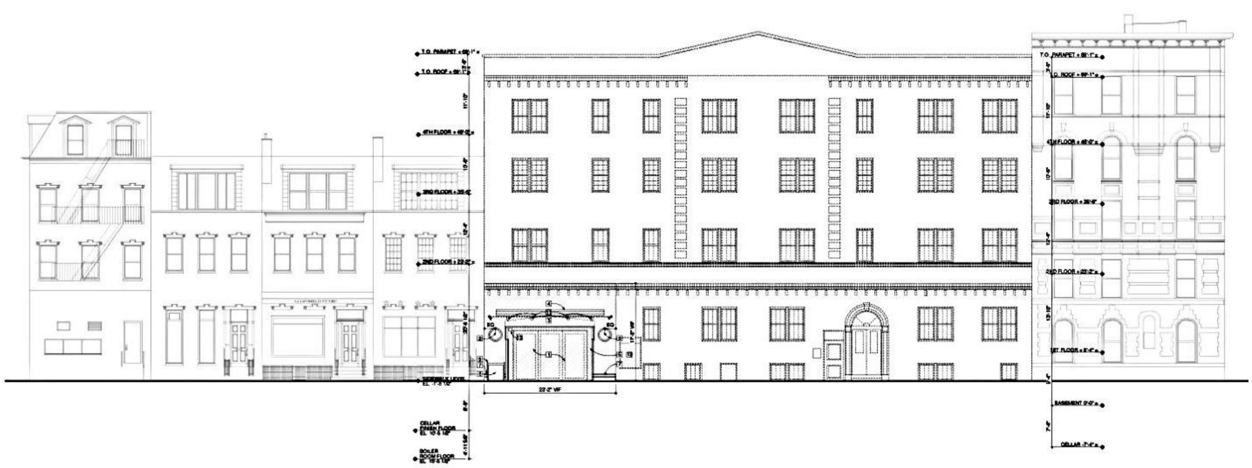


Figure33: Show the North elevation of the masonry façade prior to demolition.

AppendixH.1: Wind Load Calculations

1/4 | Wind Analysis | ASCE 7-05 | Method 2 Wind Loads

Step 1 find velocity pressure q_z & q_h

Step 1a) See figure 6-1) Determine Basic wind speed

100mph or 45 m/s

Step 1.b)
K_d = 0.85 (see table 6-4 ASCE 7-05)

step 1.c)

Building category III   Table 6-1 ASCE 7-05

Importance Factor = 1.15

Step 1.d) Detemine Exposure Category:
Exposure Category B (Because in urban Area)

ASCE 7-05 (6.5.6.2)

ASCE 7-05 (6.5.7.2) Step 1.d.1) Topographic Factor K_{zt} = 1.0
Because building is not located on a hill or Ridge

Step 1e Determine Velocity pressure Exposure Coefficient K_z, K_h (see table 6-3, 6.5.6.6)

Build Height of masonry wall = 20ft → $K_h = K_z$ = 0.62
Case 2: Because No Roof

Total Ht. 80 $K_h = K_z$ = 0.93
$K_z = K_h$ => Because exposure Exposure class B

ASCE 7-05 6.5.10 (1.f.1) $q_z = 0.00256\, K_z\, K_{zt}\, K_d\, (V^2) I$

$q_z = (0.00256)\, 0.62\, (1.0)\, 0.85\, (100\text{ mph})^2\, 1.15 = 15.51488 \frac{lb}{ft^2}$

(1.f.2.) $q_h = 0.00256\, K_h\, K_{zt}\, K_d\, V^2 I$

$q_h = q_z$ = Flat Roof
q_h = mean Roof height
q_z = calculated at height z

2/4

Gust Factor

Rigid Structure

☆ 2a) G = Assume 0.85 (see section 6.5.81)

2b) $GC_{pi} = 0$ because enclosed (see Figure 6-5)

2c) Determine pressure coefficients wall

$L/B = \frac{88'9''}{21'11''} = 4.05 \quad \frac{21'11''}{88'9''} = 0.246$

2c.1) (for use with q_z) $C_p = 0.8$ (for windward)
2c 2) (for use with q_h) $C_p = -0.2$ (for Leeward Normal 21'11")
2c 3) (for use with q_h) $C_p = -0.5$ (for Leeward Normal 88'9")
2c.4) (for use with q_h) $C_p = -0.7$ (for side walls)

2d) Determine pressure coefficients Roofs

$C_p = 0$ Because no Roof

MWFS Pressure walls

3a) $p = qG(C_{pi}) - q_i(GC_{pi}) = (15.515\ \frac{lb}{ft^2})(0.85)0.8$ (for windward)

$p = 10.55\ \frac{lb}{ft^2}$

3b) $p = 15.515\ \frac{lb}{ft^2}(0.85)(-0.2) = (-2.638\ \frac{lb}{ft^2})$ (Leeward Normal to 21'11")

3.c) $p = 15.515\ \frac{lb}{ft^2}(0.85)(-0.5) = (-6.594\ \frac{lb}{ft^2}$ Leeward Normal to 88'9"

3d) p = 0 for Roof before slab poured

Design components & Cladding

Wall effective area

3/4

6.5.15 Design Wind Loads on other Structures

$F = q_z G C_f A_f$ (lb) (N)

q_z = velocity pressure evaluated at height Z of the centroid of the area A_f using exposure defined in Section 6.5.6.3

$A_{F1} = 21'11'' \times 17'2'' = 376.24'$

$A_{F2} = 88'9'' \times 17'2'' = 1523.54'$

C_F = Force coefficients from Figure 21

$h/D = \frac{17'2''}{21'11''} = 0.783$

h = height structure

D = least horizontal dimension of square

Square (Wind Normal to face) = 1.296 → C_f

Square (Wind along diagonal) = 0.99638 → C_f

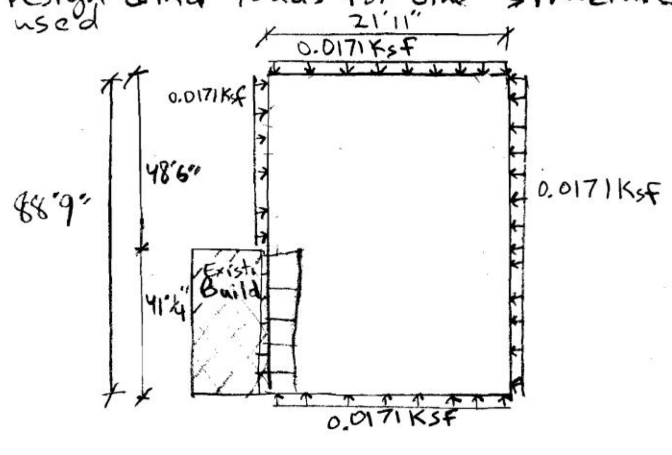
$F = q_z G C_f A_f$ (lb)(N)

$F = (15.519)0.85(1.296)(1523.54) = 26046$ lb

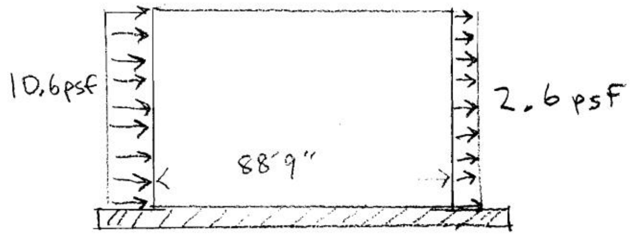
F for A_{F2} & A_{F1} = 17.1 psf

$F = (15.519)0.85(1.296)(376.24') = 6432.1$ lb

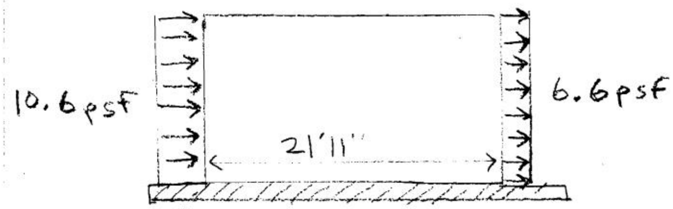
Since this is the controlling case 6.5.15 Design wind loads for othe structures will be used



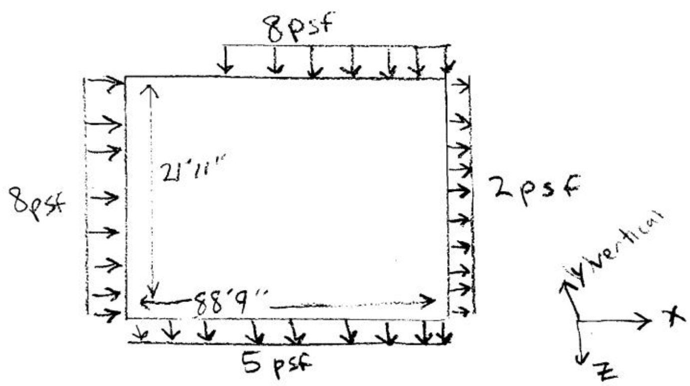
4/4



Design Pressure for MWFRS when Wind is Normal to 21'11" Wall



Design Pressure for MWFRS when Wind is Normal to 88'9" Wall



Load Case 3 0.75 P_{wy} & 0.75 P_{Ly}

These cases are shown to illustrate
The controlling case is for 6.5.15
Design of other Structures

Appendix H.2: Masonry Design LRFD

Masonry Design Check LRFD

Type M or S Mortar 60psi

3 courses wide → $3\frac{5}{8}'' \times 3 + 2 \times \frac{3}{8}'' = 11.625''$

Wind = 17.1 psf × 1ft = 17.1 plf

F'm = 1500 psi UnReinforced Masonry

DL = (11.625 in)(10 psf/in) = 116.25 psf

DL = (116.25 psf) 17.2 ft = 1999.5 plf

2/4 FLEXURE (Out of Plane)

Approximate Moment

$M_u = \frac{WL^2}{2} = \frac{(17.1plf)(17.16ft)^2}{2} = 2.52 Lb\frac{ft}{ft}$

$I = \frac{bh^3}{12} = \frac{12''(11.625'')^3}{12} = 1571.01in^4$

$F_t = \frac{(2517 Lbft)\left(\frac{12in}{1ft}\right)\left(\frac{11.625in}{2}\right)}{1571.01in^4} = 111.8psi$

Modulas of Rupture

Referencence: MSJC Table 3.1.8.2.1; 3.1.4.2

$\emptyset F_t = 0.6(60psi) = 36psi$

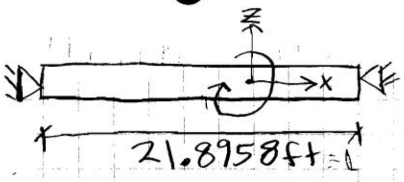
111.8psi > 36psi Therefore bracing is Required

Solving for Moment capacity Wall

$36psi = \frac{(M_u)\frac{11.625in}{2}}{1571.01in^4} \rightarrow M_u = 9730 lb\,in$

$M_u = 9730 lb\,in \left(\frac{1ft}{12in}\right)\left(\frac{1Kip}{1000lb}\right) \Rightarrow 0.81 \frac{KFt}{ft}$

3/4



h I 11.625" PLAN VIEW

$$M_u = \frac{(17.1\,plf)(21.8958)^2}{8} = 1024.7\,lb\,ft$$

$$I = \frac{bh^3}{12} = \frac{(12'')(11.625)^3}{12} = 1571.01\,in^4$$

$$f_t = \frac{(1024.7\,lb\,ft)\left(\frac{12in}{1ft}\right)\left(\frac{11.625}{2}\right)}{1571.01\,in^4} = 45.49482\,psi$$

$$\phi F_t = 0.6(60\,psi) = 36\,psi$$

45 > 36 There fore Bracing IS NEEDED

$M_{max} = 0.81\ K\frac{ft}{ft}$ (same as pg 2)

Solve for unbraced Length

$$M_u = \frac{W \cdot L^2}{8} \quad 810.83\,lb\,ft = \frac{(17.1\,plf)(Length)^2}{8}$$

Length = 19.47658 ft

4/4 SHEAR Un Reinforced Masonry

$V_u = W_u(h) = (17.1\,plf)\,17.2ft\,(1.6) = 470.6\,lb$

$$V_n \leq \begin{cases} 3.8\sqrt{1500}\,(11.625'')12'' = 20530.7\,Lb \\ 300 \times 11.625'' \times 12'' = 3487.5\,Lb \\ 90 \times 11.625'' \times 12'' + 0.45(1999.5\,plf) = 13454\,Lb \end{cases}$$

controls → $300 \times 11.625'' \times 12'' = 3487.5\,Lb$

$3487.5\,Lb > 470.6\,Lb$

IV. Analysis 2: Connecting the Electrical System to the Existing Combined Heat and Power System (CHP)

Background

The University's natural gas cogen plant decreases greenhouse gas emissions by 5,000 tons per year compared to the older cogen plant- a 30-year-old oil fired model. The Co-generation plant captures the heat produced during electricity generation for heating purposes. The CHP plant is 90% energy efficient while producing 13.4 MW of electricity. The plant consists of two 5.5 megawatts (MW) gas turbines and a 2.4MW steam Turbine. Figure ??shown in Appendix?? Illustrates how the CHP operates.

University X has recently finished replacing and expanding its cogeneration plant to improve energy efficiency, reduce emission, and improve reliability. The University X has an existing combined heat and power (CHP) plant which provides electrical power to 7 of their buildings and high temperature hot water to 40 of their buildings throughout the Washington Square campus. Because the plant is at the end of its useful life, the university has the opportunity to upgrade and replace the electrical generating equipment to increase the CHP plant output, efficiency, and environmental performance. The new plant will continue to provide high temperature hot water to 40 University's buildings and will also provide emergency electrical power to an additional 18 to 20 University's buildings.

The University X is planning to connect another building, which is adjacent to Project X, to the CHP. The University X has finished the CHP plant and is now in the process of connecting the adjacent building. The CHP project started in the spring of 2007 and was completed in the fall of 2009. Also, the underground MEP connection to adjacent buildings was constructed while the masonry was going on. Although, the project was completed ahead of schedule, site congestion could have been reduced if the underground utilities were completed before the above ground work started.

Problem Statement

Due to the inflation of costs electricity it is critical to derive alternative methods of producing electricity. Why consider peak load shaving in New York City? Over the last five years, New York prices have generally stayed 40 percent or more above the national level see Figure 32. The price of electricity has constantly rising over the last five years. Whereas the cost of gas per therm has been fairly constant refer to Figure 33.

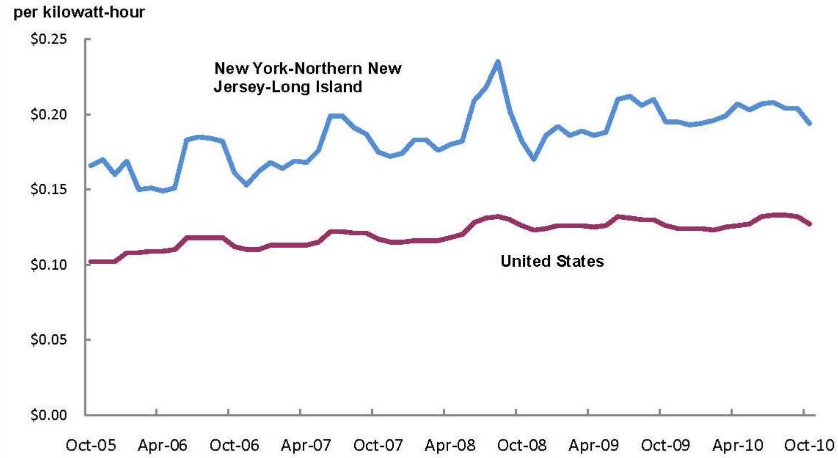


Figure 32: Average prices for electricity, NY-Northern NJ and the US

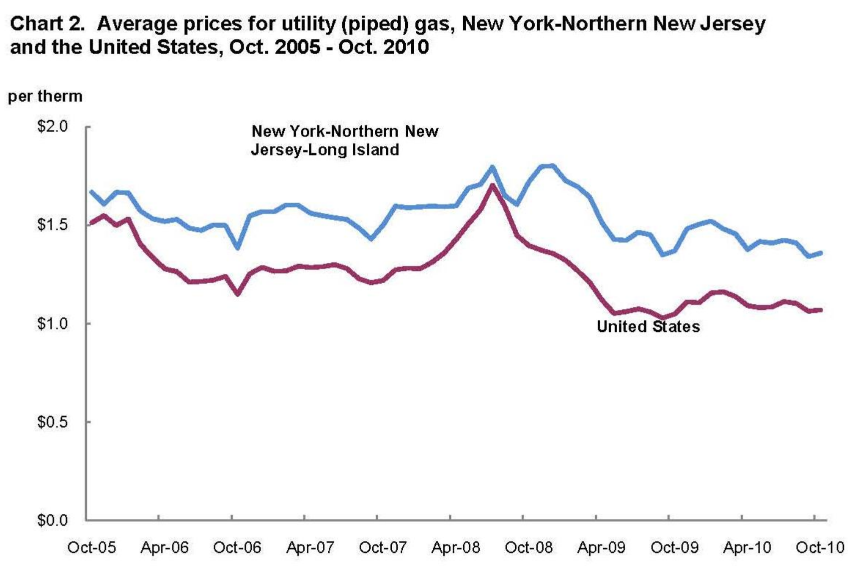


Figure 33: Average prices for utility (piped) gas, NY-Northern NJ and the US

Goals

The goal of this analysis is to determine the possibility of a demand response program at Project X. This system will serve to reduce the peak loads of the building. Interviews with the project team, electrical designers, and vendors are necessary for completing the electrical system design. This particular concept requires considerable construction coordination with the Con Edison. Moreover, the sequence of the utility tie in will be investigated in Analysis 3. The existing schedule was to tie-in the utility in the last stage of the project. Alternatively, the utility tie will be rescheduled to occur in the first stage of construction.

This analysis involves research of existing incentives, energy modeling, and sizing of the required peak loading electrical system. Next, a feasible electrical system will be developed to shift the peak demand at Project X. There is no emergency power system required for the building. However, there are battery backups for the emergency lighting and fire alarm. The elevator drops to the lobby in an emergency. Thus, the peak load shaving capability is strictly sized based on peak demand load of the building.

The primary goals are:

- Designed to delay capital costs associated with growing electric demand
- Improved electric system reliability for the university
- Identify financial incentives in New York
- Reduced demand peak load

Research/Analysis Steps (B2=Breadth 2, CM = Construction Management Analysis)

1. Identify the capabilities and purpose of the CHP current electrical distribution systems that are used on University X campus. - CM
2. Identify which electrical systems would need to be added in order to be compatible with the CHP. - B2
3. Calculate the building's electrical loads.
4. Determine the transformer, conductors, conduit, and over current protection required for the new electrical distribution system.
5. Compare the costs of the CHP compatible equipment with the existing MEP equipment.

Tools & Resources

National Fire Protection Association 70

Expected outcomes

Decide the components required to synchronize generators and the utility so that there is undisturbed power distribution. Consequently, the synchronization will attain a five year payback to the owner. The electrical tie in will be completed early in the project. This will be done due to the many possible problems that could occur during the electrical tie phase in the downtown New York City area. As a result this can reduce the chance of having to connect the building CHP system in the future.

Calculate Building Electrical Loads

The building was analyzed with the Con Edison's Online Energy Efficiency Evaluation tools. This tool was used to validate the results acquired from the Equest Software. The actual utility was not accessible. The following inputs were used to establish the building's Base Facility are shown in Table ??. The following summary report highlights the estimates for electrical and fuel energy costs in the building. These estimates were made based upon the typical end use breakdown for buildings similar to an College Science Building shown in chart ??.The following charts present an estimate of the buildings electricity usage during the past year in each of the major energy systems at the facility. Each end use area of energy use is color coded. Chart ??shows the combined electricity and fuel use by each major end use in the facility.

Table 12: Shows the input parameters for the Con Edison's Software

	Base Facility
Building Type	College Science Bldgs (EL9)
Building Age	0 - 9 years
Building Hours	3640
Sqft Heat/Cool	54640
Sqft Parking Lot	0
Cool Setting	72
Heat Setting	70
Heat Type	Heat Pump (Air)
Water Heat Type	Electric
Air Conditioning	Electric (Typical)
Percent Fluorescent	90% Fluor (T12)
Windows (Panes)	Double Pane
Cooking Equipment	None
Refrigeration	None
Elevators/Escalators	Electric
Parking Garage	No

Table 13: Shows the Detailed Report of Electric Energy Costs

	Base Facility		
	Most Efficient	Average Efficiency	Least Efficient
Indoor Lighting	$12,779	$17,850	$24,998
Outdoor Lighting	$0	$0	$0
Air Conditioning	$53,263	$80,253	$121,424
Refrigeration	$0	$0	$0
Space Heating	$16,728	$28,926	$56,657
Cooking	$0	$0	$0
Water Heating	$71,346	$121,374	$230,634
Miscellaneous	$77,344	$108,281	$151,661
Annual Total	$231,460	$356,684	$585,375
Average Electric Cost		$0.222	
Average Load Factor		26.6%	

Table 14: Shows the Detailed Report of Electric Energy Costs

	Base Facility		
	Most Efficient	Average Efficiency	Least Efficient
Indoor Lighting	57,642	80,518	112,761
Outdoor Lighting	0	0	0
Air Conditioning	240,257	362,006	547,721
Refrigeration	0	0	0
Space Heating	75,458	130,481	255,569
Cooking	0	0	0
Water Heating	321,830	547,493	1,040,346
Miscellaneous	348,883	488,436	684,113
Annual Total	1,044,068	1,608,934	2,640,510
Average Peak kW		691	

Next an Equest model was constructed to create a base line model in order to find the monthly peaks of electric demand in Kilo-Watts. In order to shave 100kW of the demand a cost analysis was done for the electrical demand charge versus gas costs to run the generators.

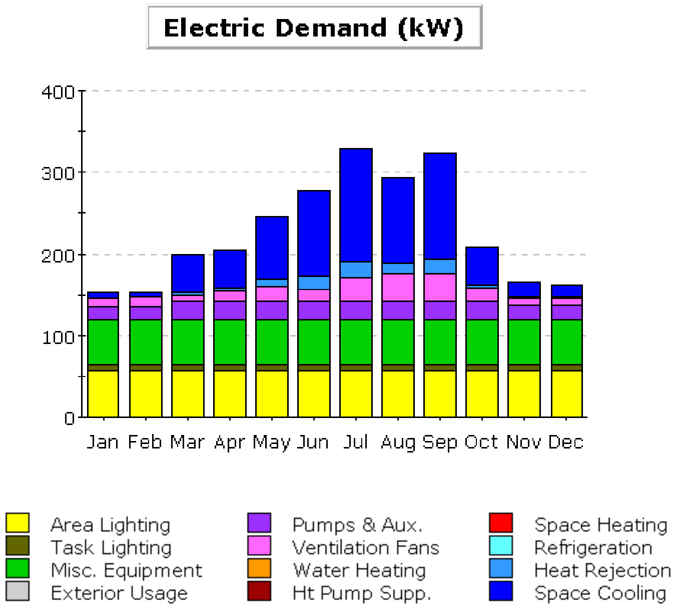


Figure34: Shows Monthly Peak Demand by Building

Electric Demand (kW)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	6.6	6.6	45.5	45.6	76.4	105.9	139.5	104.8	129.8	46.0	18.3	15.9	740.6
Heat Reject.	-	-	3.7	3.7	9.5	16.3	19.0	12.8	17.9	3.2	1.2	0.7	87.9
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	10.7	11.4	8.6	13.6	18.1	13.6	29.2	34.4	33.7	17.1	8.4	8.8	207.4
Pumps & Aux.	15.6	15.6	21.5	21.5	22.1	22.1	22.1	22.1	22.1	21.6	17.7	17.3	241.3
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8	669.7
Task Lights	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	85.8
Area Lights	57.0	57.0	57.0	57.0	57.0	57.0	57.0	57.0	57.0	57.0	57.0	57.0	683.4
Total	152.8	153.5	199.1	204.3	246.0	277.7	329.6	293.9	323.4	207.8	165.6	162.6	2,716.3

Gas Demand (Btu/h x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	1.46	1.13	1.04	0.75	-	-	-	-	-	0.49	0.82	1.19	6.87
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.00	0.03	0.03	0.32
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	1.49	1.16	1.08	0.78	0.03	0.03	0.03	0.02	0.02	0.49	0.84	1.22	7.19

eQUEST 3.63.6500 Monthly Peak Demand by Enduse Page 1

Figure 35: Shows Monthly Peak Demand by Building

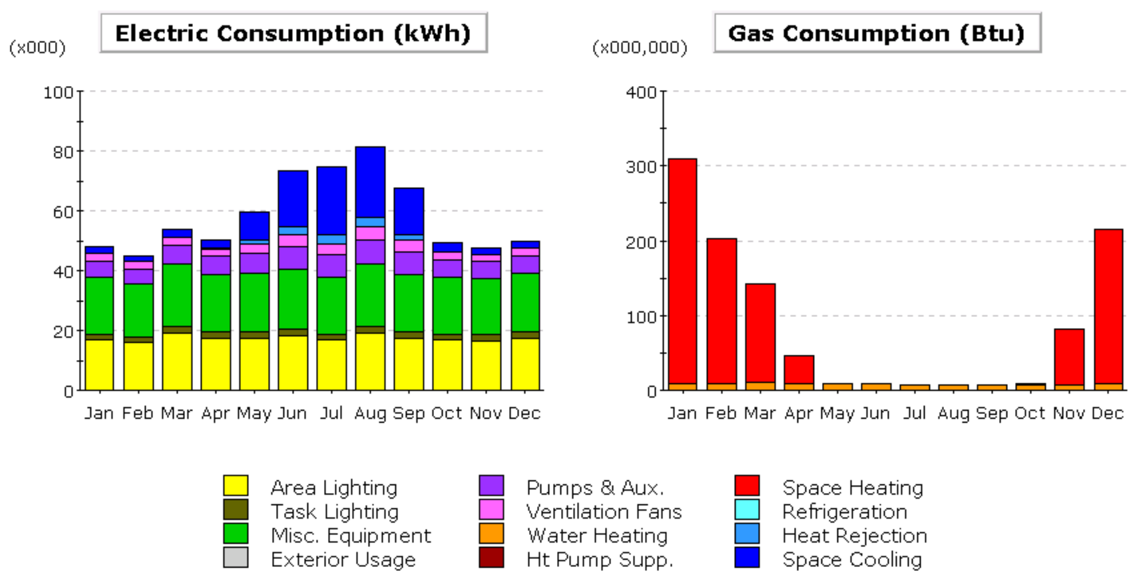


Figure 36: Shows Monthly Energy Consumption

Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	2.08	1.94	2.75	2.72	9.39	18.99	22.59	23.52	15.44	2.97	2.09	2.21	106.68
Heat Reject.	-	-	0.04	0.05	0.96	2.30	2.99	3.09	1.88	0.10	0.00	0.00	11.40
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	2.75	2.44	2.83	2.63	3.26	4.04	3.95	4.52	4.05	2.95	2.35	2.82	38.58
Pumps & Aux.	5.60	5.24	6.27	5.84	6.68	7.83	7.50	8.30	7.28	5.74	5.55	5.81	77.65
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	19.08	17.80	20.89	19.45	19.68	20.06	19.08	20.89	19.45	19.08	18.85	19.68	233.99
Task Lights	1.86	1.77	2.14	1.95	1.95	2.05	1.86	2.14	1.95	1.86	1.86	1.95	23.33
Area Lights	16.71	15.81	19.03	17.44	17.48	18.22	16.71	19.03	17.44	16.71	16.67	17.48	208.71
Total	48.07	45.00	53.94	50.08	59.40	73.48	74.66	81.48	67.49	49.41	47.38	49.95	700.35

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	301.4	194.2	132.0	37.0	-	-	-	-	-	1.3	74.4	206.8	947.0
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	8.7	8.6	10.3	9.3	8.6	8.3	7.0	7.6	7.0	7.0	7.5	8.5	98.3
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	310.1	202.7	142.3	46.3	8.6	8.3	7.0	7.6	7.0	8.3	81.9	215.3	1,045.4

eQUEST 3.63.6500 Monthly Energy Consumption by Enduse Page 1

Figure 36: Shows Monthly Energy Consumption

Components of Synchronization

Generator synchronization with utility power and generator requires detailed component consideration. There are three components needed to effectively parallel the generators service. The first component is an electronic synchronizing gear. This synchronizing gear is required for operating the generators on a parallel bus, the other generators, or the utility. The generator must be synchronized to the bus voltage reference before the paralleling switchgear will close it onto the bus. The synchronizer unit drives the generators' governor to control its speed and output voltage frequency. There are two types of synchronizers and governors (mechanical and electronic) which are chosen for this project. The generator synchronizer unit can also be used to hold distributed generators in sync with the utility or each other. This assures the upstream synchronization required in a distributed redundant design that utilizes Delta Conversion Technology

The second component is an all closed transition transfer switches. The synchronizer will match the generators' voltage when a utility reference is presented to the line side of the transfer switch. This coordinates the closed transition from generator to utility. Alternatively, paralleling switch gear can be used. Paralleling is the operation in which multiple power sources (usually two or more generators) are synchronized and then connected to a common bus. Paralleling multiple sources provided increased reliability, flexibility in load management, uninterruptible maintenance and cost saving during peak rate incentive periods. (General Electric)

The third component is a programmable logic controller (PLC). This device is used to sense each of the generator and utility voltage references. If a valid utility reference is available, the PLC will provide this reference to the synchronizer units that are connected to the distributed generators. If no utility is available, the PLC will pick an operating generator and use its output as the reference for the others. This will enable system synchronization in any operating condition. If a valid utility reference is available, the PLC will provide this reference to the synchronizer units that are connected to the distributed generators. If no utility is available, the PLC will pick an operating generator and use its output as the reference for the others. This will enable system synchronization in any operating condition. Examples of this system are shown in Figures 1 & 2.

Components Required:

- PLC controller to the set electronic generator governor
- Electronic synchronizing gear.
- All closed transition transfer switches.
- Need of additional inter-tie protection (relays included in SPM-D21).
- Need permission from the utility company.
- Paralleling switchgear

NEC Requirements

According to the National Electric Code’s section 700.5 *Capacity and Rating Part B* permits one generator to be used as a single power source to supply emergency loads, essential standby loads, and optional standby loads as long as the control arrangements for selective load pickup and load shedding are provided to ensure that adequate power is available. The priority is to provide power to the emergency loads. The second most important electrical load is the legally required standby loads. Lastly, the optional load management system loads are taken into consideration. Requirements of NEC:

Synchronization Equipment Selection

The first step in choosing the correct synchronizing hardware is identifying the type of power that is servicing the building. It must be understood the voltage output from the generator. Also, the primary side of the switch gear must be known. This entails choosing between delta or wye configurations. Then it must be determined how many generators (prime movers) there are connected to the system. Woodward power has an extensive website entailing equipment for all types of applications. Whether the prime movers are in parallel or is a single generator supplying the power Woodward has many synchronizers to choose from.

Synchronizing Unit SPM-D21

- The selection of the synchronization equipment for Project X was the SPM-D21. This was chosen because it provides microprocessor-based synchronizer designed for use on three phase AC generators equipped with Woodward or other compatible speed controls and automatic voltage regulators. The SPM-D21 provides automatic frequency, phase and voltage matching using either analog or discrete output sign output signals. It combines synchronizing for generator circuit breaker (GCB) and mains circuit breaker (MCB), load and power factor control, and generator and mains protection. From the manufactory diagram Figure?? it becomes easy to see the required equipment voltage regulator, speed control for the generator. A thorough analysis of the individual connections was required to find the size of wire and length of wire for the estimate.

Figure 37: shows the Synchronizing unit

SPM-D21 comprises the following capabilities for synchronizing:

- Separately for GCB and MCB
- Phase match or slip frequency synchronization with voltage matching
- Two-phase sensing of generator, bus, and mains
- Selectable operating modes like SPM-A (Run, Check, Permissive, and OFF)
- Synchronization check possible
- Synchronization time monitoring

Mains parallel operation

- Real power control
- True RMS power calculation
- Generator real power set point by parameter (2 values) or via 0/4 to 20 mA
- Soft shutdown
- Power factor control
- Power factor set point by parameter

APPLICATION DIAGRAM

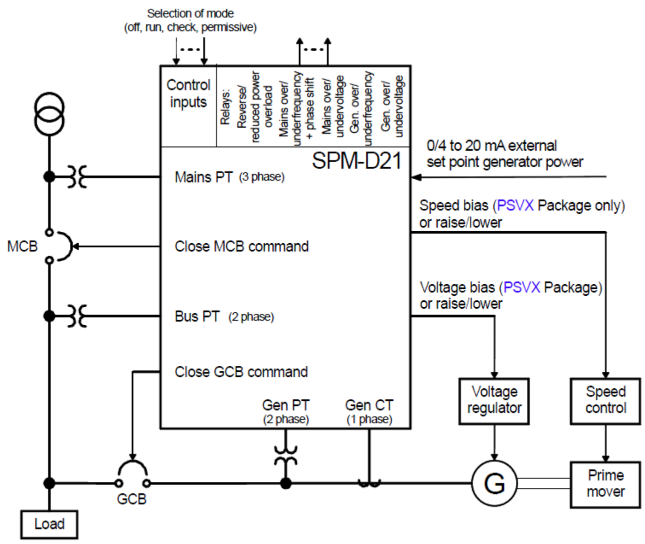


Figure 38: shows the single line of the synchronizing unit

APPLICATION DIAGRAM

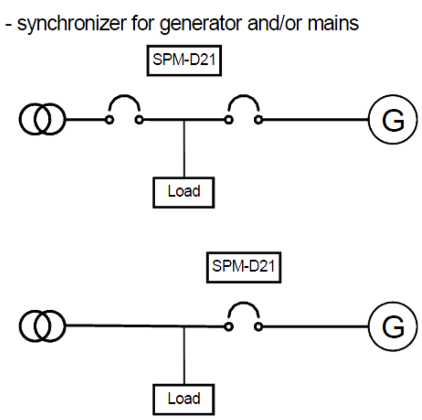


Figure 39: shows the single line of the synchronizer for the generator and mains

Figure 40 shows the wire diagram for the SPM-D21/PSV. As an example the following shows some of the inputs of the synchronizer. Terminal 0 is the reference point neutral point of the three-phase system or neutral terminal of the voltage transformer. Terminals 1 and 2 are the power supply. Generally, there are three different variants for connection of the measuring circuit voltage.

SPM-D21/PSVX

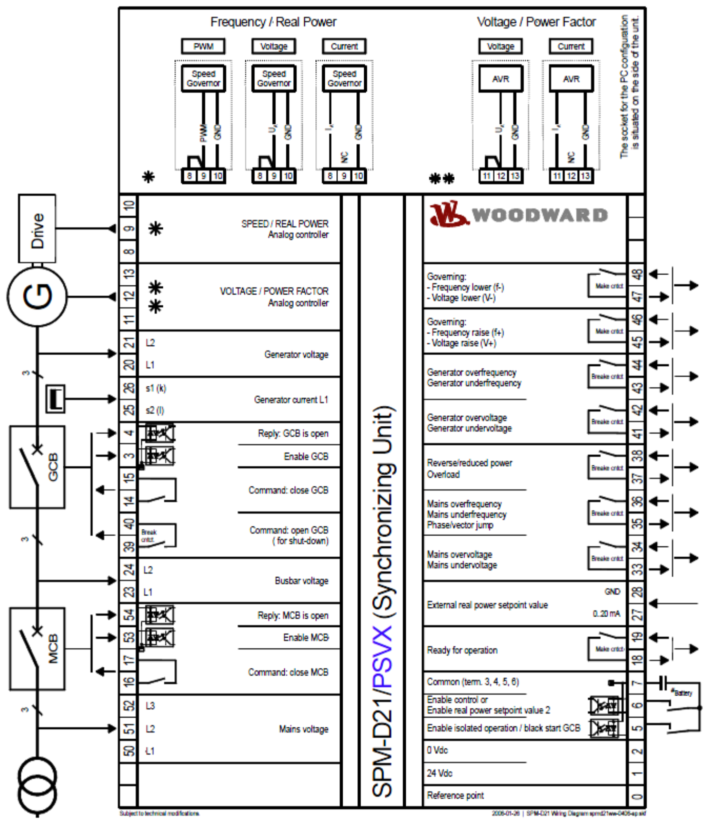


Figure 3-2: Wiring diagram SPM-D21/PSVX

Figure 40: Wire diagram for the SPM-D21/PSV

Measuring Inputs

There are three primary voltage input connections for the synchronizer measurements generator, busbar, and mains. All of the connections require 14 AWG connections. Since the generator supplies 3 phase power the connection to the medium voltage via single-pole isolated transformer (e.g. Y connection) as shown in Figure 40 is connected to terminal 20, 21,and 0 (neutral). The second consideration is the voltage measuring connection of the busbar voltage the measure is shown in Figure 40 this is connected to terminal 23 and 24. The third voltage measuring connection is the mains as shown in Figure 40 is connected to terminals 50,51, 52, and 0 (neutral).One current connection consideration is to measure the amperage of the generator.

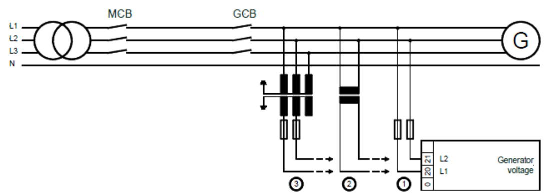


Figure 3-5: Measuring inputs - generator voltage

Figure 41: Number 3 is Connection for the Voltage Measurer to the Generator Number 3 for the Three-phase Connection.

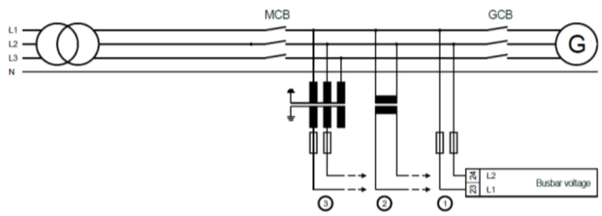


Figure 3-6: Measuring inputs - Busbar voltage

Figure 42: Number 3 Shows the Connection for the Voltage Measurer to the Busbar Number 3 for the Three-phase Connection.

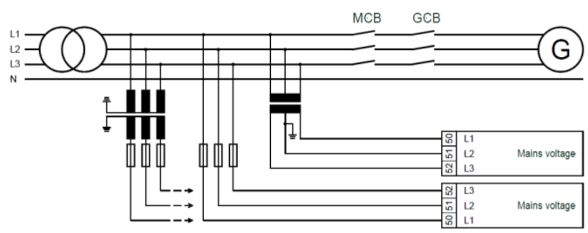


Figure 3-7: Measuring inputs - mains voltage

Figure 43: Shows the Connection for the Voltage Measurer to the Mains

Discrete Inputs

Discrete inputs to the synchronizer is a single bit (i.e. 0 or 1, false or true), data item, which is usually provided by a 1/0 system. Limit switches, push buttons, selector switches or relay contacts would be good examples of these devices used on discrete inputs. The discrete input is connected to terminals 3,4,5,6,53, and 54. The synchronizer communicates to the main circuit breaker (MCB) and generator circuit breaker (GCB). This communication not only enables the generator circuit breaker (GCB),but also it also enables the isolated operation/dead bus start (GCB), the control or the switching power set point value ½, release main circuit breaker (MCB). When normally closed the contact reply for GCB is open and the reply to (MCB) is open.

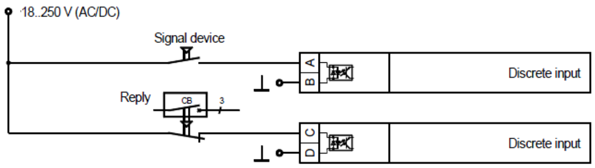


Figure 3-9: Discrete inputs

Figure 44: Illustrates the Discrete Inputs

Analog input

This analog input is not isolated galvanically. If different devices are controlled with the same signal, a buffer amplifier must be installed before each device.

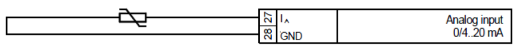


Figure 3-10: Analog input

Terminal	Associated zero-terminal	Description (acc. DIN 40 719 part 3, 5.8.3)	A_{max}
27	28	Setpoint value power	2,5 mm²

Figure 45: Shows the analog input

Auxiliary and Control Outputs

The relay "Open GCB for shutdown" is used to open the (GCB) after the power was reduced automatically (see also chapter 6 Configuration - Configure Controller). This relay is not triggered from watchdogs.

Circuit Breaker Actions

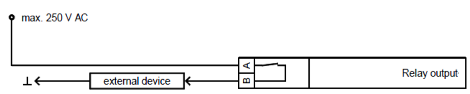


Figure 3-11: Relay outputs - control outputs I (CB control)

Root *A*	Switched *B*	Description	A_{max}
14	15	Synchronizing pulse, Command: close GCB	2.5 mm²
16	17	Synchronizing pulse, Command: close MCB	2.5 mm²
39	40	Command: open GCB for shut down	2.5 mm²

Other Actions

Other Actions

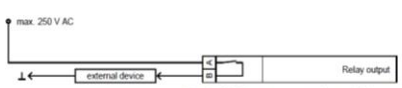


Figure 3-12: Relay outputs - control outputs II (messages)

Monitoring relay Break-contact

Root *A*	Switched *B*	Description **Note:** The relays release in case of error.	A_{max}
33	34	Mains over/under voltage	2.5 mm²
35	36	Mains over-/underfrequency, phase jump	2.5 mm²
37	38	Reverse/reduced power, overload	2.5 mm²
41	42	Generator over/under voltage	2.5 mm²
43	44	Generator over/under frequency	2.5 mm²

Signal relay Make-contact

Root *A*	Switched *B*	Description **Note:** The relays pick up in case of error.	A_{max}
18	19	Readiness for operation	2.5 mm²

Controller Outputs

The SPM-D21/PSV is equipped with two three-position controllers for voltage and frequency (made of a form C and form A relay). With the version SPM-D21/PSVX different controller output signals can be selected by configuration, which are connected in different ways.

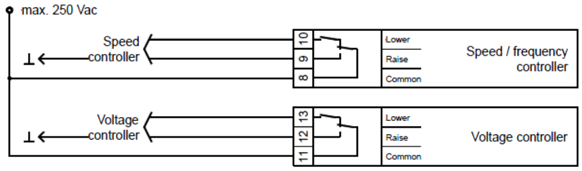


Figure 3-13: Controller - SPM-D21/PSV - three position controller

Terminal		Description	A_{max}
8	common	Speed/frequency controller	2.5 mm²
9	higher		2.5 mm²
10	lower		2.5 mm²
11	common	Voltage controller	2.5 mm²
12	higher		2.5 mm²
13	lower		2.5 mm²

Connection of the Controllers

Connection Of The Controllers

Setting: 'THREESTEP' (three-position controller)

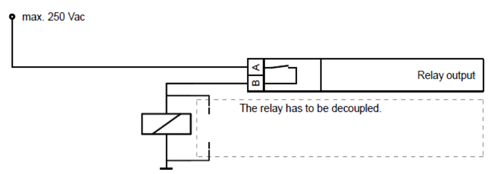


Figure 3-14: Controller - SPM-D21/PSVX - three position controller

Terminal		Description	A_{max}
45 / 46	raise	Speed / Frequency controller or	2.5 mm²
47 / 48	lower	Voltage controller	2.5 mm²

Setting: 'ANALOG' And 'PWM' (Analog Controller) - Frequency Controller

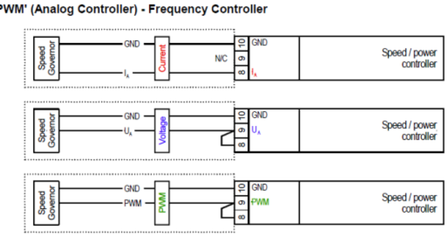


Figure 3-15: Controller - SPM-D21/PSVX - analog controller output - speed/frequency

Type	Terminal		Description	A_{max}
I Current	8	I_A	Speed controller / Frequency controller	2.5 mm²
	9			2.5 mm²
	10	GND		2.5 mm²
U Voltage	8			2.5 mm²
	9	U_A		2.5 mm²
	10	GND		2.5 mm²
PWM	8			2.5 mm²
	9	PWM		2.5 mm²
	10	GND		2.5 mm²

Setting: 'ANALOG' (Analog Controller) - Voltage Controller

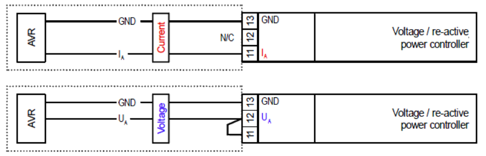


Figure 3-16: Controller - SPM-D21/PSVX - analog controller output - voltage

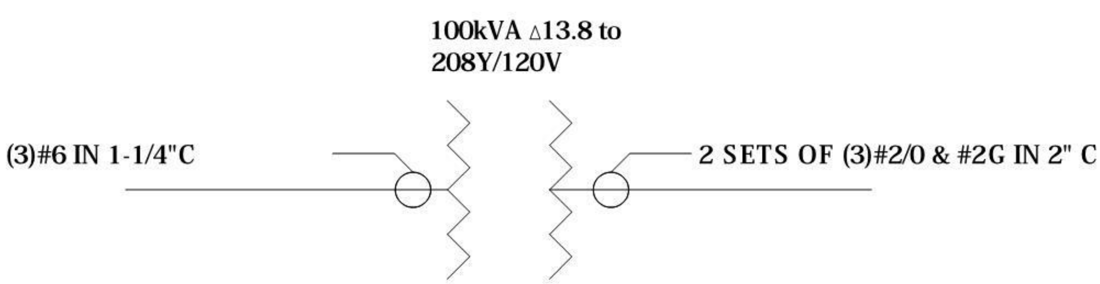
Type	Terminal		Description	A_{max}
I Current	11	I_A	Voltage controller	2.5 mm²
	12			2.5 mm²
	13	GND		2.5 mm²
U Voltage	11			2.5 mm²
	12	U_A		2.5 mm²
	13	GND		2.5 mm²

Transfer Switch, Transformer, Conductors, and Conduit

Equest was used to determine the peak demand load was 100kVA. For this project a transformer was needed, because the voltage from the generator was 13.8kVA.The transformer required is a 100kVA delta13.8kV to 208Y/120. The circuit breakers were found to be 25 amps on the primary side and 350amps on the secondary side from equations ## and ##. Both circuit breakers and three phase, therefore three pole. Circuit breaker sizes were designed based on NEC 2008 Section 450.3B). The size of the transfer switch is 350 amps. The conductors per National Electrical Code (NEC) Table 310.77 are three #6shielded underground MV-90 wires on the primary side. The conductors on the secondary side per NEC Table 310.16 are three THW wire size 500MCM. Alternatively the secondary side was chosen to be two sets of three #2/0, because #2/0 wires are easier to install. The ground on the secondary side is a #2 wire. The conduits were chosen to be 1-1/4” conduit on the primary side and two sets of 2” conduit on the secondary side per NEC Table C.8.

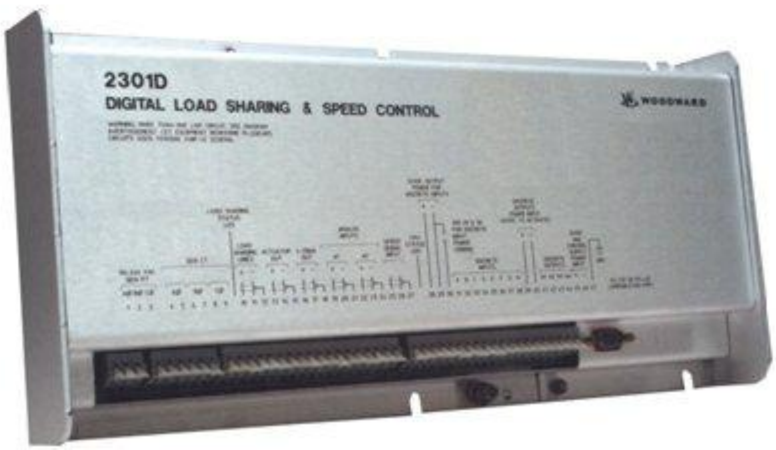
$$Ip = \frac{KVA}{KV_{primary}\sqrt{3}}\ x\ 6 = \frac{100KVA}{13.8KV\sqrt{3}} = 25\ A \qquad \text{Eq. 2}$$

$$Is = \frac{kVA}{kV_{secondary}}\ x\ 1.25 = \frac{100kVA}{0.208kV\sqrt{3}}\ x\ 1.25 = 347A \qquad \text{Eq.3}$$



PLC for Generator Woodward 2301D Load sharing and speed control

Another important component is the load sharing and speed control. The chosen control is the Woodward 2301D load sharing and speed controls. This device is used in electrical generator systems where load sharing is desired. It is used with diesel and gas engines, or steam and gas turbines. It is also compatible with all Woodward electronic controls. The microprocessor-based digital control is housed in a sheet metal chassis and consists of a single printed circuit board. The flexible configuration software incorporated in the control hardware allows easy changes to accommodate engine speed range, gear teeth, and selection of forward or reverse acting. The primary considerations in determining the control for the generator must have speed control, isochronous load sharing, droop base load, and isochronous base load.



The MSLC is used for this project to illustrate that there is synchronizing hardware capability for parallel generators. The MSLC is the master synchronizer and load control, phase matching and slip frequency automatic synchronizing of the local plant bus to the main power grid. Loading and unloading against the power grid. Base load, import/export and plant process control WYE, 120/240VAC 9907-004. The load sharing modules LSM with load sharing module with isochronous and droop load –sharing capability, 115/230 Vac power input, +/- Vdc bias output product number 9907-173. This type of master synchronizer is used when multiple generators are operating in parallel.

Return on Investment

There are kilowatt-hours (kwh), kilowatts (KW), and metering costs by the utility companies. The kilowatt-hour cost is the quantity of energy consumed. The kilowatt (kW) is the rate at which electricity is consumed. Commercial System Relief Program is the most beneficial for the client. Con Edison mandatory load reduction program notifies participants of event days/times and provides reservation payments monthly and energy payments for load reductions made by the customer during event hours. This program is activated by Con Edison during Con Edison's summer peak days or system critical situations. (Participants called an average of one to two days/year). The Client must participate during their network time-of-day peak time period if enrolled. The qualifications include having a minimum reduction of 50kW and the client must be a Con Edison customer located in the New York City with Billing Interval meter communications. Other demand response programs from Con Edison are shown in Appendix H.

The primary goal of using an onsite generator is for peak load shaving in the summer when the air handlers are used for cooling. Also, the generator will be used to replace the secondary power supply from the building. Currently, the owner is paying a monthly fee for the backup power supply. The electrical company Conedison in New York charges the customer per kWh, a peak demand load, and additional charges depending on the time of day. Since, electrical companies must size their electrical distribution system based peak demand loads.

This will reduce the peak loads on the building during the summer months when the air conditions are used. The possibility of using the generator for absorption cooling is possible and would need to be further analyzed. The building is currently using the combined heating the water for the hydronic system. The heat exchanger uses the steam from the central utility plant.

Financial Payment

Peak load shaving is when a generator is used to offset the electrical load on utility power. This saves money because the generator is fired up during peak times when kilowatt-hours are more expensive.

Energy: Payment equal to $0.50 for each kWh reduced

Reservation: Payment of $5.00 per kw-month

Bonus Payment: $5.00 for each of the average number of kW reduced during an emergency event

Table 12: Electricity and gas rates

2010 Energy Rates						
Electricity	Con Ed	Conventional Rates	Energy Charge		$0.1384097	/kWh
			Demand Charge	First 900 kW	$21.7235050	/kW
				Over 900 kW	$19.8071680	/kW
			Meter and Service Charges		$11.3679450	/month
Natural Gas	Con Ed		Firm		$17.20	/therm
			Temperature-Controlled		$10.10	/therm
			Off-Peak Firm		$17.40	/therm

Table 13: NYSERDA Demand Response Incentives

New York State Energy Research and Development Authority Demand Response Program	
Demand Response	$200/kW
Bonus Incentives - Fleet Integrated Demand Response	
Load shedding Ballasts	$50/kW

Table 14: Shows the Annual Cost Peak Load Savings

Baseline				Proposed Peak Load Shaving			
	Monthly Demand (kW)	Cost/Kw	Cost	Monthly Demand (kW)	Cost/Kw	Cost	Cost Savings
June	277.7	$21.723505	$6,032.62	177.7	$21.723505	$3,860.27	$2,172.35
July	329.6	$21.723505	$7,160.07	229.6	$21.723505	$4,987.72	$2,172.35
August	293.9	$21.723505	$6,384.54	193.9	$21.723505	$4,212.19	$2,172.35
				Annual Cost Peak Load Savings			$6,517.05

Table 15: Con Edison Commercial System Relief Program

Con Edison Commercial System Relief Program				
Assuming Three Emergency Events				
Bonus Payment: $5.00 for each of the average number of kW reduced during an Emergency Event				
	KW	$/kW	Refund	
June	100	$5.00	$500.00	
July	100	$5.00	$500.00	
August	100	$5.00	$500.00	
Payment equal to $0.50 for each kWh reduced				
	KWh	$/kWh	Refund	
June	100	$0.50	$50.00	
July	100	$0.50	$50.00	
August	100	$0.50	$50.00	
			Annual Refund	**$1,650.00**

Table 16: Shows the Total Annual Peak Load Savings

Annual Savings	
Peak Demand	$6,517.05
Con Edison Commercial System Relief Program	$1,650.00
Total	$8,167.05

Electrical Estimate and Payback

Woodward prices are used for the synchronizer and the PLC for generator. RS Means cost data was used for the other items of the estimate. The conduits for the low voltage control wiring are assumed to be ½" EMT. The hangers are assumed to be supported by bolt every 10 feet.

Table 17: Electrical Estimate

Type	Manufactor	model #	# sets	# Conductors	Quantity	Units	# Crew	Crew	Daily Output	Labor Hours	Unit	Material	Labor	Equip-ment	Total	Total Incl O&P	Total	Duration hours	Duration Week
Load Sharing and Speed Conrol for generator Clock equipments, time system components, frequenc generator, excl. wires and conduits	Woodward	2301D-EC			1	Ea.	1	1 Elec	2	4	Ea.	1526	182		1708	2135	2135	4	
PLC Controller to the set Electronic generator Governor	Included in 2301D-EC																		
Synchronizers Voltage Monitor System AC Monitor system, 208/120V,	Woodward	SPM-D21			1	Ea.	2	2 Ele	1	16	Ea.	1520	730		2250	2812.5	2813	8	
Modem Adapter for synchronizer					1	Ea.	1	2 Ele	2	8	Ea.	415	200		615	768.75	769	8	
Add-on detector only					1	Ea.	1	2 Ele	3	2	Ea.	1725	300		2025	2531.25	2531	2	
Inter-tie protection (relays)	Included in SPM-D21																		
Control Wiring 600 volt, copper, #14 THWN wire with PVC jacket, 2 wire					14.2	C.L.F.	1	1-Ele	9	0.889	C.L.F.	27.5	42		69.5	92	1306	13	
Control Conduit To 15' high,includes couplings only Electric metallic tubing,1/2" diameter					1420	L.F.	1	1-Ele	435	0.018	L.F.	0.49	0.86		1.35	1.83	2599	26	
Hangers with bolts every 10 feet					142	Ea.	1	1-Ele	200	0.04	Ea.	0.61	1.88		2.49	3.47	493	6	
EMT Field bends, 45° to 90°, 1/2" diameter every 20 ft					71	Ea.	1	1-Ele	89	0.09	Ea.		4.22		4.22	6.3	447	6	
Dry Type Transformer 3 phase, 13.8kV primary 208Y/120 V secondary 100kVA					1	EA	2	R-15	2.75	17.46	EA	3075	800	120	3995	4725	4725	9	
Transformer Handling add to labor cost in restricted areas 100kVA, approximately 700 pounds					1	EA	2	2 Ele	1.6	10	EA		470		470	700	700	5	
Transformer feeder Primary #6 MV-90			1	3	0.6	C.L.F.	1	2 Ele	4.4	3.636	C.L.F.	168	171		339	440	264	2	
Transformer feeder Secondary 2 sets (3)#2/0			2	3	0.6	C.L.F.	1	2 Ele	5.8	2.759	C.L.F.	325	130		455	555	333	2	
Transformer feeder ground for secondary side #2			2	1	0.6	C.L.F.	1	2 Ele	9	1.778	C.L.F.	168	83.5		251.5	310	186	1	
Rigid galvanized Steel 1-1/4" Conduit			1		60	L.F.	2	1 Ele	60	0.133	L.F.	6.15	6.25		12.4	16.1	966	4	
Rigid galvanized Steel 2" Conduit			2		60	L.F.	2	1 Ele	45	0.178	L.F.	9.25	8.35		17.6	22.5	1350	5	
350 AMP 3 Pole CB Secondary Side Transformer					1	EA	1	2 Ele	1.8	8.889	EA	1550	420		1970	2350	2350	9	
25 A 3 Pole CB Primary Side Transformer					1	EA	1	1Ele	5.3	1.509	EA	495	71		566	650	650	2	
																	24617	**110.6**	**2.8**

Table 18: Payback Period for Demand Response Program

Year	Demand & Incentives	System Cost	Payback
1	$8,167.05	24617	-$16,449.95
2	$14,684.10	24617	-$9,932.90
3	$21,201.15	24617	-$3,415.85
4	$27,718.21	24617	$3,101.21
5	$34,235.26	24617	$9,618.26
6	$40,752.31	24617	$16,135.31
7	$47,269.36	24617	$22,652.36
8	$53,786.41	24617	$29,169.41
9	$60,303.46	24617	$35,686.46
10	$66,820.52	24617	$42,203.52
11	$73,337.57	24617	$48,720.57
12	$79,854.62	24617	$55,237.62
13	$86,371.67	24617	$61,754.67
14	$92,888.72	24617	$68,271.72
15	$99,405.77	24617	$74,788.77

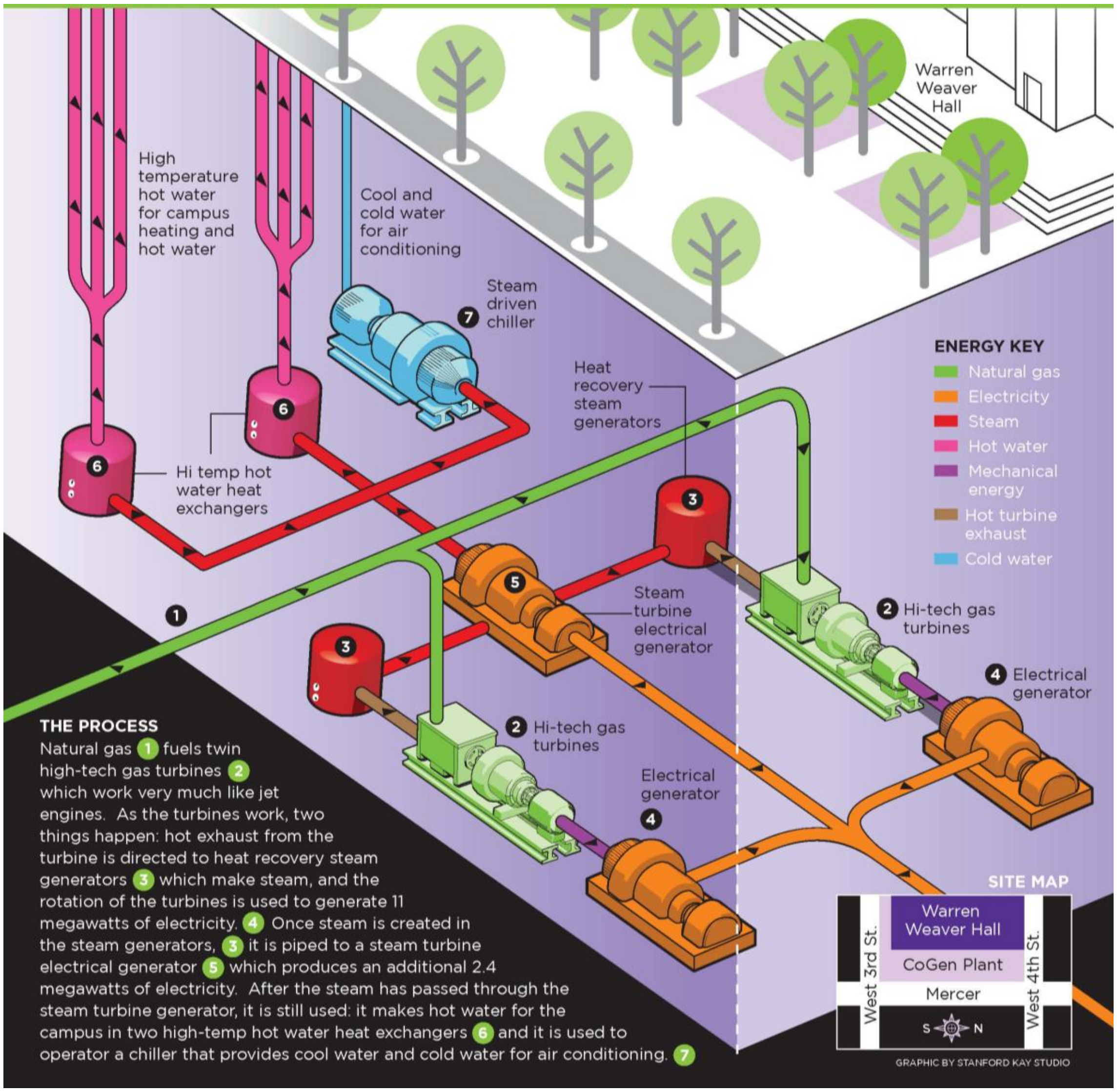
Appendix H: ConEdison Demand Response Programs

conEdison — Demand Response Program Comparison Guide - Business Customers

	CON EDISON PROGRAMS					NEW YORK INDEPENDENT SYSTEM OPERATOR (NYISO) PROGRAMS	
Program Name	Distribution Load Relief (DLRP) Voluntary Option	Distribution Load Relief (DLRP) Summer Reservation Payments Option	Commercial System Relief Program (CSRP)	Critical Peak Rebate Program (CPRP) LIMITED ENROLLMENT PROGRAM	Direct Load Control (DLC)	Emergency Demand Response (EDRP)	Installed Capacity-Special Case Resource (SCR)
Electric Tariff Rider	U	U	S	T	L	Con Edison Rider V or may enroll through NYISO or Curtailment Service Provider (CSP)	Con Edison Rider P or may enroll through NYISO or Responsible Interface Party (RIP)
Description	Con Edison voluntary load-reduction program notifies participants of event days/times and provides payments for load reductions made by the customer during event hours. Activated by Con Edison in system critical situations. (Participants called an average of less than one day/year)	Con Edison mandatory load-reduction program notifies participants of event days/times and provides reservation payments monthly and energy payments for load reductions made by the customer during event hours. Activated by Con Edison in system critical situations. (Participants called an average of less than one day/year)	Con Edison mandatory load-reduction program notifies participants of event days/times and provides reservation payments monthly and energy payments for load reductions made by the customer during event hours. This program is activated by Con Edison during Con Edison's summer peak days or system critical situations (Participants called an average of one to two days/year)	Con Edison pilot to test small and large business customers' response to reduce loads when called upon. Con Edison notifies participants of event days/times and provides payments for load reductions made by the customer during event hours. This program is activated by Con Edison during Con Edison's summer peak days or system critical situations. (Participants called an average of one to two days/year)	Activated by the NYISO or Con Edison in system critical situations. Central air-conditioning load-reduction program for residential and small commercial business customers. Wireless signal sent to thermostat to periodically cycle the central air conditioning compressor on and off; fan remains in operation. Participants can override signal if necessary. (Participation called an average of two days/year) Con Edison is conducting a pilot, in which participants are notified of event days/times when Con Edison's summer peak days reach summer forecasted system peak. Participants may be called two or three times per year.	Voluntary load-reduction program activated by the NYISO to maintain reliability of the State's transmission system. Customers can apply through the NYISO, Con Edison, or Curtailment Service Provider (CSP). (Participants called an average of two days/year)	Mandatory load-reduction program activated by the NYISO to maintain reliability of the State's transmission system. Customers can apply through the NYISO, Con Edison, or Responsible Interface Party (RIP) (Participants called an average of two days/year)
Requirements	Individual: Minimum reduction - 50 kW Aggregator: Minimum reduction - 100 kW Con Edison customer with Billing Interval Meter and communications	Individual: Minimum reduction - 50 kW Aggregator: Minimum reduction - 100 kW Con Edison customer with Billing Interval Meter and communications	Individual: Minimum reduction - 50 kW Aggregator: Minimum reduction - 100 kW Mandatory participation (as enrolled): Must participate during their network time-of-day peak time period Con Edison customer located in New York City with Billing Interval Meter and communications	Individual: Minimum reduction - 1kWh/h (less than 250kW demand) Individual: Minimum reduction - 10 kWh/h (greater than 250kW demand) Aggregator: Minimum reduction - 100 kWh/h Agreement to participate in program events Con Edison customer located in New York City with Billing Interval Meter and communications (or company approved metering device for participants less than 250kW demand)	Con Edison customers with less than 100kW of demand Central air-conditioning	Minimum reduction - 100 kW Interval Meter	Minimum reduction - 100 kW Interval Meter Load reduction minimum of four hours
Benefits	Free or reduced cost equipment to help manage your energy use Improved electric system reliability for yourself and your community Financial incentives for participation	Free or reduced cost equipment to help manage your energy use Improved electric system reliability for yourself and your community Financial incentives for participation	Improved air quality in your community Designed to delay capital costs associated with growing electric demand Free or reduced cost equipment to help manage your energy use Improved electric system reliability for yourself and your community Financial incentives for participation	Improved air quality in your community Designed to delay capital costs associated with growing electric demand Free or reduced cost equipment to help manage your energy use Improved electric system reliability for yourself and your community Financial incentives for participation	Free equipment to help manage your energy use Improved electric system reliability for yourself and your community Designed to delay capital costs associated with growing electric demand	Improved electric system reliability for yourself and your community Financial incentives for participation	Improved electric system reliability for yourself and your community Financial incentives for participation
One-Time Rebates and Incentives	May be eligible for NYSERDA metering and equipment rebates Visit www.nyserda.org for more information	May be eligible for NYSERDA metering and equipment rebates Visit www.nyserda.org for more information	May be eligible for NYSERDA metering and equipment rebates Visit www.nyserda.org for more information	May be eligible for NYSERDA metering and equipment rebates Visit www.nyserda.org for more information	Free programmable thermostat installed at no charge that can be either manually or remotely controlled by the customer via the internet, or the mobile phone. $50 after installation thank you gift Additional $50 after the summer capability, if no peak shaving events are overridden	May be eligible for NYSERDA metering and equipment rebates Visit www.nyserda.org for more information	Maybe eligible for NYSERDA metering and equipment rebates Visit www.nyserda.org for more information
Payment	Energy: Payment equal to $.50 for each kWh reduced Reservation (capacity): Not Applicable Bonus Payments: Not Applicable	Energy: Payment equal to $.50 for each kWh reduced Reservation (capacity): Tier I capacity payments are $3.00 per kW-month for up to six load events up to five hours each in a designated network. Tier II capacity payments are $6.00 per kW-month for six load events up to five hours each in a designated network. Bonus Payments: $1.00 per kW per month for a response to seven to nine Load Relief Periods or six to seven hours in an event $1.50 per kW per month for a response to ten or more Load Relief Periods or eight or more hours in an event	Energy: Payment equal to $.50 for each kWh reduced Reservation: Payment of $5.00 per kw-month Bonus Payments: $5.00 for each of the average number of kW reduced during an emergency event	Payment: $1.50 for each kWh reduced Reservation (capacity): Not Applicable Bonus Payments: $5.00 for each of the average number of kW reduced during an emergency event	Not Applicable	Energy Payment: Equal to the greater of $.50 for each kWh curtailed, or the real-time zonal locational-based marginal price, but no less than $.50 per kWh curtailed paid to CSP Reservation (capacity): Not Applicable Bonus Payments: Not Applicable	Energy Payment: Equal to the greater of $.50 for each kWh curtailed, or the real-time zonal locational-based marginal price for an event, but no less than $.50 per kWh curtailed paid to RIP Reservation (capacity): Monthly Capacity payment based on ICAP auction clearing price Bonus Payments: Not Applicable
Penalty	Not Applicable	Derating based on performance in DLRP tests or events with not less than two hour notification	Two times the reservation payment for each kW reduction in the month not achieved and derating based on performance in planned events with not less than 21 hour notification	Not Applicable	Not Applicable	Not Applicable	Participants will be derated for the following capability period if reduced kW did not meet the contracted demand. Deficiency charge equal to one and one-half times the applicable Market-Clearing Price of Unforced Capacity to RIP for MW shortfalls. For more information visit the NYISO deficiency charge
Program Period	Year-round voluntary participation	May 1 through October 31	May 1 through October 31	May 1 through October 31	May 1 through October 31	May 1 - October 31 and/or November 1 - April 30	May 1 - October 31 and/or November 1 - April 30
Notification	Planned events: Not applicable Critical situations: As system needs require Participants will be notified by the means they designate when enrolled (phone and email required, text message optional)	Planned events: Not applicable Critical situations: As system needs require, two hours in advance for mandatory participation Test events: Two hours in advance Participants will be notified by the means they designate when enrolled (phone and email required, text message optional)	Planned events: 21 hours and two hours in advance Critical situations: As system needs require Participants will be notified by the means they designate when enrolled (phone and email required, text message optional) Event information posted to www.conEd.com/dr	Planned events: 21 hours and two hours in advance Critical situations: As system needs require Participants will be notified by the means they designate when enrolled (phone and email required, text message optional) Event information posted to www.conEd.com/dr	A curtailment message is displayed on the programmable thermostat and event information is posted on www.conEd.com/cool	Notification from the NYISO to all listed Curtailment Service Providers (CSPs) email addresses and an automated phone call to each CSPs main contact phone number. The Curtailment Service Provider contacts the customer. The NYISO provides a day-ahead advisory and two hour advance notice to CSPs.	Notification from the NYISO to all listed Responsible Interface Parties' (RIP) email addresses and an automated phone call to each RIPs main contact phone number. The Responsible Interface Party contacts the customer. The NYISO provides a 21-hour advisory and two hour advance notice to RIPs.
Enrollment and Program Information	Website: www.conEd.com/dr Email: dr@conEd.com Phone: 1-877-870-6118	Website: www.conEd.com/dr Email: dr@conEd.com Phone: 1-877-870-6118	Website: www.conEd.com/dr Email: dr@conEd.com Phone: 1-877-870-6118	Website: www.conEd.com/dr Email: dr@conEd.com Phone: 1-877-870-6118	Website: www.conEd.com/cool Email: dr@conEd.com Phone: 1-888-521-0600	Visit the NYISO or Website: www.conEd.com/dr Email: dr@conEd.com Phone: 1-877-870-6118	Visit the NYISO or Website: www.conEd.com/dr Email: dr@conEd.com Phone: 1-877-870-6118

This Comparison Guide is meant for reference purposes only. Complete program information is located at www.coned.com/dr
January - 11

Appendix I.1: Project X's Generator System



Appendix I.2: Synchronizer Control Wiring Quantity Take Off

TERMINAL #	BUILDING	GENERATOR	TERMINAL #	BUILDING	GENERATOR
1	20		26	20	
2	20		27	20	
3	40		28	20	
4	20		33	20	
5	20		34	20	
6	20		35	20	
7	20		36	20	
8		60	37	20	
9		60	38	20	
10		60	39	20	
11		60	40	20	
12		60	41	20	
13		60	42	20	
14	20		43	20	
15	20		44	20	
16	20		45		60
17	20		46		60
18	20		47		60
19	20		48		60
20	40		50	40	
21	20		51	20	
23	20		52	20	
24	20		53	20	
25	20		54	20	
TOTAL LENGTH	**14 AWG**			**1420**	**LF**

V. Analysis 3: Utilizing a Matrix Schedule

Background

The University's central combined heat and power (CHP) plant was connects its high temperature hot water and chilled water piping to the Project X building. The site congestion caused the high temperature hot water and chilled water piping (hw/cw) to be moved from occurring in the interior fit-out stage to the end of the project. All of the following trades were accelerated drywall, electric trim, taping, and paint with overtime. Also, carpet and furniture was installed on second shift. Therefore material deliveries had to be made frequently. Since, second shift and overtime work had to be done there was not enough room on the site to close down both lanes of traffic in-front of the site to allow for the hw/cw piping placement.

Opportunity for Improvement

For logistical reasons it is always better to do the site utility tie-ins before the masonry and interior fit-out begins. The plumbing utilities which included hw/cw piping can be re-sequenced to occur in one of the earlier stages of construction.

Potential Solution

When the site utility tie-in occurs during the demolition stage of construction two weeks would be saved at the end of the project schedule when this activity actually occurred on the site. In analysis 2 the electrical power connection to the building was evaluated. The CHP's electrical tie-in will be considered in the new matrix schedule.

Research/Analysis Steps

1. Perform research on matrix scheduling techniques.
2. Divide the site into zones
3. Determine the duration of time to complete each construction activity.
4. Create a matrix schedule for the site plan based on the grid lines and the time durations of each construction activity.
5. Re-sequence the hw/cw piping and electrical tie-in to the Central CHP plant.
6. Discuss the viable alternatives with the Skanska project team and design team.
7. Reissue the site plan to account for the underground MEP work.

Expected Outcomes

This analysis should visually prove that there is adequate space on the site plan to conduct the hw/cw piping and electrical tie-in to the Central CHP plant at the same time as the demolition.

Resources

John Gunning- Project Manager at Skanska

Dr. Rob Leicht- Assistant Professor of Architectural Engineering, The Pennsylvania State University

Schedule Analysis

The site congestion of working in NYC creates a limit construction site. On the site there is no lay down area thus all of the deliveries had to be delivered loaded off of the truck onto the building the same day. The first step in the process of finding a suitable alternate schedule for the utilities was to evaluate the site plan in terms of zones. Next, the summary schedule was added in excel above the matrix schedule.

One of the lanes on a two way street was closed during the construction to allow for deliveries to be made on a daily basis. Throughout the duration of the construction a crawler crane was used extensively. This crawler crane was placed on the closed traffic lane. The crawler crane was used from the start of construction until the interior finishes activities started. This required a construction barricade to be constructed to allow for construction deliveries and a path for the crane to move. During nonworking hours a pedestrian walk way was constructed with overhead protection passed in between the barricade and the building footprint.

The Project was divided into four primary phases. These three phases are illustrated in Figure 1

Stage 1: 6/15/08-5/19/09 this phase includes the hw/cw CHP tie-in,domestic water tie was made, and the demolition above grade.

Stage 2: 5/15/09-9/1/09 this phase includes the below grade activities of the demolition, excavation, and foundations.

Stage 3: 9/1/09-5/1/10 this phase includes the building frame, exterior façade, site preparation, site finishes, and interior fit-out.

10/14/09-11/16/09 this phase includes the MEP connection to the building.

Stage 4: 5/12/10-5/15/10 during this time period new sidewalks were poured and trees were planted.

Stage 1 was chosen for the site utility tie-in, because at this stage, there was no crane on site. This stage had no material deliveries other than the steel needed for bracing the north wall of the adjacent structure. This steel consisted of only a few c-channels. Also, there were dump trucks used for removing debris. It was determined the best time for the underground CHP tie-in was before the superstructure’s cast-in-place concrete work and masonry work began, because both required a crawler crane. The project manager explained that the utilities could be brought to within three feet of the outside foundation wall during the demolition stage and tied in later through a knockout in the foundation wall. The design was not complete at the demolition phase 1, so measures would have had to be taken to complete the design earlier.

The durations used for the concrete work was found in Appendix F. The masonry construction durations were determined from RS Means. The masonry quantities were found by doing a manual take off of material on each of the facades. The masonry's crew sizes utilized four separate crews. The other durations were determined from evaluating the project schedule. The following equation was used to calculate the durations:

Duration=[Quantity x (man-hrs/frame)]/[(8hrs/day) x workers in crew]

Table 19: Summary of the Exterior Masonry Wall Façade

Summary of Masonry Work	
Total Cost	1,131,663.76
Total Hours	3102.0555
Total Days	387.7569375
Total Weeks	77.5513875

Figure46: Shows 3D Map of Site from Google Earth (This Illustrates the Height of the Surrounding Structures, as well as the Property Line in Red)

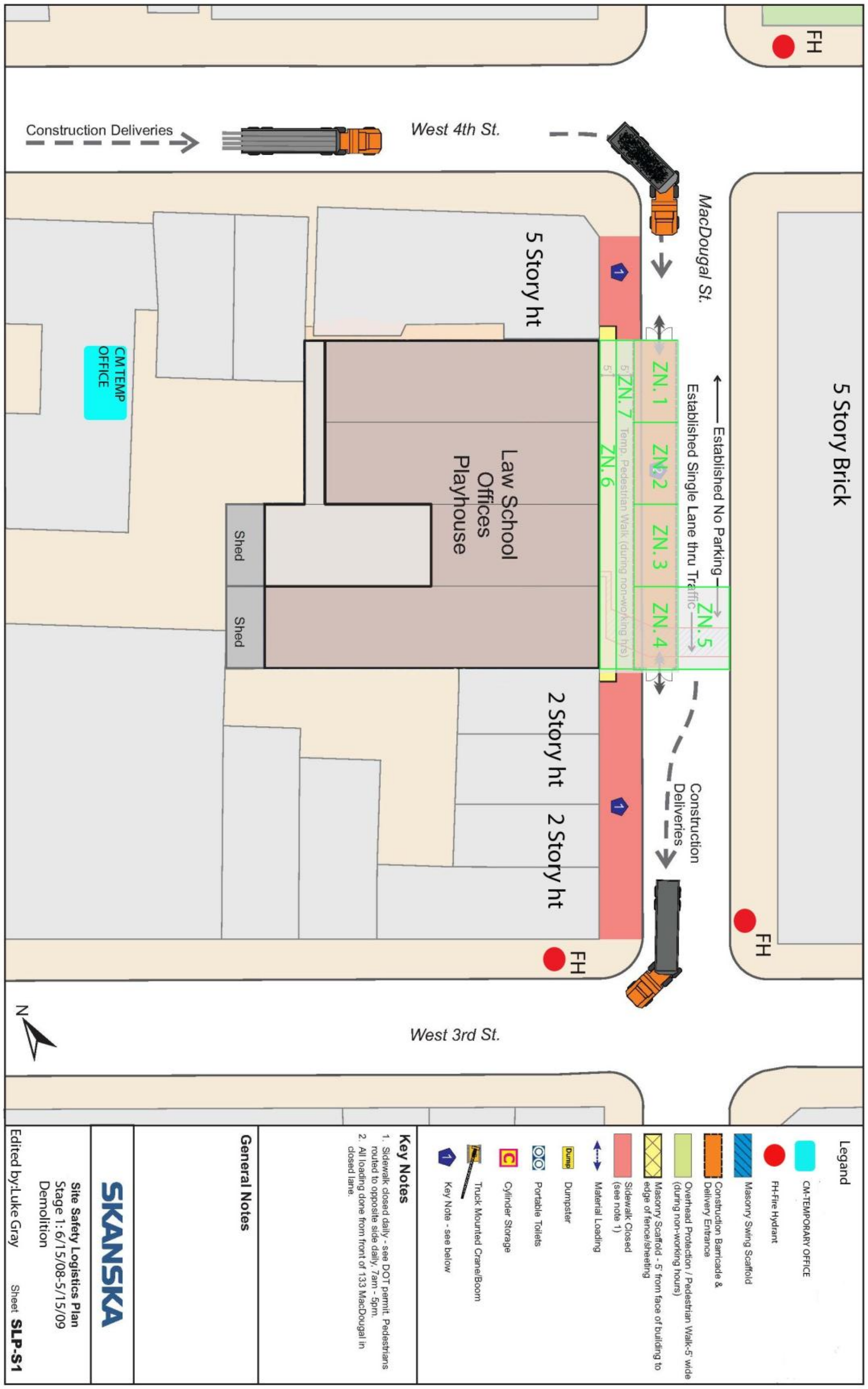
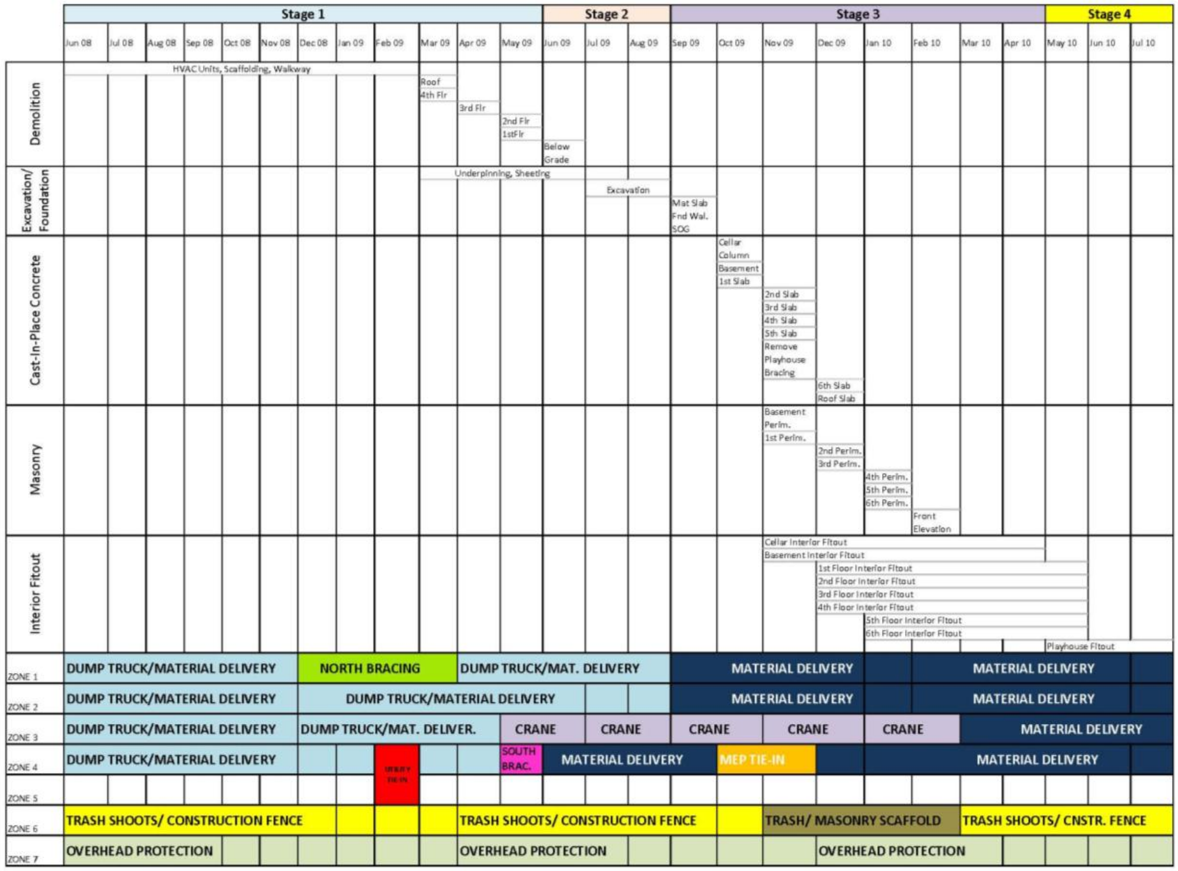


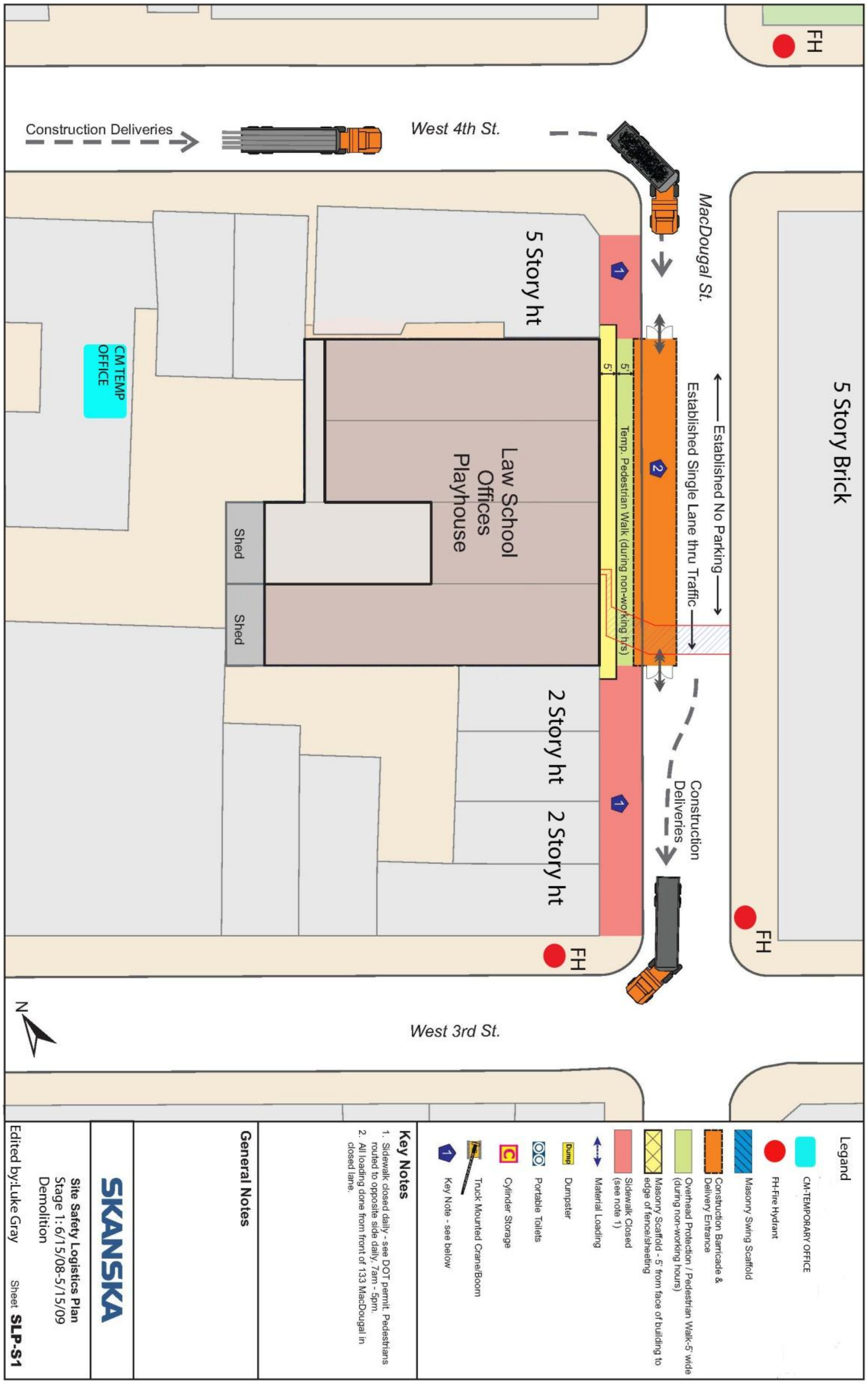
Figure 47: Shows the Site Plan with the Zones as an overlay.



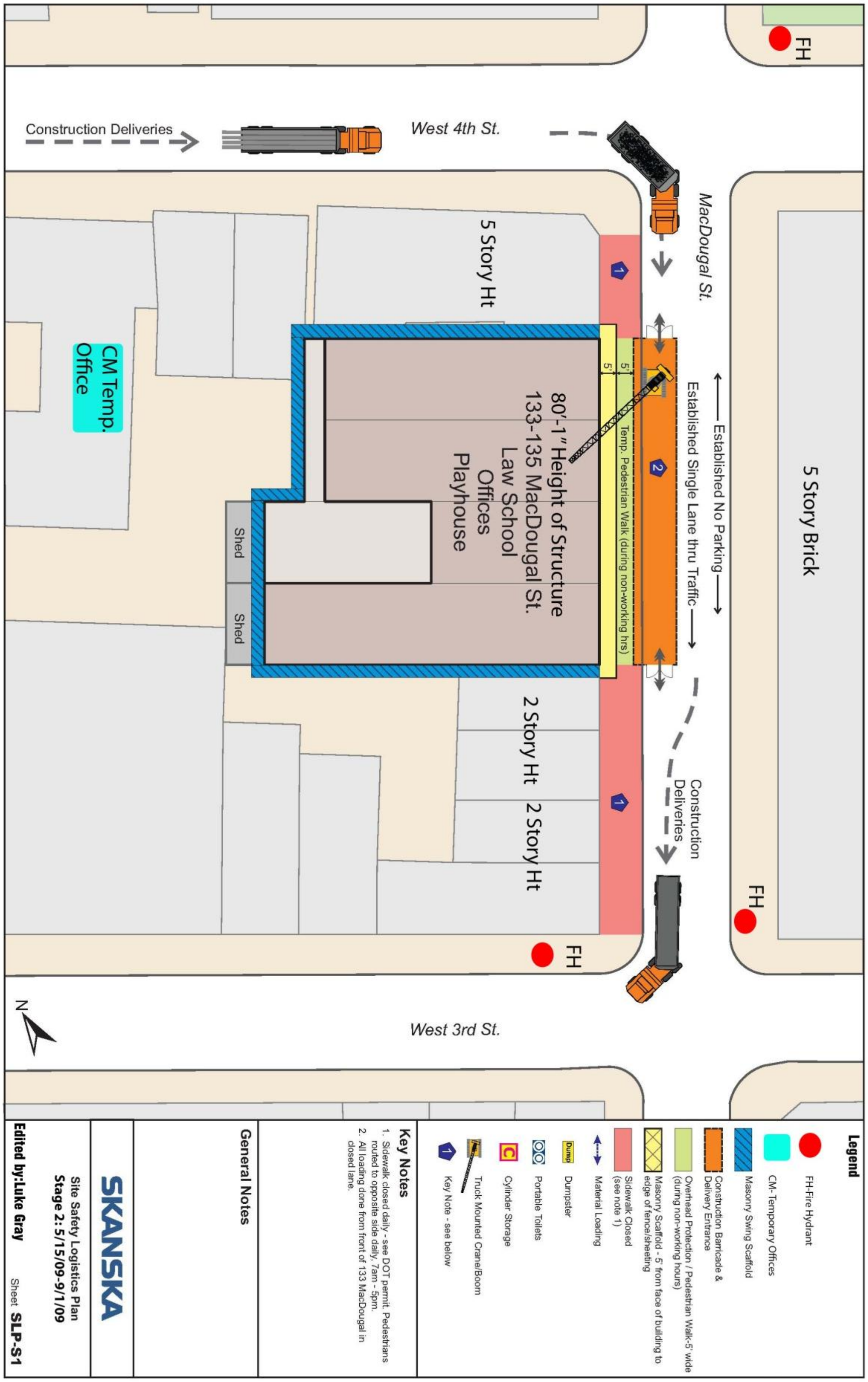
	KEY
	DUMP TRUCK/MATERIAL DELIVERY
	MATERIAL DELIVERY
	CRANE
	OVERHEAD PROTECTION
	TRASH SHOOTS/ CONSTRUCTION FENCE
	TRASH SHOOTS/ MASONRY SCAFFOLD
	SITE UTILITY TIE-IN
	MEP TIE-IN SERVICES VIA FOUNDATION WALL
	SOUTH BRACING
	NORTH BRACING

Figure 48: Matrix Schedule of site logistics zones with summary schedule above.

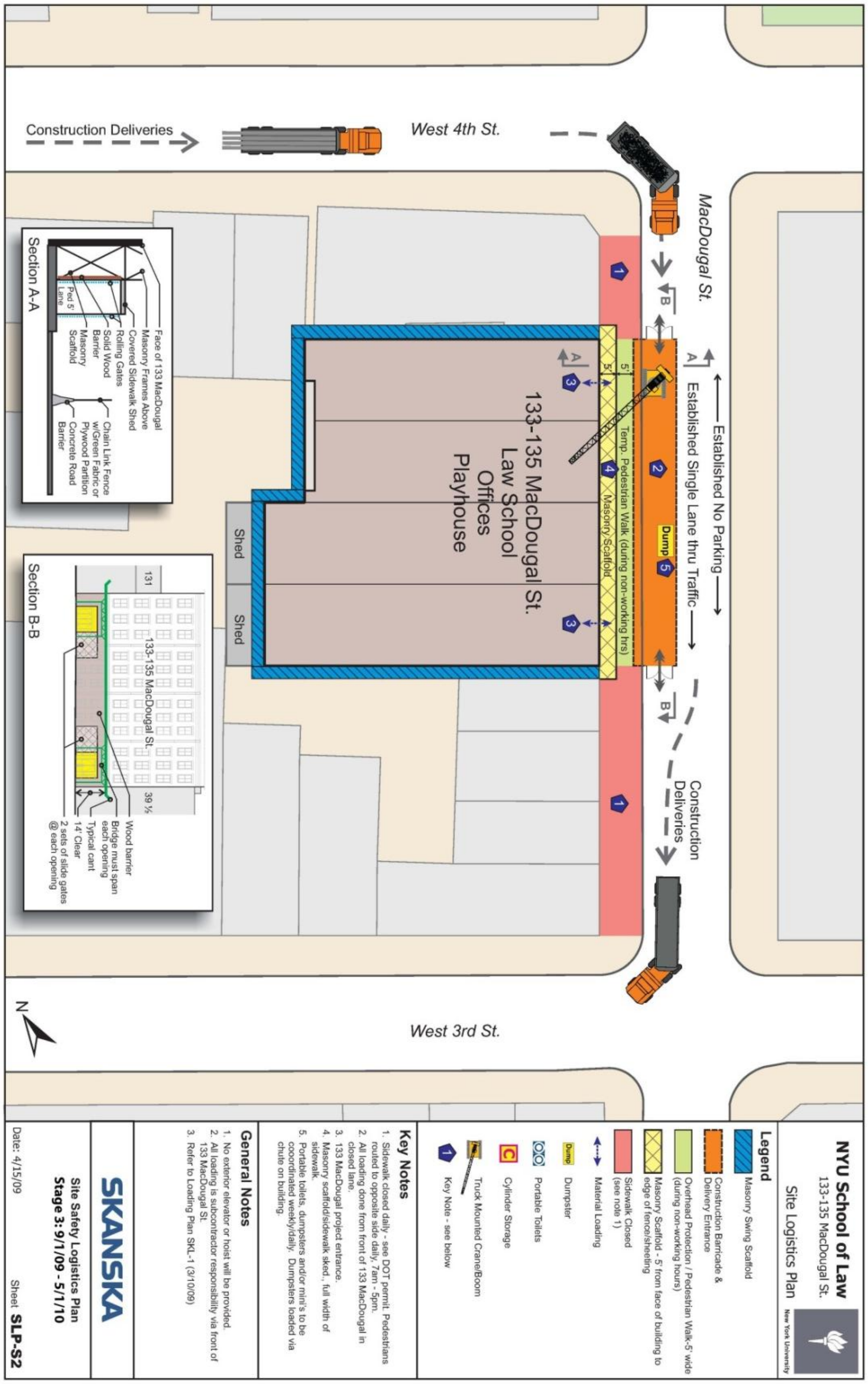
Appendix J: Stage 1 Demolition Site Plan



Appendix K: Stage 2 Super Structure and Masonry Site Plan

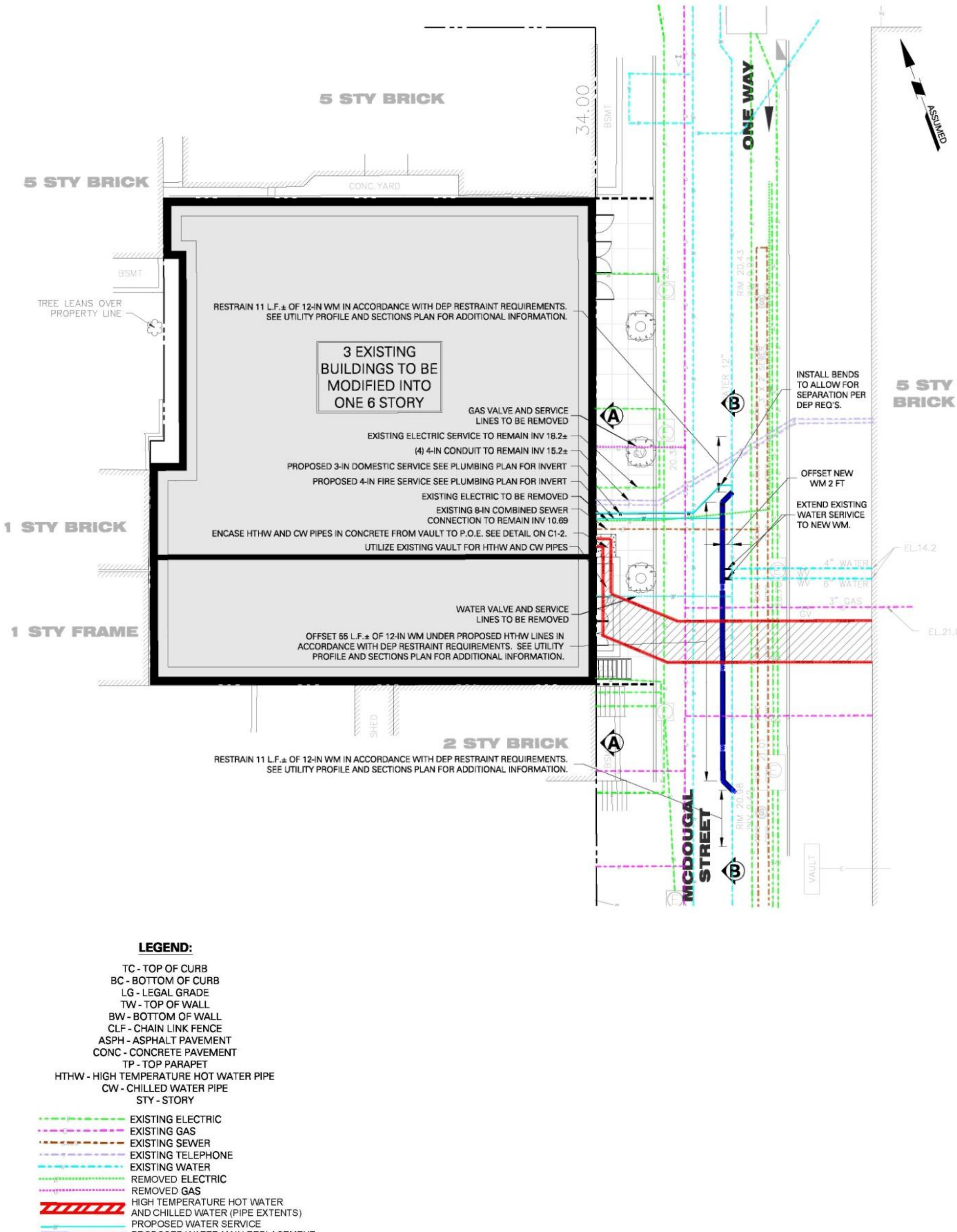


Appendix L: Stage 3 Interior Fit-out Site Plan



Telehandler equipment was used in place of the crane for the interior fit-out Phase 3.

Appendix L: Site Utility Site Plan



Appendix M: Masonry Wall Quantity Take Off

Masonry Wall						
East Elevation						
Windows G	36	SF	54	Ea.	1944	SF
Windows C	18	SF	6	Ea.	108	SF
Window E	14.4	SF	2	Ea.	28.8	SF
Window F	24	SF	1	Ea.	24	SF
Door	40	SF	4	Ea.	160	SF
Total Windows/Doors					2264.8	SF
Total Façade					5081.64	SF
Total Masonry					2816.84	SF
West Elevation						
Windows	24	SF	40	Ea.	960	SF
Total Windows					960	SF
Total Façade					5328	SF
Total Masonry					4368	SF
North Elevation						
Windows	24	SF	12	Ea.	288	SF
Total Windows					288	SF
Total Façade					5332	SF
Total Masonry					5044	SF
South Elevation						
Windows	24	SF	22	Ea.	528	SF
Total Windows					528	SF
Total Façade					3400	SF
Total Masonry					2872	SF
Total Masonry					**15100.84**	**SF**

Appendix N: Masonry Wall Façade Durations

	Crew	# of Crews	Daily Output	Labor Hours	Unit	Material	Labor	Equip-ment	Total	Total Incl O&P	Quantity	Units	Total Cost	Total Daily Outputs	Total Labor Hours	Total Days	TOTAL WEEKS
Selective Demolition of Existing Masonry																	
3 courses of 4" brick and 3/8" mortar Joint																	
Concrete block walls, unreinforced 12" thick	2-Clab	4	950	0.017	SF		0.53		0.53	0.83		SF	0		0		
New Masonry																	
Multiple-Wythe Unit Masonry Cavity Wall																	
Bricks and CMU includes joint reinforcing and ties 4" face brick 8" Block	D-8	4	125	0.32	SF	7.7	11.9		19.6	26.5	15100	SF	400150		4832		
Coloring					Lb.	5.4			4.5	5.95	100	Lb.	595		0		
Control Joint at every 20'																	
Rubber, for wythe (Brick/CMU)	1-Bric	4	400	0.2	LF	1.9	0.81		2.71	3.32	1059	LF	3515.88		211.8		
Shelf Angle 4 at each floor	E-4	4	267	0.12	LF	20.5	5.4	0.5	26.4	32.5	6938.4	LF	225498		832.608		
Masonry Anchors																	
For brick veneer, galv., corrugated, 7/8" x 7", 22 Ga	1-Bric	4	10.5	0.762	C	9.8	31		40.15	57	10	C	570		7.62		
2" Insulation Foam Board R8	1 Carp	4	675	0.012	SF	0.62	0.47		1.09	1.41	23128	SF	32610.48		277.536		
Sheet metal Flashing& Counter Flashing 0.05" thic	1 Rofc	4	145	0.005	SF	2.52	1.89		4.41	5.95	2000	SF	11900		10		
Granite Base at Mac Dougal Street 4" thick, veneer	D-10	4	110	0.291	SF	60	11.45	5.45	76.9	89.5	70	SF	6265		20.37		
Precast Lintel 4" wide, 8" high, to 5' Long	D-10	4	28	1.143	Ea.	25.5	45	21.5	92	120	48	Ea.	5760		54.864		
Precast window Sill 4" tapers to 3", 9" wide	D-1	4	70	0.229	LF	11.75	8.3		20.05	25.5	576	LF	14688		131.904		
Steel angles Lintel 3-1/2"x3"-1/2"x5/16", 5'0" Long	1-Brick	4	18	0.44	Ea.	43	18		61	75	99	Ea.	7425		43.56		
Terra Cotta Cornice (18" High)	D-1	4	90	0.178	LF	20.4	6.45		16.85	21.5	372	LF	7998		66.216		
CMU at Lot Line walls adjacent Buildings																	
C90, 2000psi Normal weight, 8" x 16" units, tooled joint 1 side Not-reinforced, 2000psi, 8" thick	D-8	4	400	0.1	SF	2.23	3.72		5.95	8.1	4000	SF	32400		400		
CMU Backup at Terra Cotta Cornice																	
(18" High) C90, 2000psi Normal weight, 8" x 16" units, tooled joint 1 side Not-reinforced, 2000psi, 8" thick	D-8	4	400	0.1	SF	2.23	3.72		5.95	8.1	744	SF	6026.4		74.4		
CMU Backup at 6th floor																	
C90, 2000psi Normal weight, 8" x 16" units, tooled joint 1 side Not-reinforced, 2000psi, 8" thick	D-8	4	400	0.1	SF	2.23	3.72		5.95	8.1	3284	SF	26600.4		328.4		
Air/Vapor Barrier Polyethylene vapor barrier, 0.10" thick	1-Carp	4	37	0.216	Sq.	1.09	8.65		9.74	14.6	23128	Sq.	337668.8		4995.648		
CMU Bond Beam																	
C-90, 2000psi including grout and 2#5 bars Regular block 8" high, 8" thick	D-8	4	300	0.133	LF	5.15	4.95		10.1	13.15	912	LF	11992.8		121.296		
TOTALS													**1,131,663.76**		**3102.056**	**387.7569**	**77.55139**

C	100
SF	Square Feet
LF	Linear Feet
Sq.	100 SF

Abbreviations

Critical Industry Issue: Building Information Model (BIM) and Facility Management Integration

Background

Currently, building owners don't know the how the BIM can be used after construction. In most cases, the BIM is archived and the long-term value of the model is lost. Another problem that arises is the fact that there is not a building management system (BMS) that is integrated into the BIM. Yet, the solution is close at hand. "Building information modeling is certainly the most talked about technology. In fact, market research indicates that more than 50% of the building and construction industry is now using BIM in some form." (ENR November 22, 2010) Despite these numbers, many owners still don't know what to do with the BIM after construction. How can owners utilize the BIM for facility maintenance and operations?

Opportunity for Improvement

The solution begins by investigating the end uses of the model before the construction begins. On most projects, the data owners need for facility maintenance, certification, and inspection is not included in the model. The reason this happens is due to the fact that owners don't incorporate these requirements in the specifications. Thus, this information must become apparent in order to include them in the BIM execution plan. This way, the contractors and designers won't include too much or too little information. Ideally, the contractor would have recommendations from the owner; however owners don't necessarily know all the choices. The University X's contract with the subcontractors does not require BIM to be used neither does it require coordination of the BIM model with the project closeout documentation. Granting all this and taking in consideration that this new technology is still in its developing stages, owners are increasingly creating BIM of their existing facilities and requiring as-built drawing without knowledge of how to utilize the BIM after construction.

Potential Solution

The University X is currently looking at alternative ways of storing maintenance information. The goal of this research is to develop a way to utilize the BIM for the owners BMS. Additionally, this research will discover maintenance data which would be beneficial to be stored in a BIM for easy accessibility by the maintenance department.

Research/Analysis Steps

The following are achieved goals in shadowing The Pennsylvania State University's OPP Area services.

1. Analyzed ways the trades can use the BIM to easily find drawings electronically through linking drawings to the model without having to reference hundreds of drawings.
2. Analyzed ways maintenance can use the model to easily find specifications electronically through linking specifications to the model without having to reference thousands of specifications.
3. Analyzed which maps and O&M are used by the universities maintenance department.
4. Analyzed ways the owners can store design intent in the BIM for reference when buying new equipment for clarification.

5. Analyzed which energy management system, BMS, Cafum, MMS, CMMS, or ARTRA is being used by The Pennsylvania State University and University X.
6. Developed a strategy for universities' maintenance department to organize data within the BIM model.
7. Recognized common renovation changes that can be updated simultaneously in the BMS and BIM.
8. Input examples MEP equipment into the Project X BIM.
    a. AHUs, VAVs, VFDs
    b. Plumbing fixtures, domestic water booster pump, storage water heater
    c. Light fixtures, panel boards, switch gears, transformers
    d. Smoke detectors, manual pull stations, fire alarm control panel

9. Input the data from steps one to six into BIM equipment using the method using the COBie approach to entering the data.

This was accomplished by shadowing The Pennsylvania State University's OPP and University X's OPP. Andy Ellenberger is the supervisor Area Services at The Pennsylvania State University. Area Services has granted me permission to shadow maintenance personal starting December 15, 2010 to December 23, 2010. In addition, this research will require shadowing Project X's Facility and Construction Management service's personal in charge of such responsibilities: electrical work, emergency repairs, environmental systems, everyday maintenance, plumbing and piping, preventative maintenance, refrigeration. It is imperative for Area Services to identify the location and O&M required for maintenance in the least amount of time possible.

Expected Outcomes
It is expected that this research will result in a greater understanding of how owners can use the BIM for facility management. Provide a guide for implementation of facility management software from the initial conceptual phase to operation and maintenance.

Implementation

CtrlSpecbuilder was used to create such documents: specifications, consistency and technical compliance checklist, sequence of points list, and equipment schematics. This was done to find typical control points for one of the multi zone air handlers unit (AHU). This simple AHU has 13 hardware points and 34 software points. The description of sequence of points can be found in Appendix O. The unit includes the following points as shown in Figure ##

Freeze Protection
Supply Air Smoke Detection
Supply Fan
Return Fan
Cold Deck Cooling Supply Air Temperature Setpoint-Optimized
Cold Deck - Cooling Coil Valve:
Hot Deck - Heating Supply Air Temperature Setpoint - Optimized:
Hot Deck - Heating Coil Valve:
Economizer:
Minimum Outside Air Ventilation - Fixed Percentage:
Mixed Air Temperature:
Return Air Temperature:

The next step after finding out which points are required is to select the equipment. The primary hardware and software is shown Figure 48. Automated Logic Controls provided the specific components for this example purposes. Eric Nulton from OPP provided the format to conform with OPP's standard parameter list. This information then can be imported into Maximo from Revit when the parameters are assigned to them in Revit. This process eliminates the owner from having to manually input these parameters into Maximo. The information workflow of the controls can be viewed in Figure 50. Another parameter which can be added is a link to the specifications and O&M manuals data sheet. This could be a link to the manufactures website. Since websites' content is vulnerable to constant change, it is recommended to create a database accessible to the designer, contractors, and owner. Also, change orders, shop drawings, L&I, commissioning documents, and photos can potentially link into the database. In addition, one of the most valuable knowledge is gained in the commissioning stage of construction. Well documented commissioning notes can save the owner's technicians many hours of troubleshooting. Another idea is to attach flags on the pdf drawings to clearify the detailed location for technicians' work orders. Thus the technicians will be able to quickly locate the exact location of the problem.

Ideally, the owner's technicians can work with the commissioning agent. This enables the owner's technicians to be exposed to the buildings specific controls operation. Thus, being exposed to the facility management operations was a key to determining what information would be valuable to be included in the Revit model parameters. Therefore, the first month of the spring semester was spent shadowing the Area Services maintenance department.

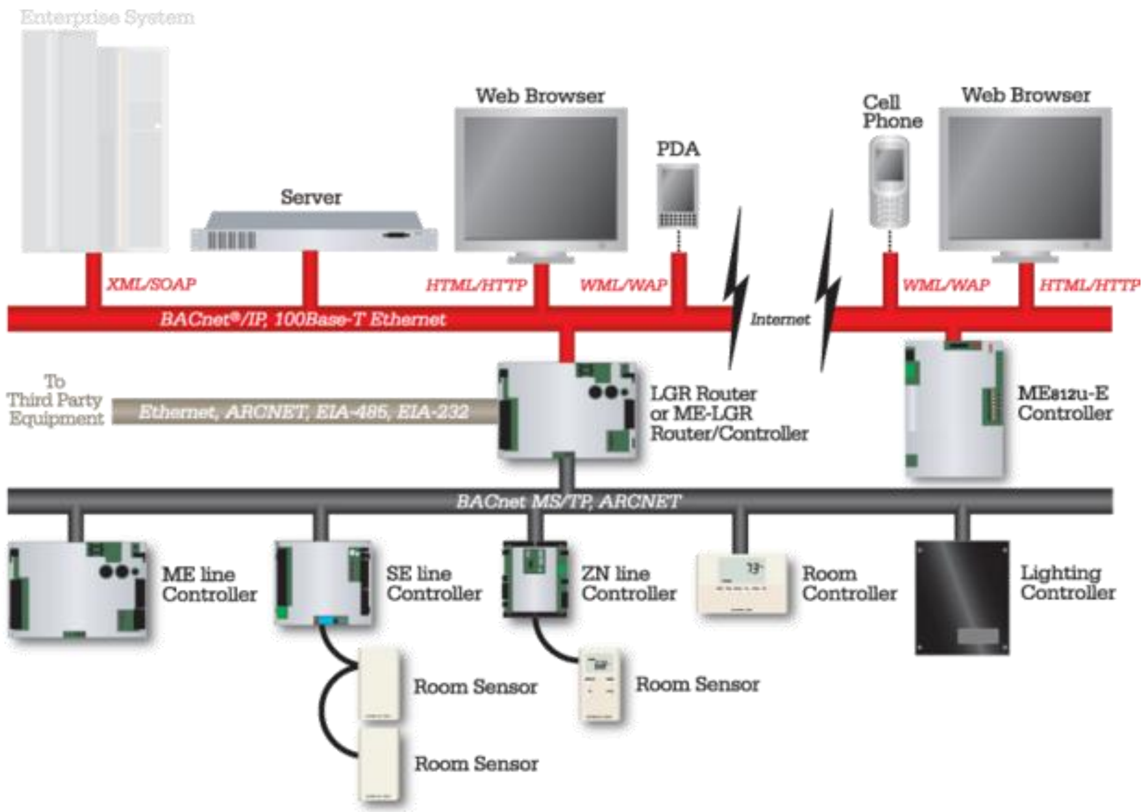


Figure 48: Typical ATC Layout

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
Cooling Supply Air Temp	×							×		×
Heating Supply Air Temp	×							×		×
Mixed Air Temp	×							×		×
Return Air Temp	×							×		×
Cooling Valve		×						×		×
Heating Valve		×						×		×
Mixed Air Dampers		×						×		×
Freezestat			×					×	×	×
Supply Air Smoke Detector			×					×	×	×
Supply Fan Status			×					×		×
Return Fan Status			×					×		×
Supply Fan Start/Stop				×				×		×
Return Fan Start/Stop				×				×		×
Cooling Supply Air Temp Setpoint					×			×		×
Heating Supply Air Temp Setpoint					×			×		×
Economizer Mixed Air Temp Setpoint					×			×		×
Supply Fan Failure									×	
Supply Fan in Hand									×	
Supply Fan Runtime Exceeded									×	
Return Fan Failure									×	
Return Fan in Hand									×	
Return Fan Runtime Exceeded									×	
High Cooling Supply Air Temp									×	
High Heating Supply Air Temp									×	
Low Heating Supply Air Temp									×	
High Mixed Air Temp									×	
Low Mixed Air Temp									×	
Low Return Air Temp									×	
High Return Air Temp									×	
Totals	**4**	**3**	**4**	**2**	**3**	**0**	**0**	**16**	**15**	**16**
	Total Hardware (13)				**Total Software (34)**					

Figure 49: shows the points list derived from ALC Spec Builder

Job Shadowing

The primary goal of job shadowing the controls' technicians from The Pennsylvania State University was to define what information is used daily in facility maintenance as well as what type of information is valuable to the technicians in the field. Since most of the technicians don't have a personal laptop only a pda, it is critical to limit the file sizes. This can be accomplished by dividing the Revit model in smaller pieces using only the Revit Architecture or Revit MEP in the field via dwf file. Since the dwf can be troublesome to navigate, the components assets in the Automated Logic front end model can be linked into the Cobie database file.

One important lesson I learned is to always develop a prototype. OPP now utilizes scanning drawings in a way that enables them to be searchable. This could be made use of in three dimension space as well. For example, if a technician is given a work order for an air handler, which he doesn't know the exact location. He can search the dwf file for the described name and find the air handler immediately.

The primary information used by the controls technicians that could be incorporated into the Automated Logic front end components as hyperlinks are the single line drawings, schematics, and sequence of operations. Thus if changes are made in the field the drawings could be marked and documented. Also within Maximo another parameter could be added to with a drawing hyperlink or a description referencing the drawing filing system to help technicians address the problem promptly.

Key findings of shadowing of Penn State's Area services:

- Everyone has PDA
- Only a few people have laptops
  - Some trades men have laptops, but they don't take laptops into the buildings mechanical rooms
    - Due to limited internet access
  - There are computer stations in the central OPP Office
- Only paper and Microfiche copies available for some buildings
  - New specifications are on pdf format
  - Lesson learned: run a pilot program of one building and test it.
- Filing system:
  - Building name_Project #_yearmonthday_Short Description
  - Problems:
  - Updating drawings
  - Size of files
  - U drive

The following is a list of the controls' manufactures used at The Pennsylvania State University.

- Area services Control logic
  - Automated logic Control
    - Temperature Pressure, pumps inlet outlet air temperature
- Johnson Control System (JCI)
- Stefatalon
- EUMS Itron system
  - Utility Network

  - Common Wealth Locations
  - Siemens Aogee
  - Lutron System
    - Includes Electrical and Mechanical

Most Commonly Accessed Drawings:

Mechanical Electrical Plumbing

Construction

Facility Data: Associated intelligent attribute data (e.g. Manufacturer, part number, warranty information etc.)

Preventive Maintenance

Check over Mechanical System twice per Month

Facility Management

Work orders

Description of Work: Room too cold. HVAC Unit Blowing Cold Air
Location: 0503000-543 DEIKE Building -05 Staff Office
Equipment:
F/P:
RPT: 3:45pm 12/15/2010
Contact: Name
Phone Number:

Design and Build

ALC=ControlSpec Builder
Quality control Checks
Revit to Maximo Checks
Provide report verifying model compliance with the Autodesk Revit to IBM Maximo Data Integration

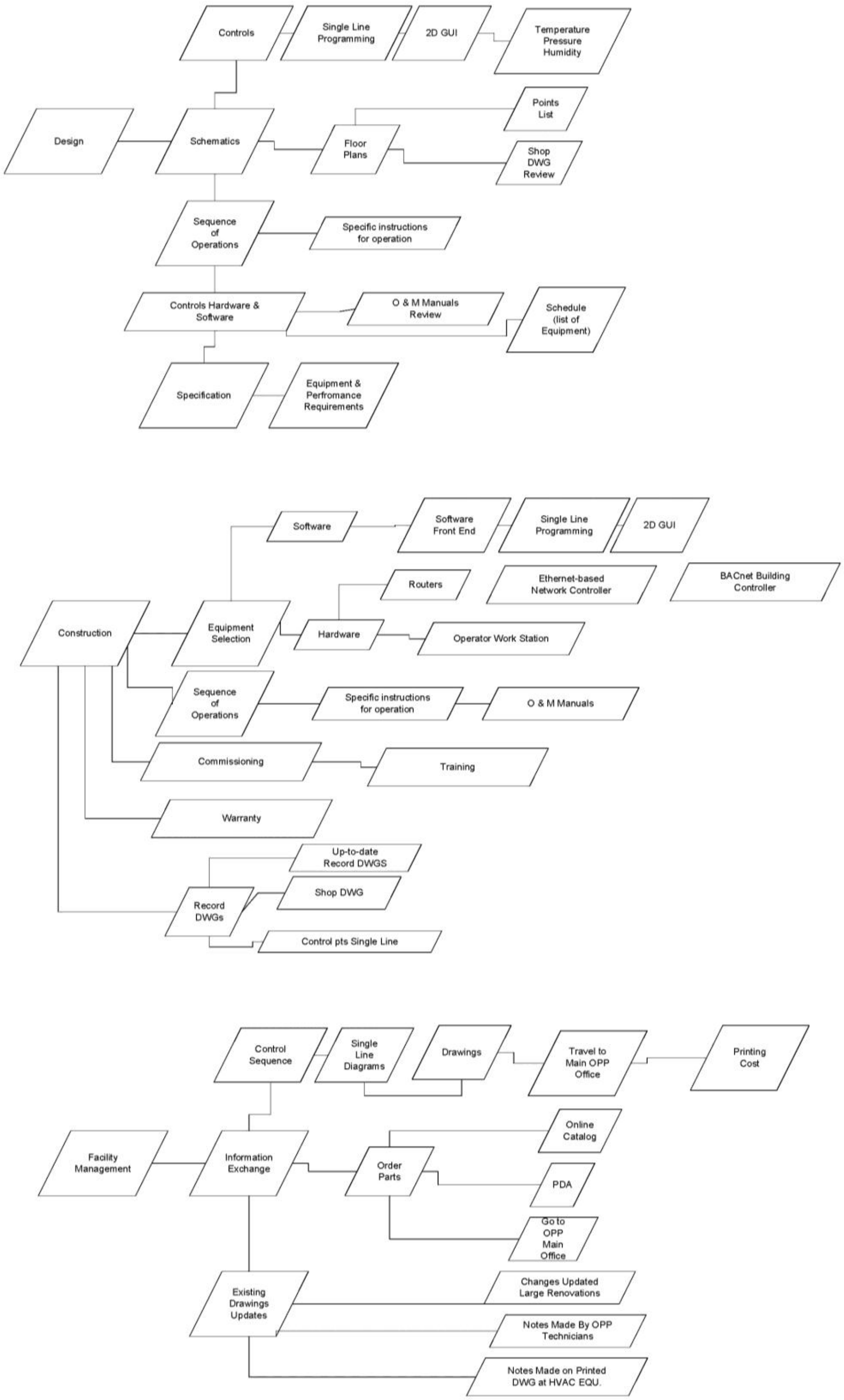


Figure 50: Outputs in the Design, Construction, and Facility Management

COBie Overview

The primary goals of implementing COBie information exchange is to eliminate information loss without cost increase. The COBie process is an open standard excel based program and does not requires any additional software. By planning the information reuse with COBie can reduce costs of data reentry. COBie provides an organized format for submittal request and approval. Also, the automate production of construction handover documentation. The last step of the construction process is to automatically load the data into a CMMS and/or CAFM. If BIM is utilized on the project the data pertaining to the individual components of the BIM model can be easily accessible to the owner.

Worksheets have standard Format:

Unique Name
Author/time stamp
External classification
Internal Reference
Description
External system reference
As-specified Information
Color coding:
Yellow = required information
Orange = required information
Purple = external system reference
Green = as-specified information

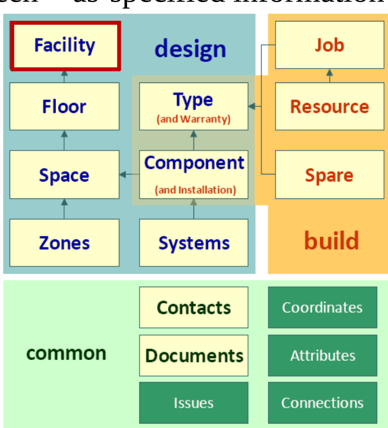


Figure 51: Overview of the COBie Information exchange

Means and Methods

Two different methods are under consideration at Penn State - Uniformat system or the COBie format. Since the COBie format is still being developed it is difficult to follow its method completely. The primary goal is to have a uniform format for inputting data into the BIM. The workflow supported by the current Revit to COBie template uses Revit schedules to organize the relevant COBie data. These schedules are exported via a text extraction and an Excel macro processes the text data to populate the COBie spreadsheet. The Uniformat example is illustrated in Appendix P.

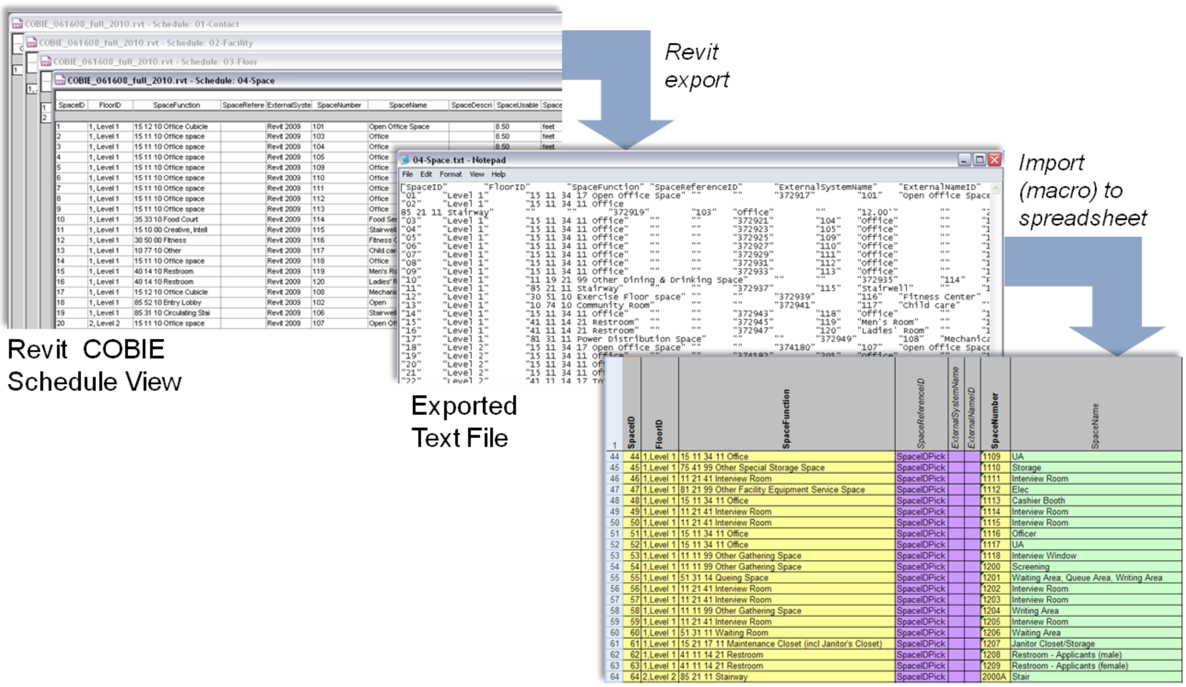


Figure 52: Revit to COBIE Workflow

The COBie data can be entered into the model as different parameters. These parameters would include a breakdown based on the COBie worksheets. Facility, resource, spare, job resource, and component worksheet would be defined within the model for each of the components.

Type Worksheet

This worksheet includes an overview of the designers, builders, and manufactures' information. If an owner was to specify only one worksheet in the Revit model this would be the most comprehensive. The designers information includes materials, products, equipment, min scheduled items, and fixed or movable property. The builder's information includes the manufacturer, model, and std warranty terms. The manufacturers' information includes expected life and replacement cost.

Type Worksheet		
Multi-Equipment Contoller & Router Controller, receiver Electric, Single Snap switch	Name	Contoller & Router
	CreatedBy	lag290@psu.edu
	CreatedOn	7/31/2011
	Category	ATC
	Description	
	AssetType	
	Manufacturer	ALC
	ModelNumber	ME-LGR Line
	PartsWarrantyGuarantor	
	PartsWarrantyEndDate	
	LaborWarrantyGuarantor	
	LaborWarrantyStartDate	
	LaborWarrantyEndDate	
	ExtSystem	
	ExtObject	
	ExtIdentifier	
	ReplacementCost	
	ExpectedLife	
	DurationUnit	
	WarrantyDescription	

Table 19: Shows the Type Worksheet

Resource Worksheet

This worksheet includes information that is useful for facility management. Although, at Pennsylvania State University is not widely executed in Maximo. This worksheet includes labor, materials, tools, and training.

Resource Worksheet		
Multi-Equipment Contoller & Router Controller, receiver Electric, Single Snap switch	Name	Contoller & Router
	CreatedBy	lag290@psu.edu
	CreatedOn	7/31/2011
	Category	ATC
	Description	
	ExtSystem	
	ExtObject	
	ExtIdentifier	

Table 20: Shows the Resource Worksheet

Spare Worksheet

This worksheet is another valuable attribute for facility maintenance. This worksheet includes parts suppliers, replacement parts ordering, required lubricants, and supplier ordering information.

Spare Worksheet		
Multi-Equipment Contoller & Router Controller, receiver Electric, Single Snap switch	Name	
	CreatedBy	
	CreatedOn	
	Category	
	Description	
	TypeName	
	Suppliers	
	ExtSystem	
	ExtObject	
	ExtIdentifier	
	SetNumber	
	PartNumber	

Table 21: Shows the Spare Worksheet

Job Resource Worksheet

The job worksheet may be one of the most valuable pieces for the facility maintenance. This worksheet includes information pertaining to adjustments, calibrations, emergency operations plans, inspections, operational instructions, preventative maintenance schedule, safety issues, shut down procedures, startup procedures, testing schedule, and troubleshooting flowchart.

Job Resource Worksheet		
	Name	
	CreatedBy	
	CreatedOn	
Multi-Equipment Contoller & Router	Category	
Controller, receiver	Status	
Electric, Single Snap switch	TypeName	
	Description	
	DurationUnit	
	Start	
	TaskStartUnit	
	Frequency	
	FrequencyUnit	
	ExtSystem	
	ExtObject	
	ExtIdentifier	
	TaskNumber	
	Priors	
	ResourceNames	

Table 22: Shows the Job Resource Worksheet

Component Worksheet

This worksheet includes design phase and construction phase information. The design phase information includes scheduled products and locations. The construction phase includes the serial number, installed date, tag, barcode, and asset id.

Component Worksheet		
Multi-Equipment Contoller & Router Controller, receiver Electric, Single Snap switch	Name	
	CreatedBy	
	CreatedOn	
	TypeName	
	Space Names	
	Description	
	ExtSystem	
	ExtObject	
	ExtIdentifier	
	SerialNumber	
	InstallationDate	
	TagNumber	
	BarCode	
	AssetIdentifier	

Table 23: Shows the Component Worksheet

Appendix O: AHU Typical Sequence of Points

Multizone - AHU-2 (typical of 1)

Run Conditions - Requested:
The unit shall run whenever:

- Any zone is occupied.
- OR a definable number of unoccupied zones need heating or cooling.

Freeze Protection:
The unit shall shut down and generate an alarm upon receiving a freezestat status.
Supply Air Smoke Detection:
The unit shall shut down and generate an alarm upon receiving a supply air smoke detector status.
Supply Fan:
The supply fan shall run anytime the unit is commanded to run, unless shutdown on safeties. To prevent short cycling, the supply fan shall have a user definable (adj.) minimum runtime.

Alarms shall be provided as follows:

- Supply Fan Failure: Commanded on, but the status is off.
- Supply Fan in Hand: Commanded off, but the status is on.
- Supply Fan Runtime Exceeded: Status runtime exceeds a user definable limit (adj.).

Return Fan:
The return fan shall run whenever the supply fan runs.

Alarms shall be provided as follows:

- Return Fan Failure: Commanded on, but the status is off.
- Return Fan in Hand: Commanded off, but the status is on.
- Return Fan Runtime Exceeded: Status runtime exceeds a user definable limit (adj.).

Cold Deck - Cooling Supply Air Temperature Setpoint - Optimized:
The cooling supply air temperature setpoint shall be reset using a trim and respond algorithm based on zone cooling requirements. If there is a demand for cooling then the setpoint shall be reset to a lower value (adj.). If the demand for cooling decreases then the setpoint shall reset to a higher value (adj.). Once the zones are satisfied then the setpoint shall gradually moderate over time to reduce cooling energy use.
The supply air temperature setpoint shall be reset based on zone cooling requirements as follows:

- The initial supply air temperature setpoint shall be 55°F (adj.).

- As cooling demand increases, the setpoint shall incrementally reset down to a minimum of 53°F (adj.).
- As cooling demand decreases, the setpoint shall incrementally reset up to a maximum of 72°F (adj.).

Cold Deck - Cooling Coil Valve:
The controller shall measure the cooling supply air temperature and and modulate the cooling coil valve to maintain its cooling setpoint.

The cooling shall be enabled whenever:

- Outside air temperature is greater than 60°F (adj.).
- AND the economizer (if present) is disabled or fully open.
- AND the supply fan status is on.

The cooling coil valve shall open to 50% (adj.) whenever the freezestat (if present) is on.
Alarms shall be provided as follows:

- High Cooling Supply Air Temp: If the cooling supply air temperature is 5°F (adj.) greater than setpoint.

Hot Deck - Heating Supply Air Temperature Setpoint - Optimized:
The heating supply air temperature setpoint shall be reset using a trim and respond algorithm based on zone heating requirements. If there is a demand for heating then the setpoint shall be reset to a higher value (adj.). If the demand for heating decreases then the setpoint shall reset to a lower value (adj.). Once the zones are satisfied then the setpoint shall gradually moderate over time to reduce heating energy use.
The supply air temperature setpoint shall be reset based on zone heating requirements as follows:

- The initial supply air temperature setpoint shall be 82°F (adj.).
- As heating demand increases, the setpoint shall incrementally reset up to a maximum of 90°F (adj.).
- As heating demand decreases, the setpoint shall incrementally reset down to a minimum of 72°F (adj.).

Hot Deck - Heating Coil Valve:
The controller shall measure the heating supply air temperature and modulate the heating coil valve to maintain its setpoint.

The heating shall be enabled whenever:

- Outside air temperature is less than 65°F (adj.).
- AND the supply fan status is on.

The heating coil valve shall open whenever:

- Heating supply air temperature drops from 40°F to 35°F (adj.).
- OR the freezestat (if present) is on.

Alarms shall be provided as follows:

- High Heating Supply Air Temp: If the heating supply air temperature is greater than 120°F (adj.).
- Low Heating Supply Air Temp: If the heating supply air temperature is 5°F (adj.) less than setpoint.

Economizer:
The controller shall measure the mixed air temperature and modulate the economizer dampers in sequence to maintain a setpoint 2°F less than the cooling supply air temperature setpoint. The outside air dampers shall maintain a minimum adjustable position of 20% (adj.) open whenever occupied.
The economizer shall be enabled whenever:

- Outside air temperature is less than 65°F (adj.).
- AND the outside air temperature is less than the return air temperature.
- AND the supply fan status is on.

The economizer shall close whenever:

- Mixed air temperature drops from 40°F to 35°F (adj.).
- OR on loss of supply fan status.
- OR the freezestat (if present) is on.

The outside and exhaust air dampers shall close and the return air damper shall open when the unit is off. If Optimal Start Up is available the mixed air damper shall operate as described in the occupied mode except that the outside air damper shall modulate to fully closed.
Minimum Outside Air Ventilation - Fixed Percentage:
The outside air dampers shall maintain a minimum position (adj.) during building occupied hours and be closed during unoccupied hours.
Mixed Air Temperature:
The controller shall monitor the mixed air temperature and use as required for economizer control (if present) and preheating control (if present).
Alarms shall be provided as follows:

- High Mixed Air Temp: If the mixed air temperature is greater than 90°F (adj.).
- Low Mixed Air Temp: If the mixed air temperature is less than 45°F (adj.).

Return Air Temperature:

The controller shall monitor the return air temperature and use as required for economizer control (if present).

Alarms shall be provided as follows:

- High Return Air Temp: If the return air temperature is greater than 90°F (adj.).
- Low Return Air Temp: If the return air temperature is less than 45°F (adj.).

Appendix P: Asset Information According to PSU UNIFORMAT Standard

Asset Information organized according to PSU UNIFORMAT Standard

Asset	Parameter	UOM
D30 HVAC		
D3060 Controls & Instrumentation		
D3061 Heating Generating Systems		
D3062 Cooling Generating Systems		
D3063 Heating/Cooling Air Handling Units		
D3064 Exhaust & Ventilating Systems		
D3065 Hoods and Exhaust Systems		
D3066 Terminal Devices		
D3067 Energy Monitoring & Control		
D3068 Building Automation Systems		
Multi-Equipment Contoller & Router Controller, receiver Electric, Single Snap switch	Equipment Number	
	Operate Range Temp	-20ºF to 140ºF (-29ºC to 60ºC)
	Operate Range Humidity	10 to 90% relative humidity,
	Type	Controller & Router
	Model #	ME-LGR Line
	Manufacturer	ALC
	Communication	BACnet Building Controller (B-BC)
	Communication	EIA-232-485 port 156kbps
	Microprocessor	32-bit
	Memory	16 Mbyte
	Protection	Built-in surge and transient protection
	Voltage	24 V-ac ± 10%
	Frequency	50 to 60Hz
	Power	10 Watts
	Services	MS-TP Channel for ctrl integration

Asset	Parameter	UOM
Router	Equipment Number	
	Type	Controller & Router
	Model #	ME-LGR Line
	Manufacturer	ALC
	Communication	BACnet Building Controller (B-BC)
	Communication	Ethernet Port (10/100Mps)
	Microprocessor	32-bit
	Memory	16 Mbyte
	Protection	Built-in surge and transient protection
	Voltage	24 V-ac ± 10%
	Frequency	50 to 60Hz
	Power	10 Watts
	Services	MS-TP Channel for ctrl integration

Asset	Parameter	UOM
Applications Software Front End For Building Control	Equipment Number	
	Type	GUI
	Model #	WebCTRL
	Manufacturer	ALC
	Communication	BACnet(TCP/IP)
Graphical Programming	Equipment Number	
	Sensing Range	
	Type	
	Model #	EIKON-Logic Builder
	Manufacturer	ALC
	Voltage	
	Amperage	
Freeze Protection	Equipment Number	
	Sensing Range	
	Type	
	Model #	
	Manufacturer	
	Communication	
Return Air Smoke Detector	Equipment Number	
	Sensing Range	
	Type	
	Model #	
	Manufacturer	
	Voltage	
	Amperage	
Supply Air Smoke Detector	Equipment Number	
	Sensing Range	
	Type	
	Model #	
	Manufacturer	
	Voltage	
	Amperage	
Temperature Sensor Duct Mount Duct Unit with 4” Probe and J-Box Enclosure	Equipment Number	411885
	Sensing Range	
	Type	Temp.Sensor
	Model #	BAPI# ALC/10K-2-D-4"
	Manufacturer	BAPI
	Power	ZN, SE, or ME line Controllers

Asset	Parameter	UOM
Intelligent Room Sensor	Equipment Number	
	Sensing Range	50F-95F (10C-35C)
	Type	Temp. Sensor
	Model #	RS
	Manufacturer	ALC
	Precision	0.36F
	Wire	18 AWG if using BACview
	Thermistor	10k ohm
	Power	ZN, SE, or ME line Controllers

Transducers	Equipment Number	
	Sensing Range	
	Type	
	Model #	
	Manufacturer	
	Precision	
	Wire	
	Thermistor	
	Power	

Relays	Equipment Number	
	Sensing Range	
	Type	
	Model #	
	Manufacturer	
	Precision	
	Wire	
	Thermistor	
	Power	

Valves	Equipment Number	
	Sensing Range	
	Type	Cooling or Heating
	Model #	
	Manufacturer	
	Precision	
	Wire	
	Thermistor	
	Power	

Asset	Parameter	UOM
Damper Operators	Equipment Number	
	Sensing Range	
	Type	
	Model #	
	Manufacturer	
	Precision	
	Wire	
	Thermistor	
	Power	
Return Fan	Equipment Number	
	Sensing Range	
	Type	
	Model #	
	Manufacturer	
	Precision	
	Wire	
	Thermistor	
	Power	
Supply Fan	Equipment Number	
	Type	
	Model #	
	Manufacturer	
Operator Workstation Computer meeting DDC manufacturer's Requirements for web Server software	Equipment Number	
	Type	
	Model #	
	Manufacturer	
Printer	Equipment Number	
	Type	
	Model #	
	Manufacturer	
Ethernet-based Network Contollers	Equipment Number	
	Type	
	Model #	
	Manufacturer	
Printer	Equipment Number	
	Type	
	Model #	
	Manufacturer	

Appendix Q: Compliance Check

User Interface:

- Does the system have a graphical interface with point & click navigation that allows the operator to log in, view and adjust properties (setpoints, schedules, PID gains, etc.), view and respond to alarms, view and configure trend graphs (including multiple points on one page), and view & configure reports? (Ref: 2.3.D)
- Will the system provide one graphic per each piece of equipment or occupied zone? Will the system graphics include floor plans that use dynamic colors to represent each zone's temperature relative to its setpoint? (Ref: 2.3.E.2)
- Does the system provide scheduling capabilities that include a weekly repeating schedule, the ability to schedule exceptions (dated changes to the weekly schedule) up to 365 days in advance, and annual holiday schedules that repeat each year? (Ref: 2.4.C)
- Does the system or the application programs provide a demand limiting function that will automatically adjust setpoints and de-energize low priority equipment when power consumption exceeds a user definable level? (Ref: 2.4.H)

System Programming and Maintenance Tools:

- Will the contractor provide all tools necessary to program and maintain the system? Tools must provide the capability to: (Ref: 2.3.F)
    - Configure the system database
    - Download memory to the controllers
    - Add operators, delete operators, and control privileges of each operator
    - Configure alarms, alarm messages, and alarm reactions (print, send e-mail, start program, etc.)
    - Configure trends including setting the interval time or change of value increment that causes a trend sample to be recorded
    - Configure and run standard reports to show point status, alarm status, locked points, and operator activity
    - Create and edit system graphics and to display dynamic system data on the graphics
    - Create and edit custom control programs, and download these programs to the controller
- Does the programming language allow the user to develop custom control programs that include standard mathematical and Boolean functions, read values from sensors or from other control modules on the network, and activate the controller outputs or communicate with other control modules based upon the results? (Ref: 2.3.F.17)
- Can the user develop "free form" programs, as opposed to column-oriented or "fill-in-the-blanks". (Ref: 2.3.F.17.a)
- Can the operator run the program in a simulation mode, adjusting input variables to simulate actual operating conditions and stepping through the program while observing intermediate values and results? Can the operator adjust each step's time increment to observe operation of delays, integrators, and other time-sensitive control logic? (Ref: 2.3.F.17.d)

- Are BACnet objects being used for all schedules, setpoints, trends, and alarms listed in the Sequences of Operation and Points Lists? (Ref: 1.5.D)

Operator Security:

- Does the system security allow an authorized operator to control the privileges associated with each user name & password combination? Privileges should include the ability to view, edit, add, and delete objects or functions. (Ref: 2.3.F.5)
- Can an authorized operator add, delete, and configure privileges for other operators? (Ref: 2.3.D.9)
- Does the system provide an adjustable automatic log-out time? (Ref: 2.3.F.5.b)
- Are stored operator passwords encrypted so they cannot be read by others? (Ref: 2.3.F.5.c)

Appendix R: Specification Consistency Checklist

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- **Cross-Reference with AHU Specs.** This project includes installing controls on one or more air handling units (AHUs) or evaporative coolers. Sometimes these units are available with factory installed controls, which will probably not be compatible with the controls to be installed under this project. To ensure factory mounted controls are not supplied with these units, select the "Packaged AHU or evaporative cooler controls" option in the third section on the "Spec Details - Related Products" page in CtrlSpecBuilder. You should also click the "Edit Text" button and revise the text as appropriate for your project. (If only some units are to be supplied without factory mounted controls, you should clearly delineate which units should and should not have factory controls.) This text will appear in Section 23 09 23, paragraph 1.3 of the completed specification. It would also be advisable to reference this paragraph in section 23 70 23 (not prepared by CtrlSpecBuilder) of the project specification to ensure the equipment supplier is aware of these requirements.
- **Need Multi-Zone Terminal Units?** This project includes one or more VAV Terminal Units with the "Optimal Start Up" option selected, but the project does not include a VAV AHU with the "Requested" run condition option. The Optimal Start Up routine requires an air handler unit that will run when requested by the terminal unit. If this project is an addition to a system that already has such an AHU you can address the run requests to that AHU. Otherwise, you may want to add a VAV AHU with the "Requested" run condition to this project.
- **Need Multi-Zone Terminal Units?** This project includes one or more Multi-Zone AHUs with "Trim & Respond" setpoint control, but the project does not include any Multi-Zone Terminal Units. The "Trim & Respond" optimization algorithm depends upon the AHU receiving heating or cooling requests from the terminal units. If this project is an addition to a system that already has terminal units you can use them to send heating and cooling requests to the AHU. Otherwise, you may want to add Multi-Zone Terminal Units to this project.
- **Mark Existing Ethernet.** This project allows the contractor to use an existing Ethernet backbone as part of the project. The sections of the existing Ethernet which he is allowed to use should be marked as "existing" in the project drawings.
- **Mark Existing Control Components.** The options you chose in Step 3 - Site Conditions direct the contractor to remove all existing control wiring, tubing, control panels, etc. The wiring and tubing become the property of the contractor, everything else is to be turned over to the owner. See paragraph 3.6 of the specification for details. If there are existing control components you do not want him to remove, or if you want to make other arrangements for handling the removed material, you should revise the specifications and drawings accordingly.
- **Need OA Conditions monitoring equipment?** You have selected one or more pieces of equipment which require information about the outdoor air conditions to operate properly, but your project does not include an OA Conditions monitoring station. This monitoring station is required to measure the outdoor temperature and humidity and broadcast it to all equipment that needs this information. If this is an addition to an existing building that already has a monitoring station you can use that equipment's

broadcast. Otherwise, you should consider adding an OA Conditions monitoring station to this project.

- **Electrical Service:** Make certain the scope of work and drawings under Division 26 require the electrical contractor to provide electrical service (120 VAC) to all Division 23 control panels. Additionally, coordination of work performed under section 23 09 23 should be required of the Division 26 contractor.

References

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