THE PENNSYLVANIA STATE UNIVERSITY
SCHREYER HONORS COLLEGE

DEPARTMENT OF ARCHITECTURAL ENGINEERING

SSM ST. CLARE HEALTH CENTER: STRUCTURAL REDESIGN WITH REINFORCED CONCRETE FLAT SLAB CONSTRUCTION CONSIDERING COST AND SCHEDULING IMPLICATIONS

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A thesis
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Abstract

An alternative reinforced concrete structure was proposed and designed for SSM St. Clare Health Center's new hospital facility in Fenton, Missouri. The original composite steel structure, with a lateral system consisting of special moment frames, special concentrically braced frames, and perforated special reinforced concrete shear walls, was altered to a flat slab and drop panel construction, with a lateral system of unperforated special reinforced concrete shear walls. An analysis of resulting construction and schedule implications demonstrated the feasibility of a flat slab to reduce cost and accelerate the construction time line. The proposed structure was designated as government use and the site was redesigned to meet UFC Minimum Antiterrorism Standards for Buildings. A single degree of freedom blast load analysis verified the effectiveness of the redesigned landscape.

SSM St. Clare Health Center

Fenton, Missouri: St. Louis County

General Information

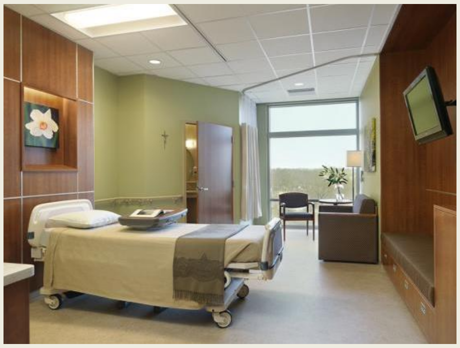
Full Height:	90 feet
Number of Stories:	6
Size:	427,000 square feet
Cost:	$223.5 million
Date of Construction:	Sept. 2006 – March 2009
Project Delivery Method:	Integrated “Lean” Project Delivery

Project Team

Owner:	SSM Health Care, St. Louis
Owner’s Program Manager:	Hammes Company
Architect of Record:	HGA Architects and Engineers
Associate Architect:	Mackey Mitchel Associates
Structural Engineers:	HGA Architects and Engineers
MEP Engineers:	KJWW Engineering
Construction Manager:	Alberici Construction
Elevator Consultants:	Lerch, Bates & Associates Inc.

Architecture

The hospital program contains a wide variety of medical use spaces, including 158 emergency supported inpatient beds, diagnostic and surgical services, administrative offices, dietary facilities, and pharmaceutical dispensaries. The floor plans were developed using Lean process principles classically used in manufacturing facilities.



Structural Systems

Framing:.......................... Steel framing, composite deck and lightweight concrete over composite wide flange members

Foundation:..................... Slab on grade, drilled concrete column piers connected by grade beams

Lateral:............................ Various systems including special moment frames (SMF), special concentrically braced frames (SCBF), special reinforced concrete shear walls (SRCSW), and ordinary concentrically braced frames (OCBF)

Mechanical Systems

Fan coil units in each patient room fed by central boiler and chiller system for heating and cooling. VAV dedicated outside air for ventilation.

Lighting and Electrical Systems

Electrical system supported by back up generators designed to power the entire hospital for at least 90 minutes. Lighting controls include ultrasonic ceiling sensors and infrared wall switch sensors for energy savings.

Construction

Noise control procedures were specified to mitigate problems with surrounding residents. Smoking was prohibited on the site to comply with hospital policies and avoid contaminating the patient rooms.

Photos compliments of HGA Architects and Engineers

Christopher Brandmeier | Structural Option
https://www.engr.psu.edu/ae/thesis/portfolios/2015/aqb5205/index.html

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Chapter 1

Overview of Site Location and Existing Structure

1.1 General Overview

SSM St. Clare Health Center is a 420,000 square foot hospital located in a residential area of Fenton, Missouri. The building and parking areas sit on a 54 acre site, which was previously a 9-hole golf course with gently varying topography, large stands of trees, and a 3 acre pond. The hospital program contains a wide variety of medical use spaces, including 158 emergency supported inpatient beds, diagnostic and surgical services, administrative offices, dietary facilities, and pharmaceutical dispensaries. Budgeted at $226.8 million, the hospital was constructed with an Integrated Project Delivery method and came in well under budget at $223.5 million.

Structurally, the hospital is a composite steel frame building resting on concrete drilled piers connected by grade beams. The structure is broken up into three buildings (bed tower, surgery tower, and interventional care unit) isolated by expansion joints. These individual buildings each contain their own lateral force resisting systems which include special moment frames (SMF), special concentrically braced frames (SCBF), special reinforced concrete shear walls (SRCSW), and ordinary concentrically braced frames (OCBF).

HGA Architects and Engineers served as the architect on record and structural engineers on record for the project. The HGA project team worked with the MEP engineers, KJWW, and the construction manager, Alberici Construction, through an integrated Lean project delivery contract that focused on improving coordination and quality through assumption of shared risks. The project began construction in September of 2006 and reached completion in March of 2009. SSM St. Clare Health Center was designed in 2004 and uses the 2003 Edition of the International Building Code and ASCE 7-02 as a reference standard. Design loads were determined based on these codes, additional St. Louis County Codes and Ordinances, and practical engineering judgments.

1.2 Site Location

SSM St. Clare Health Center is located in Fenton, Missouri (St. Louis County) surrounded on three sides by residential communities. The site was previously a golf course, with wide property setbacks and gently sloping terrain. On the next page, figure 1.1 shows the relative location of Fenton, notably near the New Madrid fault line, which lies south of St. Louis. Figures 1.2 and 1.3 show the virgin site, as well as the buildings location on the site as dictated by zoning codes and city ordinances respectively.

Note that the structure is located on the site of the former golf-course pond. This choice in building placement, combined with the proximity to residential communities heavily influenced foundation design. Foundations will be discussed further in the following section.

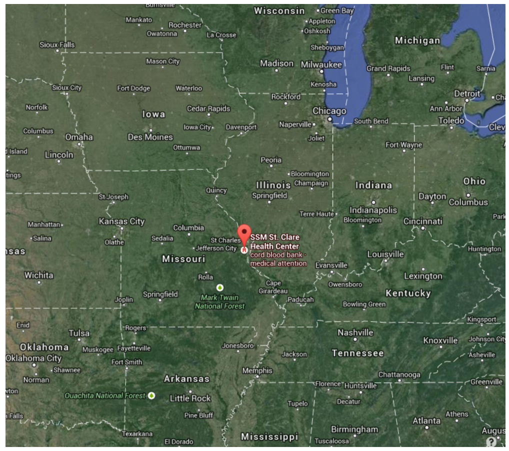


Figure 1.1: Site location north of St. Louis, Missouri

Figure 1.2: Site landscape before construction

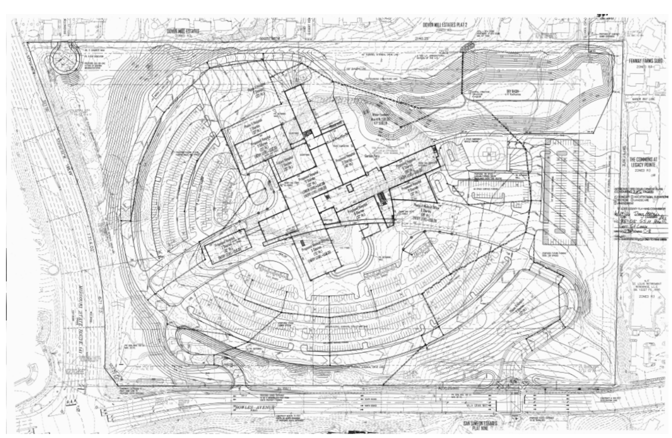


Figure 1.3: Site landscape and building placement accomodating for local zoning setbacks

1.3 Existing Structure

SSM St. Clare Health center is divided structurally into three distinct buildings: the bed tower, surgery tower, and interventional care unit as shown in Figure 1.4. The structural analysis and redesign presented herein refers to the patient bed tower shown in green. Distinguishing between the bed tower and the isolated structures allowed for a narrower scope and greater depth of investigation.

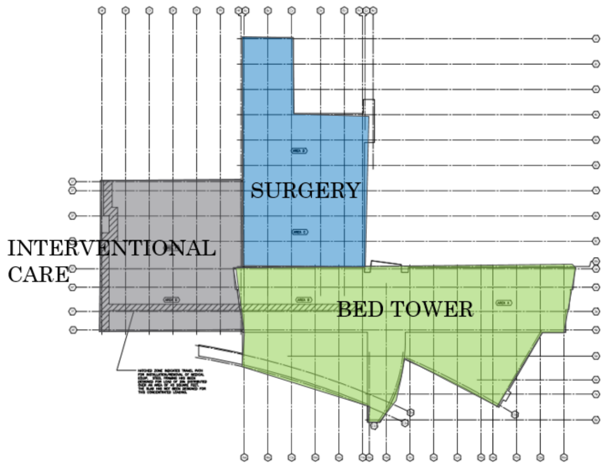


Figure 1.4: Structurally isolated building segments

1.3.1 Existing Gravity System

The load path of vertical gravity loads such as live, dead, snow, and rain start at horizontal surfaces such as roof or floor diaphragms, then travel through beams, into girders, and into the foundations through vertical columns. The structural elements mentioned make up what is known as the "gravity system."

SSM St. Clare Health Center's existing gravity system consists of a steel frame with composite steel beams supporting composite steel deck. Bays are approximately 30 ft. square but vary between 15 to 40 ft. based on geometry or plan architecture (as seen in Figure 1.5). The structural grid can be seen in Figure 1.6. Beams are mainly W16x26 or W18x35 wide flange members, the majority of which are cambered between in. and 2 in. The girders are almost entirely 24 in. deep wide flanges with linear weights varying between 55 lbs. and 94 lbs. depending on span and loading conditions.

The typical floor system is 3 inch, 18 gauge composite steel deck with a 3 in. lightweight concrete topping that is reinforced with 6x6-W2.1xW2.1 welded wire fabric. Deck is connected to framing members with 5/8 inch diameter puddle welds, and composite action is achieved with in. diameter, 5 in. long shear studs. Rebar reinforcing is specified at geometric transitions to strengthen the diaphragm collector regions, which are located at the transition between the main tower structure and the outward-jutting tower wing. The roof construction is a 1 inch, 20 gauge steel roof deck.

Columns are W14 steel wide flange members spliced at 4 ft above the second and fourth levels. The columns range in linear weight between 61 lbs. and 120 lbs. Columns beginning at the penthouse floor (sixth floor) are W8x24 members and are bolted to transfer girders to transfer penthouse roof vertical loads to the full-height columns.

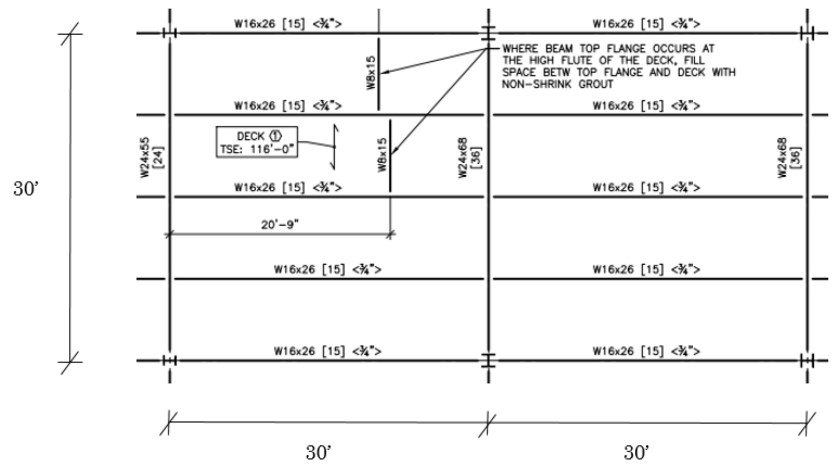


Figure 1.5: Typical structural bay, dimensioned 30' by 30'

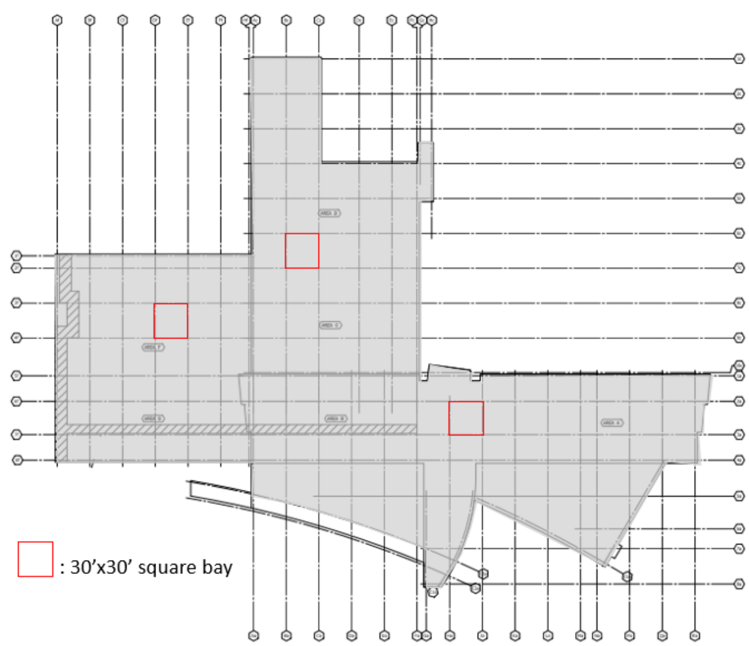


Figure 1.6: Structural grid layout producing regular bay sizes

1.3.2 Existing Lateral System

Lateral loads such as wind pressures are transferred through the facade to the floor and roof diaphragms. In the case of seismic loads, the mass of the building reacting to ground accelerations causes lateral forces. The floor and roof diaphragms transfer shears to collector struts by means of welds and studs. Collectors frame into lateral load resisting elements such as shear walls, moment frames, or braced frames, which then direct the loads to the ground by means of tension in the case of braced frames, or shear and flexural forces in the case of moment frames and shear walls. These forces are then transferred to the foundations and into the ground.

Structural elements that resist lateral forces make up what is known as the ”lateral force resisting system” or LFRS. The main lateral force resisting system (MLFRS) provides stability for the building, while other lateral systems such as envelope cladding are not essential for global stability.

The MLFRS elements in SSM St. Clare Health Center are special moment frames (SMF), special concentrically braced frames (SCBF), special reinforced concrete shear walls (SRCSW), and ordinary concentrically braced frames (OCBF). Figure 1.7 below shows the location of these lateral resisting elements in the patient bed tower. Note that elements are located efficiently at the exterior edges of the building to optimally resist torsional irregularities in the building. The stiffer elements (concrete shear walls and braced frames) are oriented along the short axis of the building while the less stiff moment frames are in the long direction. The layout is not only symmetrical in plan, but is also relatively equal in stiffness between the two orthogonal directions. Ordinary concentrically braced frames are used in the penthouse where energy dissipation and ductility are not primary concerns. Special concentrically braced frames are employed in the bed tower and interventional care structure where rigidity is needed beyond standard moment frames but a higher R value was desired to reduce design loads.

Figure 1.7: Locations of lateral force resisting elements in the patient bed tower

Table 1.1 indicates the lateral force resisting elements used in other segments of the hospital.

Table 1.1: Lateral load elements utilized in each building segment

Seismic Design Criteria	Bed Tower	Interventional Care	Surgery	Penthouse
Ie	1.5	1.5	1.5	1.5
SUG	III	III	III	III
Site Class	D	D	D	D
SLRS N-S	SMF	SCBF	SMF	OCBF
SLRS E-W	SCBF + SRCSW	SCBF	SMF	OCBF

1.3.3 Existing Foundations

SSM St. Clare Health Centers foundations consist of a grid of drilled piers connected by grade beams with a strip footing around the perimeter to support exterior walls.

Reinforced concrete drilled piers are required to support any column bearing more than 200 kips of compressive force, thus nearly every column on the project rests on a pier. 26 different pier types are scheduled with diameters ranging from 3 ft. to 8 ft. Each pier is reinforced with spiral reinforcement at 4 in. on center to a depth of three shaft diameters below the lowest grade beam, then with #4 ties at 12 inches on center to the bottom of the pier as shown in Figure 1.8. The depth of piers varies between 16 ft. and 29 ft. Piers are 3000 psi concrete, have a bearing capacity of 40 ksf, and an assumed skin friction capacity for tension of 2.5 ksf.

Potential uplift on the foundations from lateral loads are resisted by skin friction forces in the drilled piers of approximately 2.5 kips per foot. Also the drilled pier foundations are socketed at least 10 ft. into limestone to resist net uplift and to reduce settlement.

Grade beams connect the piers and assist in stabilizing the structure to resist seismic forces. 22 types of grade beams are specified with maximum dimensions of 48 in. by 24 in. and a minimum dimensions of 16 in. by 22 in. Grade beams are 4000 psi concrete.

Based on the analysis and design challenge presented by atypical soil conditions and poor seismic site class, and the advantages of the existing system for noise control around residential areas over alternative foundation systems such as driven piles, analysis and redesign of the foundation systems have been determined to be out of the scope of this project. Given more time, a full investigation of the foundation system could yield potential alternative solutions advantageous to cost or schedule.

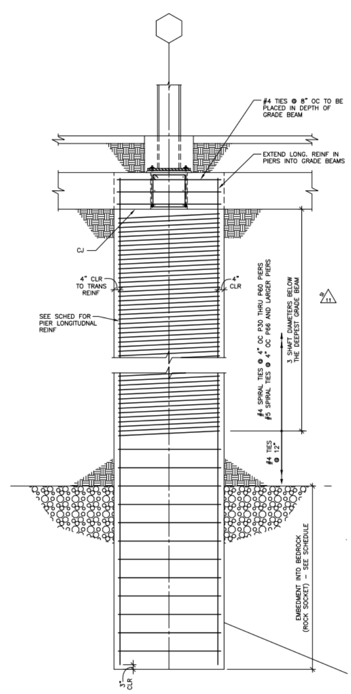


Figure 1.8: Typical drilled pier reinforcement detail (Credit: HGA Architects and Engineers)

Chapter 2

Overview of Codes and Relevant Loading Conditions

2.1 Applicable Codes

SSM St. Clare Health Center complies codes adopted prior to its construction date in 2006. The most notable are IBC 2003 Edition and ASCE 7-02. While these codes are used as reference during analysis, the redesign utilizes the most current available codes: most notably IBC 2012 Edition and ASCE 7-10. For a list of applicable state and local codes, see Table 2.1 below.

Table 2.1: Applicable Codes

Code Category	Applicable Code
Zoning	St. Louis County Codes and Ordinances
Building Code	International Building Code (IBC) 2003 Edition
Hospital Code	Title 19, Division 30, Chapter 30 for Hospitals and Ambulatory Surgical Centers
	NFPA Life Safety Code (101) 2000 Edition
	AIA Guidelines for Design and Construction of Hospitals and Healthcare Facilities
Fire Code	International Fire Code (IFC) 2003 Edition
Mechanical Code	International Mechanical Code (IMC) 2003 Edition
	International Gas and Fuel Code (IGFC) 2003 Edition
Energy Code	International Energy Conservation Code (IECC) 2003 Edition
Plumbing Code	St. Louis County Codes and Ordinances
Electrical Code	National Electric Code
Elevator Code	ANSI A17.1 Safety Code for Elevators and Escalators, 2000 Edition
State Accessibility Code	Americans with Disabilities Act (ADA)

2.2 Load Combinations

The loads in this chapter are combined in standard load combinations according to ASCE 7-10 Chapter 2. A list of load combinations can be seen in Table 2.2.

Table 2.2: ASCE 7-10 Load Combinations

Index	Combinations
1	$1.4D$
2	$1.2D + 1.6L + 0.5(L_r \text{ or } S \text{ or } R)$
3	$1.2D + 1.6(L_r \text{ or } S \text{ or } R) + (L \text{ or } 0.5W)$
4	$1.2D + 1.0W + L + 0.5(L_r \text{ or } S \text{ or } R)$
5	$1.2D + 1.0E + L + 0.2S$
6	$0.9D + 1.0W$
7	$0.9D + 1.0E$

2.3 Site Loading Conditions

The following sections describe the determination of typical loading conditions per ASCE 7-10 under IBC Edition 2012.

2.3.1 Gravity Loads

Dead

Dead loads in Table 2.3 are determined based on standard material weights, manufacturer data, and engineering experience.

Table 2.3: Typical Dead Loads

Dead Load	Original Values (psf)	Calculated Values (psf)
Hospital Floor	60	64
Hospital Roof	78	70

Live

Live loads in Table 2.4 were determined from ASCE 7-10 and through engineering experience.

Table 2.4: Typical Live Loads

Live Load	Value (psf)	Code Minimum (psf)
Operating Room	60	60
Offices	50	50
Private Rooms	40	40
Corridors (1st Floor)	100	100
Corridors (other)	80	80
Stairs and Exits	100	100
Equipment Rooms	125	125

Snow

A ground snow load value was calculated in accordance with ASCE 7-10 equation 7.3-1:

$$p_f = 0.7C_eC_tI_sp_g$$

Using a building occupancy category of IV, snow importance factor of 1.2, exposure factor of 1.0, thermal factor of 1.0, and ground snow load of 20 psf, it can be found that the flat roof snow load is 24 psf. This load controls of the alternative 20 psf roof live load for most load combinations.

2.3.2 Lateral Loads

Wind

Wind loads were determined based on the design criteria in Table 2.5

Table 2.5: Wind load design criteria

Parameter	Symbol	Value
Occupancy Category	-	IV
Basic Wind Speed	V	115 mph
Exposure Category	-	B
Wind Directionality Factor	Kd	0.85
Importance Factor	Ie	1.5
Topographical Factor	Kzt	1
Gust Effect Factor	G	0.8205
Enclosure Classification	-	Enclosed

For wind load calculation, the structure was divided into two segments: the main tower and the tower "arm" (east-jutting tower spur). These two building segments have significantly different length to depth ratios, which made the distinction necessary for calculating accurate leeward and roof loads.

Tables 2.6 and 2.7 contain wind loads and base shears in the North-South and East-West directions respectively. Note that for the structural redesign presented later in this report, the building geometry does not change, and thus the wind loads in Tables 2.6 and 2.7 remain valid.

Table 2.6: Wind design loads in the North-South direction

ARM			External Pressure			Internal Pressure				
Location	z (ft)	Story Height (ft)	qzGCp (psf)	Tributary Width (ft)	External Pressure (kip)	GCpi	qhGCpi (psf)	Tributary Width	Internal Pressure (kip)	Total Pressure (kip)
Windward	-16	16.0	11.7	0.0	**0.0**	0.18	5.0	0.0	**0.0**	**0.0**
	0	16.0	11.7	113.8	**0.0**	0.18	5.0	0.0	**0.0**	**0.0**
	16	14.0	11.9	113.8	**20.3**	0.18	5.0	0.0	**0.0**	**20.3**
	30	14.0	14.2	113.8	**22.6**	0.18	5.0	0.0	**0.0**	**22.6**
	44	14.0	15.8	113.8	**25.2**	0.18	5.0	0.0	**0.0**	**25.2**
	58	14.0	17.1	113.8	**27.3**	0.18	5.0	0.0	**0.0**	**27.3**
	72	18.8	18.2	113.8	**34.0**	0.18	5.0	0.0	**0.0**	**34.0**
	90.75	0.0	19.5	67.0	**12.2**	0.18	5.0	0.0	**0.0**	**12.2**
Leeward	90.75	90.8	-7.3	113.8	**75.4**	0.18	5.0	0.0	**0.0**	**75.4**
Parapet WW	93	2.2	0.0	113.8	**0.0**	1.5	41.5	0.0	**0.0**	**0.0**
Parapet LW	93	2.2	0.0	113.8	**0.0**	-1	-27.7	0.0	**0.0**	**0.0**
TOWER			External Pressure			Internal Pressure				
Windward	-16	16.0	10.5	0.0	**0.0**	0.18	5.0	0.0	**0.0**	**0.0**
	0	16.0	10.5	0.0	**0.0**	0.18	5.0	0.0	**0.0**	**0.0**
	16	14.0	10.7	0.0	**0.0**	0.18	5.0	77.3	**5.8**	**5.8**
	30	14.0	12.7	77.3	**13.8**	0.18	5.0	0.0	**0.0**	**13.8**
	44	14.0	14.2	77.3	**15.4**	0.18	5.0	0.0	**0.0**	**15.4**
	58	14.0	15.4	77.3	**16.7**	0.18	5.0	0.0	**0.0**	**16.7**
	72	18.8	16.4	77.3	**20.7**	0.18	5.0	0.0	**0.0**	**20.7**
	90.75	0.0	17.5	31.0	**5.1**	0.18	5.0	0.0	**0.0**	**5.1**
Leeward	90.75	90.8	-10.9	77.3	**76.7**	0.18	5.0	0.0	**0.0**	**76.7**
Parapet WW	93	2.2	33.0	77.3	**5.5**	1.5	41.5	0.0	**0.0**	**5.5**
Parapet LW	93	2.2	22.0	77.3	**3.7**	-1	-27.7	0.0	**0.0**	**77.33**
									Base Shear:	**454.1**

Table 2.7: Wind design loads in the East-West direction

ARM			External Pressure			Internal Pressure				
Location	z (ft)	Story Height (ft)	qzGCp (psf)	Tributary Width (ft)	External Pressure (kip)	Gcpi	qhGCpi (psf)	Tributary Width	Internal Pressure (kip)	Total Pressure (kip)
Windward	-16	16.0	11.0	0.0	**0.0**	0.18	5.0	0.0	**0.0**	**0.0**
	0	16.0	11.0	42.3	**0.0**	0.18	5.0	0.0	**0.0**	**0.0**
	16	14.0	11.2	42.3	**7.1**	0.18	5.0	0.0	**0.0**	**7.1**
	30	14.0	13.4	42.3	**7.9**	0.18	5.0	0.0	**0.0**	**7.9**
	44	14.0	14.9	42.3	**8.8**	0.18	5.0	0.0	**0.0**	**8.8**
	58	14.0	16.1	42.3	**9.5**	0.18	5.0	0.0	**0.0**	**9.5**
	72	18.8	17.2	42.3	**11.9**	0.18	5.0	0.0	**0.0**	**11.9**
	90.75	0.0	18.3	42.3	**7.3**	0.18	5.0	0.0	**0.0**	**7.3**
Leeward	90.75	90.8	-11.5	42.3	**43.9**	0.18	5.0	0.0	**0.0**	**43.9**
Parapet WW	93	2.2	34.6	42.3	**3.2**	1.5	41.5	0.0	**0.0**	**3.2**
Parapet LW	93	2.2	23.1	42.3	**2.1**	-1	-27.7	0.0	**0.0**	**2.1**
TOWER			External Pressure			Internal Pressure				
Windward	-16	16.0	11.4	0.0	**0.0**	0.18	5.0	0.0	**0.0**	**0.0**
	0	16.0	11.4	224.8	**0.0**	0.18	5.0	0.0	**0.0**	**0.0**
	16	14.0	11.6	224.8	**39.0**	0.18	5.0	150.0	**11.2**	**50.2**
	30	14.0	13.9	374.8	**72.7**	0.18	5.0	0.0	**0.0**	**72.7**
	44	14.0	15.5	374.8	**81.1**	0.18	5.0	0.0	**0.0**	**81.1**
	58	14.0	16.7	374.8	**87.7**	0.18	5.0	0.0	**0.0**	**87.7**
	72	18.8	17.8	374.8	**109.1**	0.18	5.0	0.0	**0.0**	**109.1**
	90.75	0.0	19.0	71.0	**12.6**	0.18	5.0	0.0	**0.0**	**12.6**
Leeward	90.75	90.8	-4.8	374.8	**161.6**	0.18	5.0	0.0	**0.0**	**161.6**
Parapet WW	93	2.2	41.5	374.8	**33.7**	1.5	41.5	0.0	**0.0**	**33.7**
Parapet LW	93	2.2	27.7	374.8	**22.5**	-1	-27.7	0.0	**0.0**	**374.8**
									Base Shear:	**1085.2**

Seismic

Seismic loads were determined based on the design criteria in Table 2.8

Table 2.8: Seismic load design criteria

Parameter	Symbol	Value
Occupancy Category	-	IV
Site Class	-	D
Seismic Design Category	-	D
Short Period Spectral Response Acceleration	Ss	0.414
One Second Spectral Response Acceleration	S1	0.163

Seismic loads were calculated with the weights of original composite steel floor assemblies, partitions, structural walls, and facades. Table 2.9 below contains the seismic loads at each floor and the combined base shear for the original structure. Note that for the structural redesign presented later in this report, the structural weight changed and thus a new seismic force table is presented.

Table 2.9: Seismic story forces and base shear for composite steel structure

Story	Dia.	Wx (kips)	Hx (ft)	k	Hxk	Wx*Hxk	Cvx	Fx
First Floor	1	5076.9	16.0	1.23	30.7	155682.6	0.1	77.9
Second Floor	2	4987.5	32.0	1.23	72.2	359902.5	0.1	180.1
Third Floor	3	3417.4	46.0	1.23	113.0	385998.0	0.1	193.1
Fourth Floor	4	3417.4	60.0	1.23	156.8	535862.2	0.2	268.1
Fifth Floor	5	3147.4	74.0	1.23	203.1	639381.2	0.2	319.9
Roof	6	3141.9	88.0	1.23	251.6	790509.9	0.3	395.5
Penthouse Roof	7	640.0	106.0	1.23	316.6	202619.7	0.1	101.4
		23828.5						**1434.6**

Chapter 3

Depth: Investigation of Reinforced Concrete Flat Slab Construction

3.1 Weighing Alternative Solutions

Several alternative structural solutions were considered for a proposed system redesign. These included non-composite steel framing, two-way flat plate slab, one-way slab, and one-way slab with intermediate beams. One bay of each system was designed and compared against the other alternatives, using the original design as the benchmark. Results of the feasibility study are shown in Table 3.1. Since the two way slab system achieved the thinnest profile, cheapest cost, and least environmental impact, it was proposed that SSM St. Clare Health Center be redesigned using two-way slab construction. The proposed system is to be implemented on floors 2-6, however the mechanical/telecommunications penthouse on the 7th story will remain a steel structure to reduce structural weight.

Table 3.1: Alternative design matrix

Criteria	Composite Steel Framing	Non-Composite Steel Framing	2 Way Flat Plate Slab	1 Way Slab with Intermediate Beam	1 Way Slab
Weight (psf)	53.5	49.5	124.4	127.4	165.3
Depth	24"	24"	10"	24"	24"
Cost	$14.25 / SF	$13.43 / SF	$11.25 / SF	$13.67 / SF	$11.72 / SF
Fire Protection	None	None	None	None	None
Fire Rating	2 Hr	2 Hr	4 Hr	4 Hr	4 Hr
Environmental Impact (lbCO2/lb)	9107.6	8744.7	6209.7	6349.6	8239.7

3.2 Gravity System Analysis and Design

The alternative gravity system for SSM St. Clare Health Center is composed of a reinforced concrete flat slabs with drop panels, transfer and edge beams, and columns. Each element was designed using different software and approach, but the most important criteria for the gravity redesign was the maintenance of the original column layout. This requirement solidified span lengths and drove decisions throughout the design process. The following sections describe the design process for each element, including design approach, modeling assumptions, and results.

3.2.1 Two-Way Flat Slab with Drop Panels

A two-way flat slab system was selected for its shallow depth and ability to span over regularized bays with economical use of material. In general terms, 30 ft. bays are large for a flat slab, so drop panels were a consideration from the outset.

The slabs are generally monolithic, but have some small mechanical openings spread over the plan. Three mechanical shafts are located at column lines Aa, La, Ha, which interrupt large portions of typical mesh reinforcement and require special detailing. Slab depressions at shower locations were present on floors with patient rooms.

Four typical floor slabs were designed, the typical lower level (1st floor), lower level roof (2nd floor), upper level (3rd, 4th, and 5th floors), and upper level roof (6th floor).

Assumptions and Approach

Code Requirements: Two-way slab design follows ACI 318-11 Chapter 9, ”Strength and Serviceability Requirements,” Chapter 13, ”Two-Way Slab Systems” and Chapter 21, ”Earthquake Resistant Structures.” Table 9.5(c) was used to determine a minimum thickness for slabs so that design calculations could be simplified. Typical dead, live, roof live, snow, construction, and other loads were calculated based on ASCE 7-10 requirements and can be found in Section 2.3.

Layout Development: Originally, a slab depth of 10 inches was chosen based on the assumption that ACI 318-11 Table 9.5(c) would be overly conservative. After long term slab deflections were found to be greater than span/240 per Table 9.5(b) (with creep factor of 3.35), the slab thickness was proportioned according to Table 9.5(c). The desire to reduce weight led to the development of two slab thicknesses to meet deflection requirements. A 10.5 in. slab met the minimum table requirements for a 31 ft. span, while a 14 in. slab met the requirements for a 40 ft. span. Since longer spans are located on only the East side of the building, the East depth was increased to 14 in. and was separated from the thinner slab by a drop panel strip along grid line 4a. The resulting layout can be seen in Figures 3.1 and 3.2 for the lower levels and upper levels respectively.

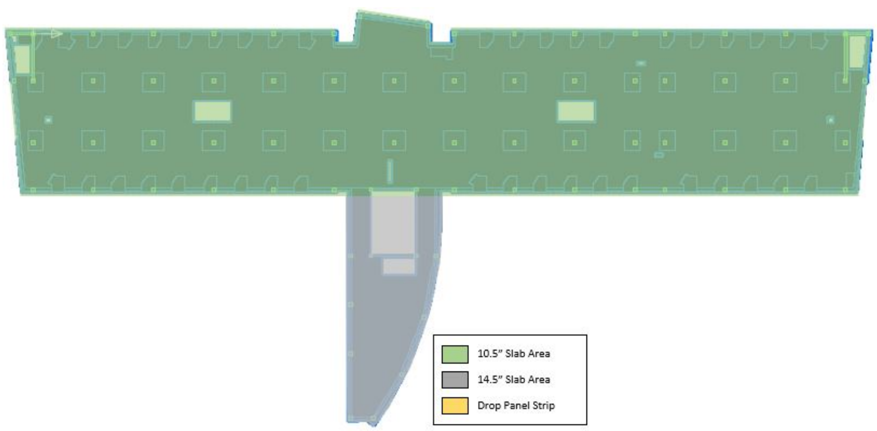


Figure 3.1: Lower Story Slab Layout

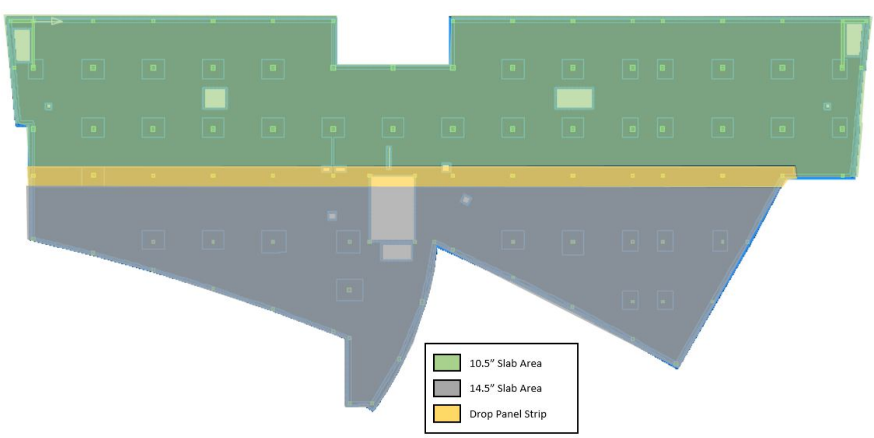


Figure 3.2: Upper Story Slab Layout

The layout above represents the result of four design iterations.

- A 10 in. slab throughout with drop panels.
- A 14 in. slab throughout with drop panels.
- A 10.5 in. slab throughout with drop panels on the west side of the building and beams on column lines on the east side.
- The final design: a 10.5 in. slab on the west side of the building and 14 in. slab on the east, separated by a drop panel strip.

Initial iterations each failed long term deflection criteria of l/240 at mid-bay.

Constructibility played an integral role in the sizing of slabs and drop panels. Drop panel depth is based on the depth of the slab plus the sizes of typical dimensioned lumber, and the depth of horizontal 3/4 in. plywood formwork. All drop panels were sized to minimum widths of span/6.

$$D_{droppanel} = D_{lumber} + 3/4\text{''} \tag{3.1}$$

Modeling

The four typical floor geometries were modeled in RAM Concept to determine minimum reinforcement and rebar layout.

Design strips were generated in the latitudinal (N-S) and longitudinal (E-W) directions. Column strips and middle strips were assigned to have the same design properties. For bottom reinforcement #5 rebar was specified, while #8 was specified for the top. The design intent was to create a standard mesh of #5 rebar, which could carry a minimum design moment in the unlikely case of a simply supported condition developing, then add additional top reinforcement to satisfy the negative moment developing over supports. A typical longitudinal design strip layout for the lower floor can be seen in Figure 3.3and typical latitudinal design strip layout in Figure 3.4.

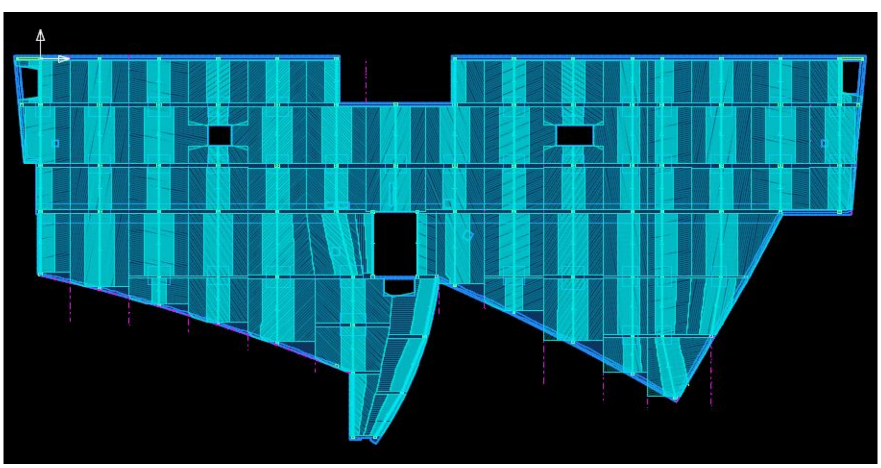


Figure 3.3: Longitudinal Design Strip Plan

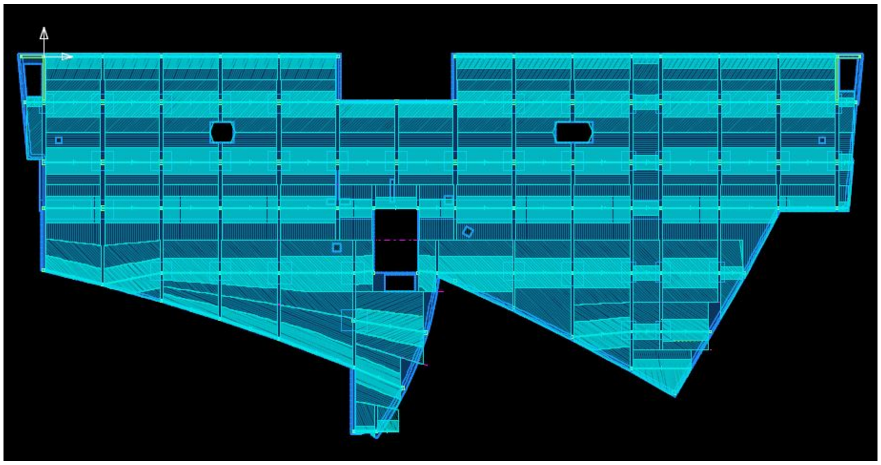


Figure 3.4: Latitudinal Design Strip Plan

The bottom reinforcement along the longitudinal (N-S) direction was identified as critical due to the longer spans in that direction, and thus was given minimum clear cover of 0.75 in. The latitude direction bottom cover was 1.375 in. Similarly, top cover in the longitudinal direction was assigned 0.75 in. and latitudinal, 1.75 in. At slab depressions, the placement of top reinforcement was 1.5 inches lower than in other portions of the slab.

Punching shear checks were specified at all interior columns. These checks were assigned to auto-align with rectangular columns. Cross section trimming was set as ”Max Shear Core” to allow RAM Concept to account for drop panel depth in shear utilization calculations. Punching shear was not checked at columns with beams, as the beams were designed to accommodate design shears. A punching shear layout for the typical lower floor can be seen in Figure 3.5.

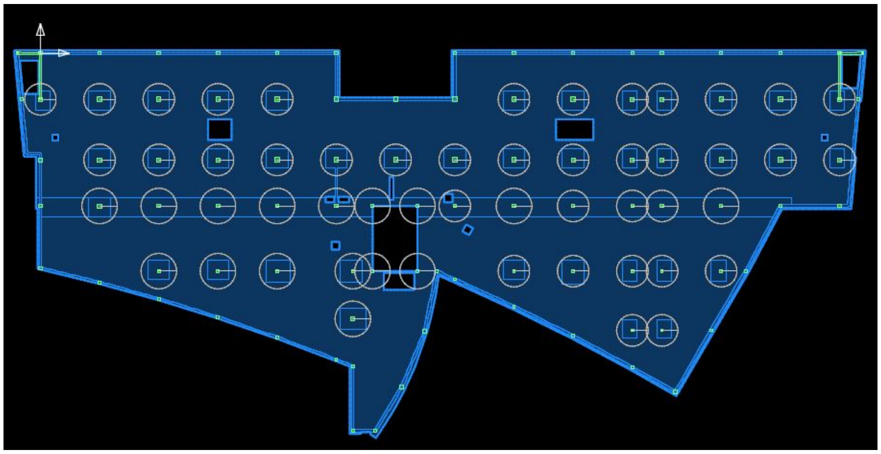


Figure 3.5: Punching Shear Design Plan

Results

On the bottom of the slab, reinforcement was specified as a mat with additional bars where needed. The mat was determined to be #5 bars at a spacing of 12 inches in both the latitudinal and longitudinal directions. This mat accounts for just over 40% of total bottom reinforcement.

Figures 3.6 and 3.7 below show the bottom reinforcement for a typical lower story. Note that the mesh is included in the spacings called out in the figure.

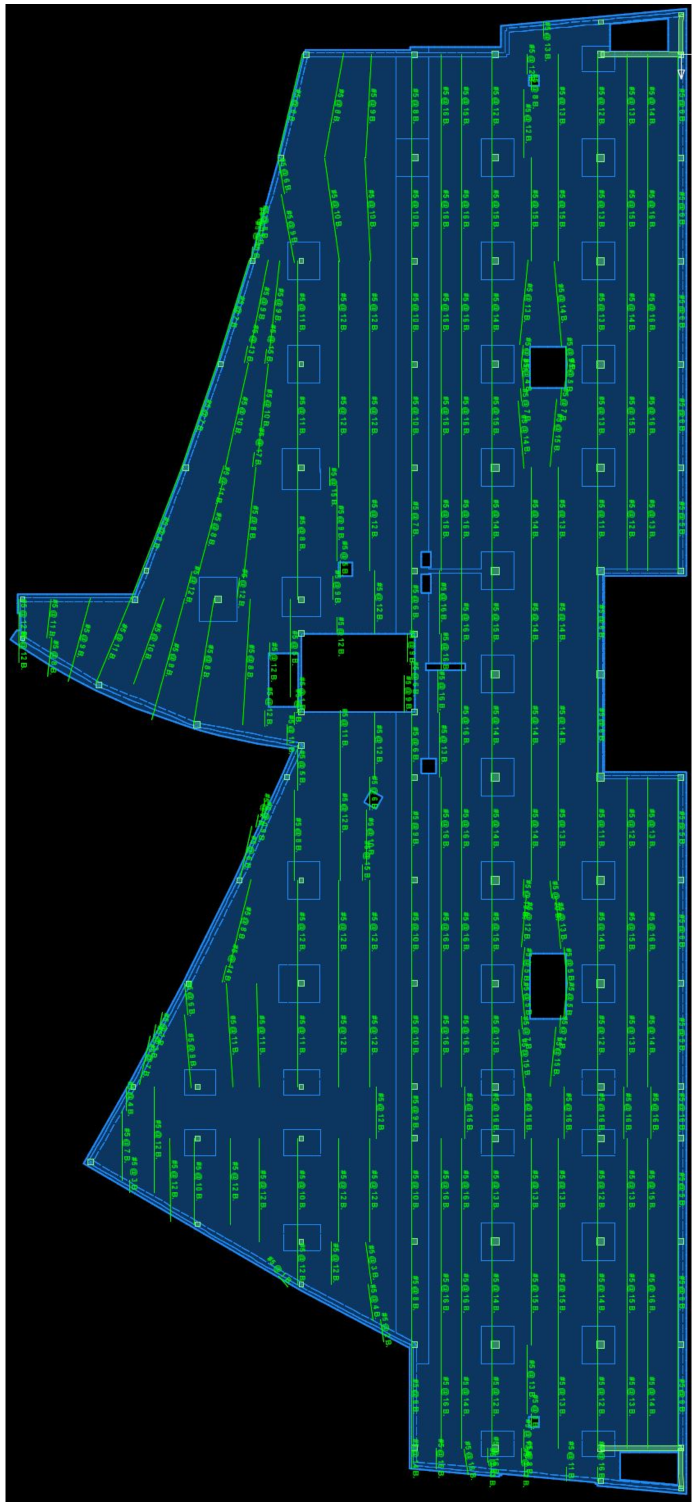


Figure 3.6: Latitudinal Bottom Reinforcement

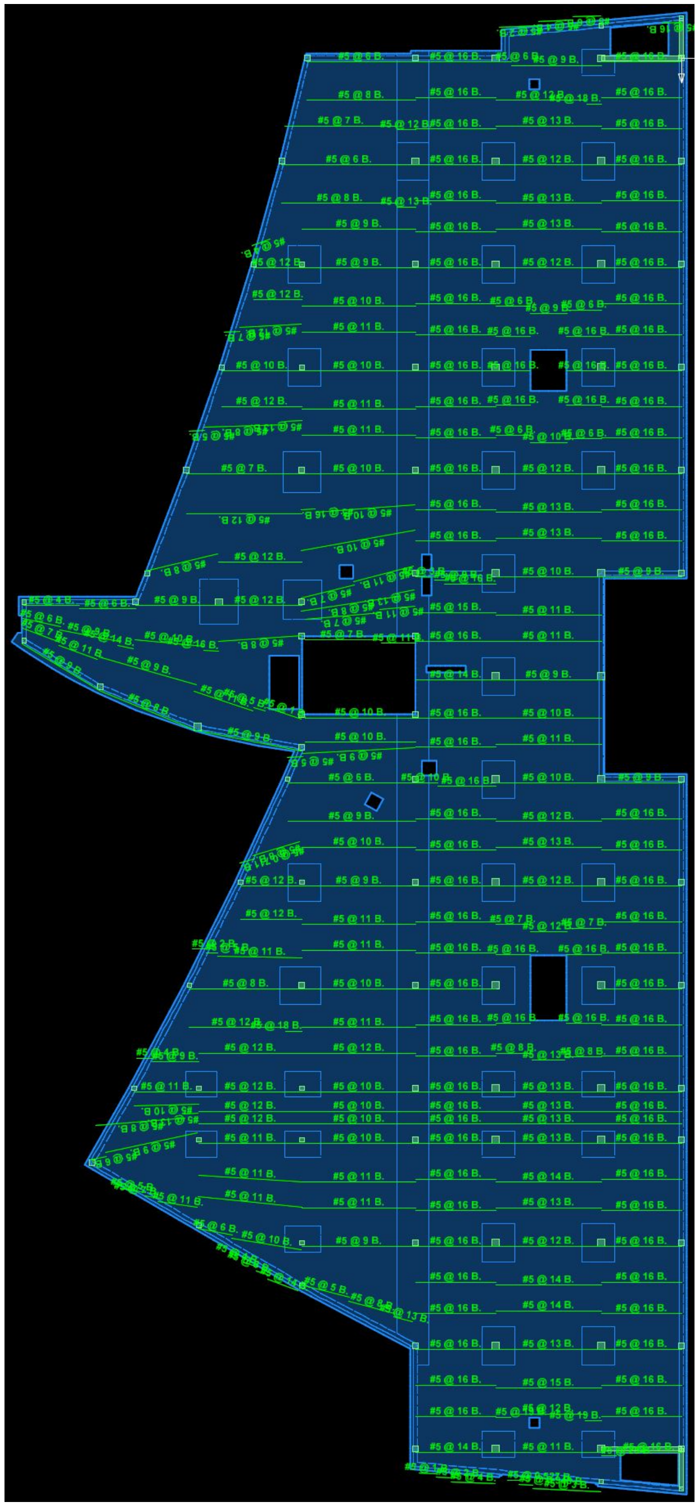


Figure 3.7: Longitudinal Bottom Reinforcement

On the top of the slab, reinforcement was specified by bar and spacing. #8 Bars were used consistently throughout the top layer in both the latitudinal and longitudinal directions.

Other reinforcement layouts can be found in Appendix A.

3.2.2 Gravity Beams

Gravity beams were positioned in the slab to solve issues with localized shear, to reduce deflections, to transfer penthouse loads, and support envelope loads at the slab perimeter. The following section describes the design of gravity beams for SSM St. Clare Health Center. Refer to Figures 3.8 and 3.9 for locations of gravity beams in the typical lower level and upper roof level plans, respectively.

Figure 3.8: Lower Level Interior Beam Location

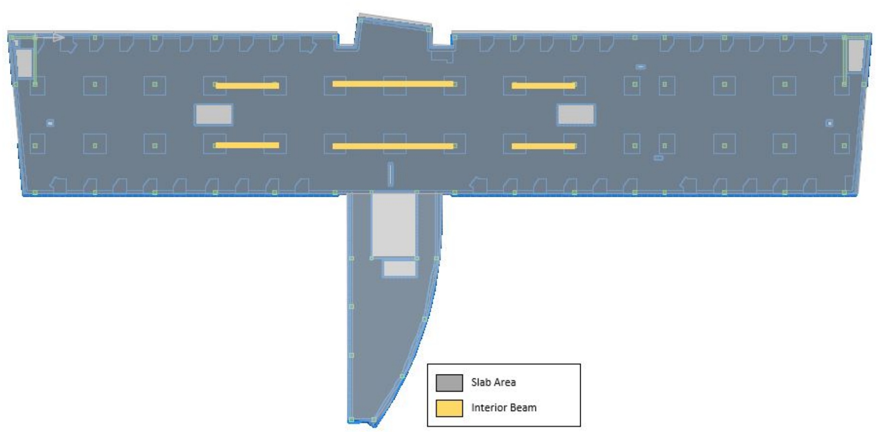


Figure 3.9: Upper Level Transfer Beam Locations

Assumptions and Approach

Code Requirements: Gravity beam design follows ACI 318-11 Chapter 9, "Strength and Serviceability Requirements," Chapter 10, "Flexure and Axial Loads," Chapter 11, "Shear and Torsion," and Chapter 21, "Earthquake Resistant Structures." Table 9.5(a) was used to determine a minimum thickness for slabs so that design calculations could be simplified. Typical dead, live, roof live, snow, construction, and other loads were calculated based on ASCE 7-10 requirements and can be found in Section 2.3.

Layout Development: At story six, penthouse columns frame into the slab at off-grid locations and are supported by transfer girders spanning between interior columns. These transfer girders were assumed to be integral with the slab and thus "continuous" across column supports. Design moments for transfer girders were determined from ACI moment coefficients in ACI 318-11 Section 8.3.3. Torsion was determined to be negligible by torsion threshold checks in section 11.5.1.

Edge beams were located around the perimeter of the slab at column lines. The design moments were calculated using direct design method according to beam-slab relative stiffnesses.

Both transfer girders and edge beams were sized to take advantage of t-beam behavior for positive moments.

Results

Transfer Beam Design: Transfer beams are typically 24 in. by 26 in. The sizing represents a balance between constructibility considerations and maximum reinforcement ratios. For constructibility, width of the beams was set at 24 in. to match the width of interior columns and thus simplify formwork fabrication. The depth was the minimum necessary to meet maximum reinforcement ratio limits for the beams.

Transverse reinforcement design was governed by shear, rather than torsion, at a distance d/2 from the edge of support.

Figure 3.10 shows a diagram of typical beam reinforcement. Appendix A contains flexural and shear calculations for the three levels of girder reinforcement.

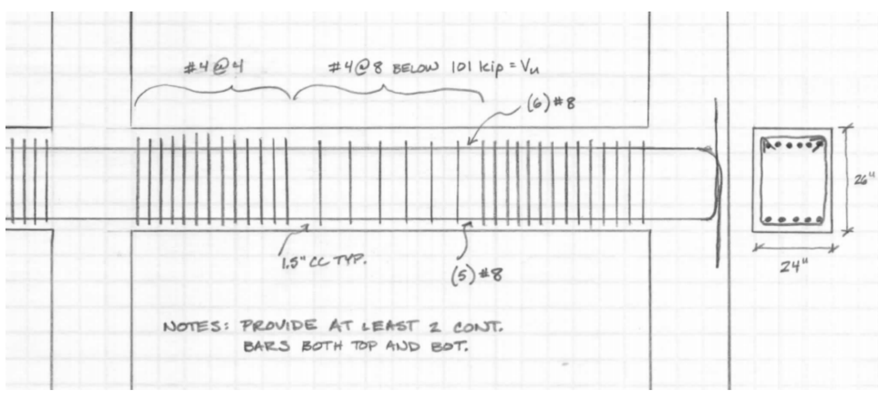


Figure 3.10: Typical reinforcement for a transfer beam

Edge Beam Design: Edge beams are typically 14 in. by 20 in., with the horizontal dimension limited by slab edge at some locations. Initial sizing was based on CRSI Manual tables for spans of 30 ft. and loads of 80 psf. The beams were designed for moment, shear, and torsion. Transverse reinforcement design was governed by torsion, rather than shear. Figure 3.11 shows a typical reinforcement design for an edge beam. Further hand calculations can be found in Appendix A.

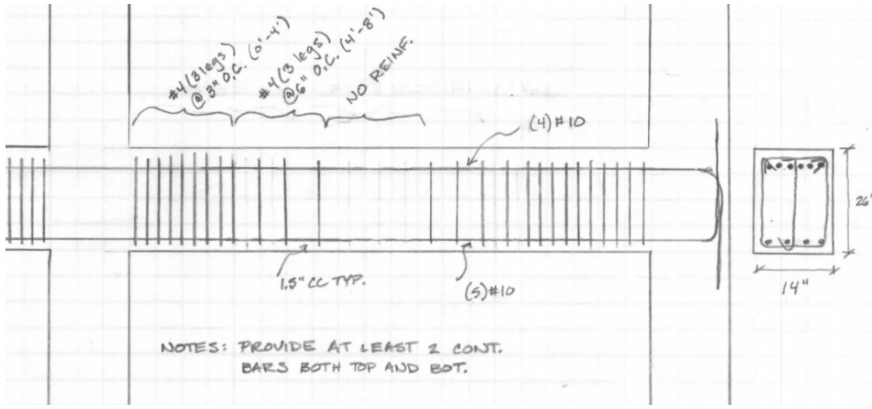


Figure 3.11: Typical Edge Beam Reinforcement

3.2.3 Gravity Columns

The design of columns to support all gravity loads is an important distinction because it alleviates shear walls from taking axial loading. The effects of this assumption will later allow for an increase in the seismic R-factor from 5 to 6, reducing seismic story forces and base shears.

Assumptions and Approach

Code Requirements: Gravity beam design follows ACI 318-11 Chapter 9, ”Strength and Serviceability Requirements,” Chapter 10, ”Flexure and Axial Loads,” and Chapter 21, ”Earthquake Resistant Structures.” Slenderness of the columns was checked according to section 10.10.1 and 10.10.5.2. A hand calculation of slenderness checks can be found in Appendix A. Typical dead,live,roof live, snow, construction, and other loads were calculated based on ASCE 7-10 requirements and can be found in Section 2.3.

Layout Development: As previously stated, the column layout matches that of the original steel structure, with the design intent of minimally impacting the hospital architecture. A view of the original column layout can be seen in Figure 3.12. For constructibility, and because of some penthouse-induced moments, the columns were designed to remain the same size from the ground level to the 6th story roof.

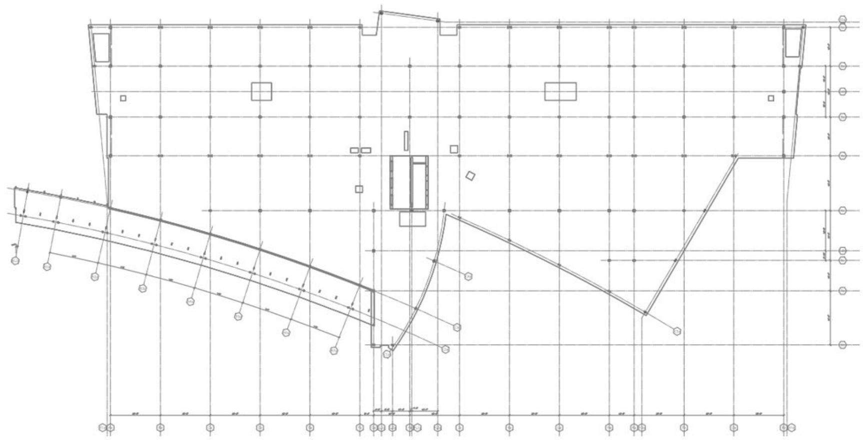


Figure 3.12: Column layout on typical lower floor plan

Modeling

Columns were modeled in an iterative method that cycled between RAM Concept and StructurePoint (SP) Column. Initially, all columns were assumed to be 22 in. square based on design rules of thumb. These columns were modeled in RAM Concept with "pinned-fixed" end conditions for first and roof levels, and "fixed-fixed" conditions for middle floors. All columns were assumed to be compressible with a bending stiffness factor of 1. Factored design forces, including M_r, M_s, and F_z were obtained from the Concept model and exported to an excel spreadsheet where columns were sorted based on force percentiles. From these percentiles, four groupings were defined and columns were designed in SP Column based on height and worst-case loading within the four groupings.

Once the columns were designed, the Concept model was updated and new factored design forces were obtained. These forces were then applied back into the SP column files to ensure the sizes were still viable. Columns were designed to have a reinforcement ratio less than 4% to avoid need for mechanical splices and to reduce rebar congestion during construction.

Results

Reinforced concrete columns in SSM St. Clare Health Center range in size from 16 in. square to 26 in. square. Table 3.2 below shows a schedule of column sizes and reinforcement. Figure 3.13 shows the relative location of these columns on the floor plan.

Table 3.2: Column schedule per floor

Column Type	Count (per floor)	Square Dimension (in)	Bars	As	ρ
1	23	16	(8) #10	10.16	0.0397
2	33	20	(12) #10	15.24	0.0381
3	18	24	(16) #10	20.32	0.0353
4	21	26	(16) #11	24.96	0.0369

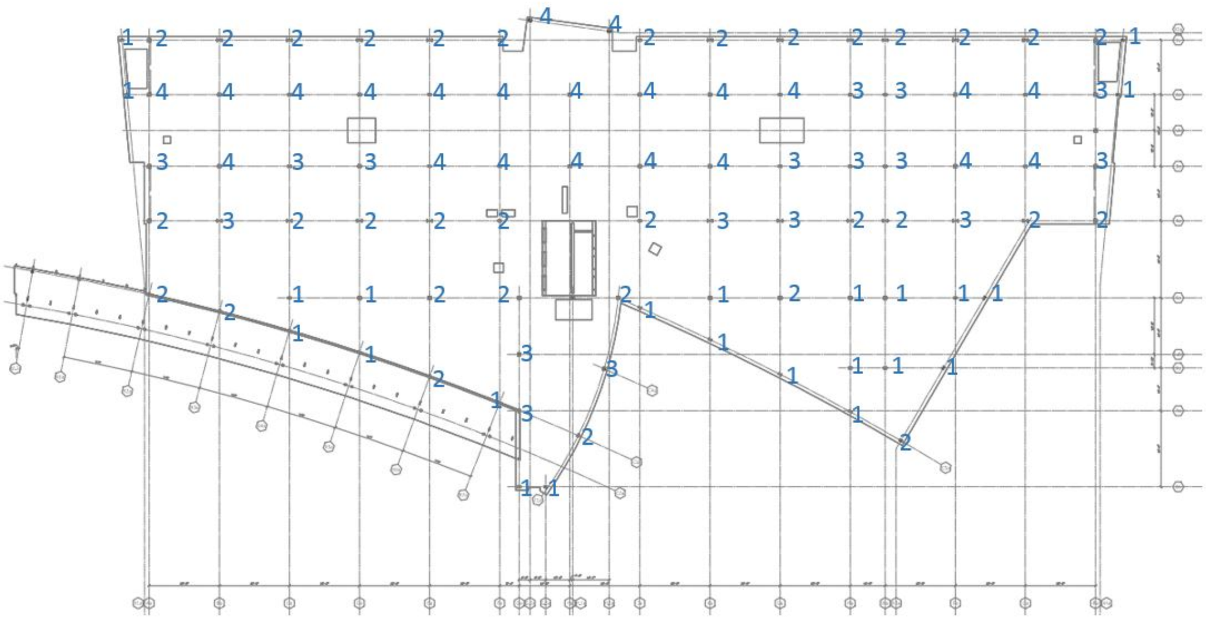


Figure 3.13: Column locations on typical lower floor

3.2.4 Gravity System Comparison

Out of the several factors associated with system efficiency, the most important are cost, construction schedule, and weight. A cost and schedule comparison is presented in detail in Chapter 4.

Weight of the structure, and particularly weight reduction, in SSM St. Clare Health Center to reduce seismic base shears in controlling seismic load cases. In the case of this structural redesign, the weight of the structure has increased significantly from the original system to the redesigned system. Table 3.3 shows the weights per square foot for both systems.

A significantly higher weight does not preclude the reinforced concrete flat slab system from being more economical, but does make the design of an efficient lateral system more challenging.

Table 3.3: Weight comparison of existing and redesigned structure

System	Weight	SF	lbs/sf
Composite Steel	23828.5	255760.1	93.2
Flat Slab Reinforced Concrete	51195.2	255760.1	200.2

3.3 Lateral System Analysis and Design

The lateral system redesign modified existing elements from special steel moment frames (SMF), special concentrically braced frames (SCBF), and specially reinforced concrete shear walls (SRCSW) to all SRCSWs. SWCSWs provide higher rigidity than the original systems and better serve to resist the additional seismic weight of the redesigned gravity system.

The following sections outline the SRCSW design, including code requirements, load determination, system layout, modeling procedure, and design results.

3.3.1 Code Requirements

Shear wall design follows ACI 318-11 Chapter 9, "Strength and Serviceability Requirements," Chapter 10, "Flexure and Axial Loads," Chapter 11,"Shear and Torsion," and Chapter 21, "Earthquake Resistant Structures." Typical lateral wind and seismic loads were calculated based on ASCE 7-10 requirements and can be found in Section 2.3.

3.3.2 Lateral Loads

Both wind and seismic loads were considered in the structural redesign. Wind loads, which can be found in Section 2.3, were found not to control for strength design, but were considered for deflection criteria. Seismic loads were recalculated to reflect the additional mass of the new reinforced concrete structure. Seismic story forces and base shear can be seen in Table 3.4 below.

Table 3.4: Seismic story forces and base shear

Story	Dia.	Wx (kips)	Hx (ft)	k	Hxk	Wx*Hxk	Cvx	Fx
First Floor	1	11036.9	16	1.2	27.47409	303228.83	0.058659	196.8982
Second Floor	2	11124.85	30	1.2	58.23176	647819.57	0.125319	420.6542
Third Floor	3	7313.6	44	1.2	92.02926	673065.22	0.130202	437.0472
Fourth Floor	4	7313.6	58	1.2	128.0255	936327.24	0.18113	607.9933
Fifth Floor	5	7313.6	72	1.2	165.7724	1212393.3	0.234534	787.2537
Sixth Floor	6	6452.6	90	1.2	216.4312	1396543.7	0.270157	906.8296
Penthouse Roof	7	640	108	1.2	269.1172	172234.98	0.033318	111.8388
		51195.2						**3356.68**

ASCE 7-10 section 12.5.3 requires orthogonal combination of seismic loads of 100 percent in one direction and 30 percent in perpendicular direction. Since the building is in SDC D, section 12.5.4 also applies and the maximum forces determined from either direction of these loadings was used in design.

3.3.3 Layout Development

The design criteria for developing lateral element plan were:

- Minimize impact to plan architecture
- Minimize impact to facade architecture
- Maximize shear wall length
- Maximize wall distance from diaphragm centers of mass
- Avoid seismic horizontal and vertical irregularities specified in ASCE 7-10 tables 12.3-1 and 12.3-2

A plan view of the resulting design can be seen in Figure 3.14.

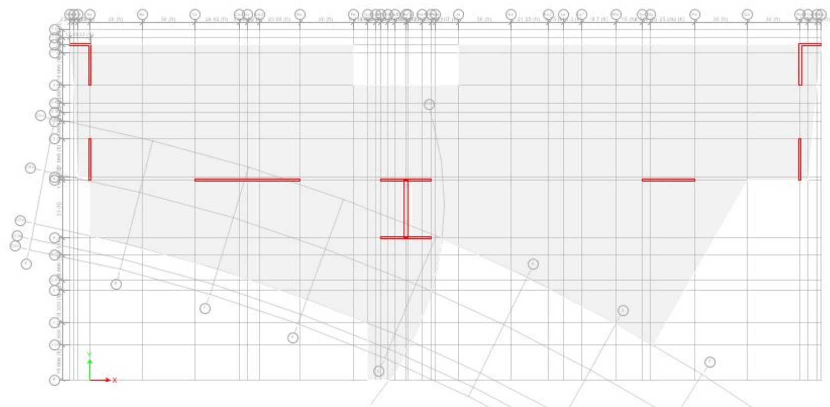


Figure 3.14: Plan view of lateral system layout

3.3.4 Modeling

The lateral system was modeled and iteratively designed using Etabs. The Etabs model included only floor diaphragms and shear walls. This decision was based on the assumption that gravity loads were carried solely by the gravity columns, which allowed for a seismic ”R” value of 6.

Analysis Procedure

By ASCE 7-10 table 12.6-1, equivalent lateral force procedure (ELF) is not permitted for a building in SDC D with structural irregularities. The structure has several irregularities including horizontal torsional (1a.) and reentrant corner (2.) irregularities, as well as a vertical weight (mass) irregularity (2.). Thus a modal response spectrum analysis was used. The analysis followed provisions in section 12.9.

Results of the analysis showed a decrease in base shear by greater than 85 percent of ELF base shears, so the response factors were increased to meet the 85 percent limit as shown in Table 3.5.

Table 3.5: Modal response scale factors

	Base Shear X	Base Shear Y
ModalX Max	1679.357	1059.403
ModalY Max	728.667	3219.239
Seismic 1	-3411.224	0
Seismic 2	0	-4992.871
.85 Seismic 1	-2899.5404	0
.85 Seismic 2	0	-4243.94035
	X-Case	Y-Case
Scalar	1.726577732	1.31830546
Current 100%	96.6	96.6
Current 30%	28.98	28.98
Scale Factor 100%	**166.787409**	**127.34831**
Scale Factor 30%	**38.2044922**	**50.036223**

Due to the horizontal torsional irregularity, modal response forces have an additional eccentricity given by equation 12.8-14:

$$A_x = (\frac{\delta_{max}}{1.2\delta_{avg}})^2$$

This amplified the standard 5 percent eccentricity to 5.2 percent.

With 25 modes, the model was able to achieve the modal mass participations shown in Table 3.6. The majority of mass participation was concentrated within the first five modes.

Table 3.6: Modal mass participations

Item	Static	Dynamic
	%	%
UX	99.94	94.46
UY	99.98	98.1
UZ	0	0

Assumptions and Considerations

Section 12.7 of ASCE 7-10 provides criteria for seismic modeling. Section 12.7.3 requires the use of a 3-D model for structures with torsional irregularities. The Etabs model satisfies this requirement. Table 3.7 provides a list of the assumptions used during modeling for each element type. ASCE 7-10 permits period approximations that would have yielded a higher period than the Etabs-calculated value for ELF base shear determination; a lower ELF base shear would have allowed for a smaller increase in modal response analysis forces. However the calculated value was used to yield the most ”true” value for ELF base shears, considering that in Etabs modal response is determined from model-calculated modal periods.

Table 3.7: Modeling assumptions for lateral system modeling

Lateral Component	Element Type	Assumptions	Modifiers
Special Reinforced Concrete Shear Walls	Thin-Shell	· No out-of-plane rigidity	· Self-weight factor set to 1.0
		· Shear wall fixed at ground level	· Moment in-plane set to 0.7 per ACI 318-11
		· Shell method is more accurate than frame method.	· Shear modifiers out-of-plane set to zero.
		· All floors are cracked (designed as “special” reinforced shear walls for ductility)	
Diaphragms	N/A	· Semi-rigid diaphragm	· Self-weight factor set to zero
		· Center of diaphragm mass is center of story mass	· Superimposed mass equal to total of floor assembly, facades, shear walls, and partitions.
		· Continuous over entire level.	
		· Penthouse loads applied at 6th story COM.	
		· Mass distributed uniformly	

P-delta effects were also considered in calculations. A P-delta stability coefficient was calculated for each story per ASCE 7-10 Section 12.8.7, and the results are presented below in Table **??**

Table 3.8: P-delta stability coefficients exceed 0.1

Story	Px	Δ	Ie	Vx	Hsx	Cd	θ
1	51195.15	0.070991	1.5	365.84	192	5	0.01552
2	40158.28	0.221664	1.5	701.28	192	5	0.01983
3	29033.43	0.398928	1.5	671.38	168	5	0.03081
4	21719.82	0.601727	1.5	889.53	168	5	0.02624
5	14406.22	0.81551	1.5	1108.67	168	5	0.01892
6	6452.00	1.030091	1.5	1253.50	168	5	0.00947
7	640.00	1.24467	1.5	153.72	216	5	0.00720

3.3.5 Results

Drift

Story drift under wind and seismic loads was a major design criteria for lateral system design. Note that the Cd factor for seismic loading is 5 for special reinforced concrete shear walls and seismic deflections are scaled according to this value to check against maximum permitted deflections of h*.025.

The graphs in Figures 3.15, 3.16, and 3.17 show the total building displacements for wind and seismic loading respectively.

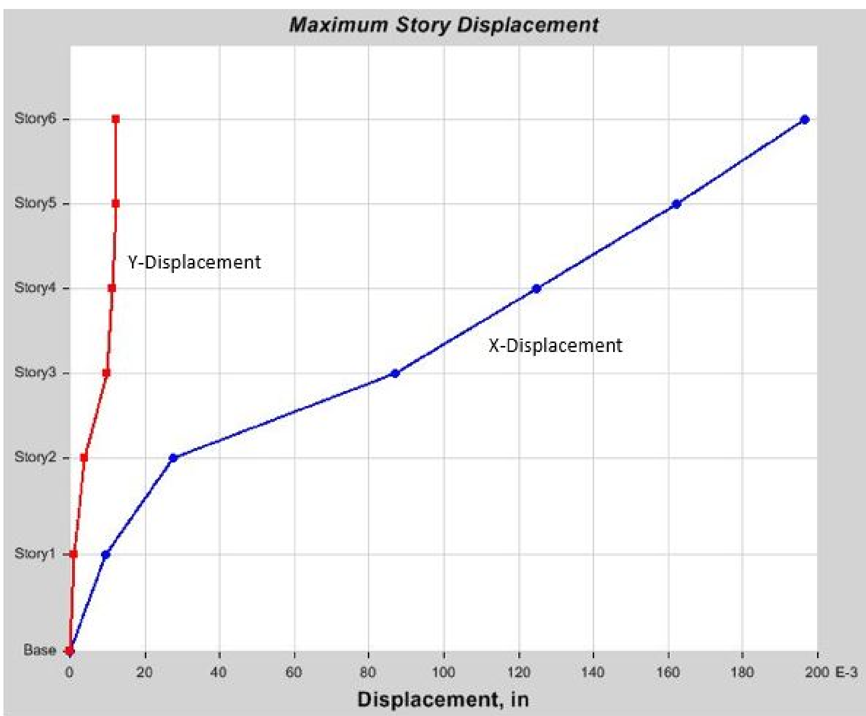


Figure 3.15: Drift due to wind loading

Figure 3.16: Drift due to seismic loading in the X-direction

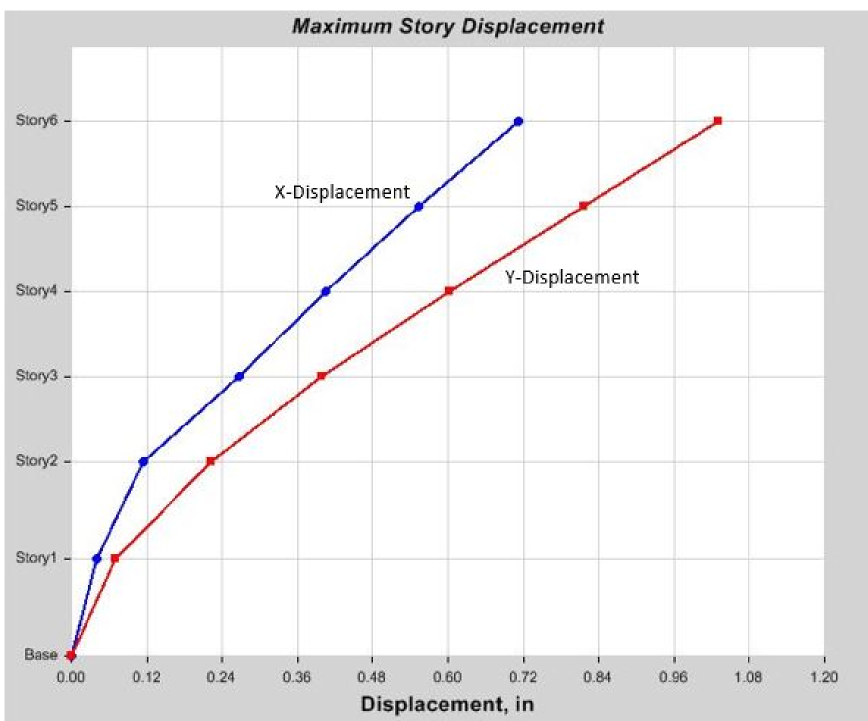


Figure 3.17: Drift due to seismic loading in the Y-direction

Typical Shear Wall Design

An example shear wall design (plan and elevation) is shown in Figures 3.18 and 3.19.

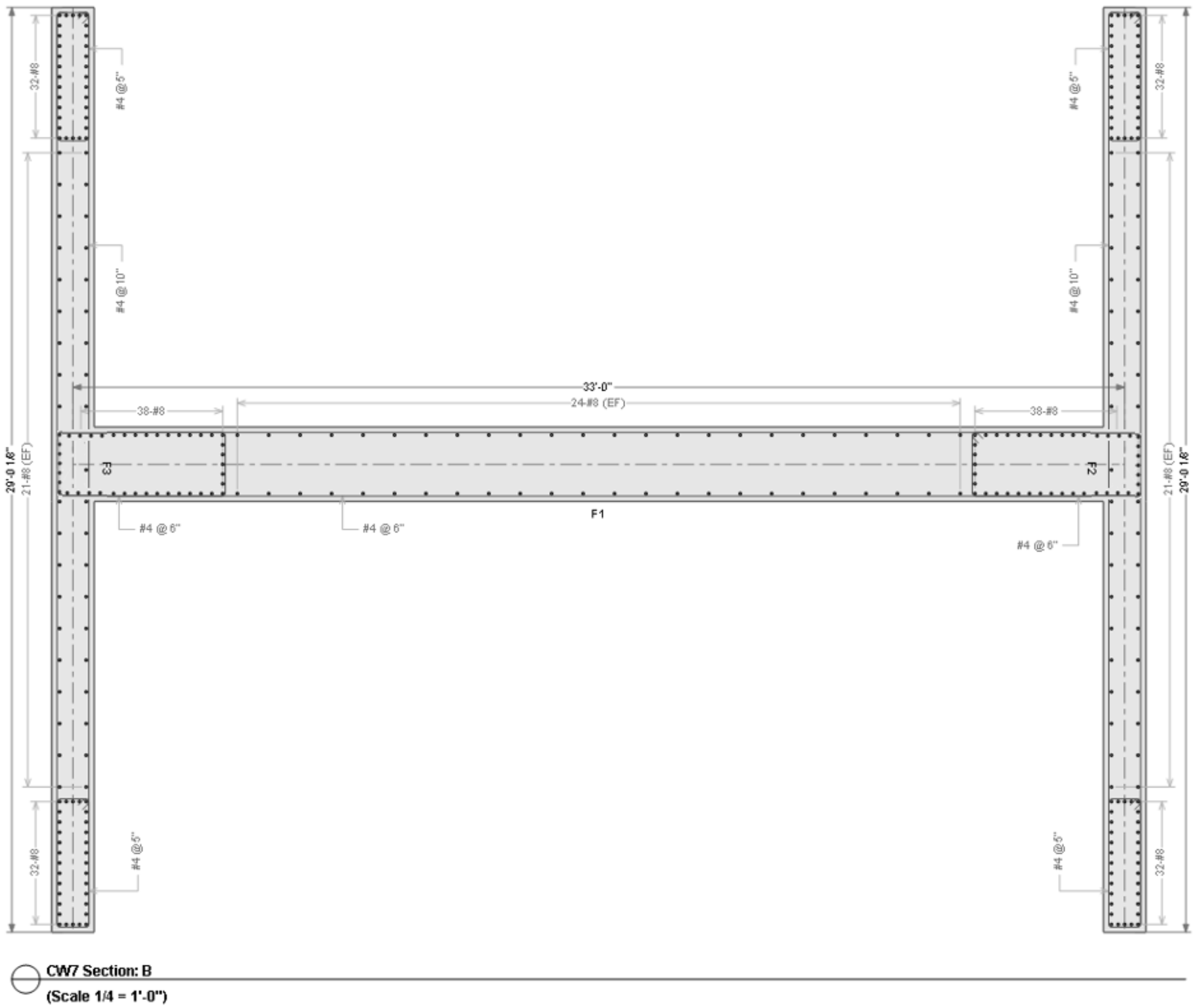


Figure 3.18: Plan view of shear wall reinforcement

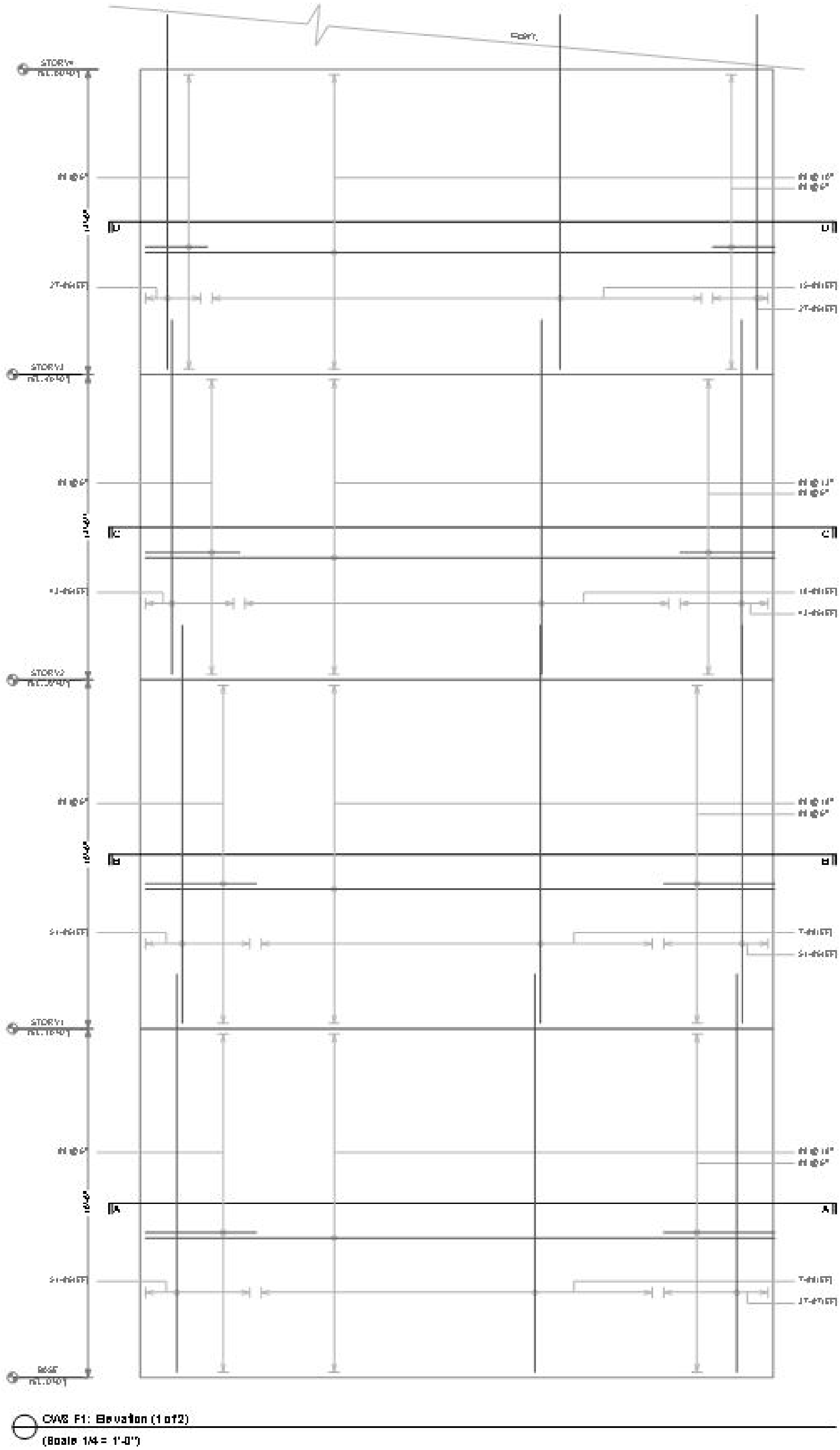


Figure 3.19: Elevation view of shear wall reinforcement

Other shear wall designs as well as sample calculated hand checks can be found in Appendix A. Seismic detailing of shear walls is described in detail in report Section 3.4.2.

3.3.6 Lateral System Comparison

The redesigned lateral system of SSM Health Center is significantly less efficient than the original design in terms of weight.

The central East-West shear wall located along column lines is 30 in. wide and could cause coordination issues in the elevator core. The original lateral system specified 16 in. wide perforated reinforced concrete shear walls (total of 32 in.) along column lines Ga and Ja. These walls were less efficient than the 30 in. wall due to their more complicated reinforcement detailing and formwork requirements. The net savings of 2 inches along the East-West direction in the core is offset by the need for partitions (most likely 6 in. steel stud) along elevator lobbies. The total width of the core would thus be increased by a net of roughly 12 inches. This change could easily be accommodated without noticeable alterations to plan architecture.

The additional rigidity of the reinforced concrete lateral system increased the controlling seismic base shears by reducing building period from 0.970 seconds in the North-South direction to 0.843. Since the response modification coefficient (R) remained 6 between designs, the change in period is a controlling parameter (excluding weight) in the elevated base shears.

Overall, the lateral system is determined to be less efficient than the original design based on weight, period, and base shear. Nevertheless, cost and schedule criteria govern system selection. Cost and schedule data for the structural system are discussed in Chapter 4.

3.4 Seismic Detailing

SSM St. Clare Health Center is located in a seismic category D site, which means reinforcement must meet the requirements of ACI 318-11 Chapter 21. This section provides a general overview of the requirements, although for scope reasons, only a shear wall example has been investigated. The shear wall example can be found in Appendix A

3.4.1 Slab and Beam Detailing

Flexural members must have at least 2 bars continuous on the top and bottom. Transverse reinforcement should be specified with 135 degree and 90 degree hooks in two pieces for constructibility. Any flexural lap splices should be confined by transverse reinforcement with a maximum spacing of 4 inches or one quarter ”d”.

3.4.2 Wall Detailing

A demonstrative example of seismic shear wall detailing can be found in Appendix A. The Etabs detailing in that section have been validated for shear, flexural, and axial reinforcement. However, the Etabs transverse reinforcement for special boundary elements do not satisfy Section 21.4.4.2 or 21.4.4.3 for minimum transverse reinforcement spacing and horizontal cross-tie spacing. These elements would have to be examined further prior entering the construction document phase. Nevertheless, the Etabs output was valuable in verifying wall sizing and general reinforcement layouts.

Chapter 4

Construction Breadth: Cost and Schedule Comparison

4.1 Data and Sources

All construction cost and scheduling data presented in the following sections comes from RS Means Facilities Construction Cost Data 2014. It has been converted for applicability in Fenton, Missouri in 2007. Alberici Constructors has provided the original cost estimate and schedule data for the composite steel structure.

4.2 Construction Estimate

The following sections contain a detailed cost estimate for the existing composite steel system and redesigned reinforced concrete flat slab with drop panels.

4.2.1 Steel Structure Estimate

A structural estimate for the composite steel structure can be seen below in Table 4.1. The budget reflects total costs from steel and cement contractors including overhead and profit. The source estimate provided by Alberici Constructors can be found in full in Appendix B

Table 4.1: Steel Cost Estimate

Code	Description	Cost
140000	Vee-Jay Cement	$2,339,075.00
190000	Hammert's Iron Works	$8,784,148.00
980000	10% of Total Fee	$324,348.90
	Total Structure:	$11,447,571.90
	SF Ratio:	0.59
	Total for Bed Tower:	**$6,808,911.94**

4.2.2 Reinforced Concrete Estimate

A detailed cost estimate was created for the redesigned reinforced concrete structure. The results are presented in Table 4.2. The full cost estimate can be found in Appendix B.

Table 4.2: Conrete Cost Estimate

Code	Description	Cost
0311	Forms in Place	$1,471,661.15
0315	Shores	$665,732.79
0315	Expansion Joints	$2,190.59
0321	Rebar Accessories	$2,329,072.51
0331	Placing Concrete	$1,652,434.17
	Total Cost:	**$6,121,091.21**

4.3 Construction Schedule

The following sections contain schedule data for the existing composite steel system and re-designed reinforced concrete flat slab with drop panels. The schedules provided include only structural activities, and span from beginning of the first floor to the completion of the mechanical penthouse.

4.3.1 Steel Structure Schedule

The steel erection and concrete deck placement schedule can be found in Appendix B. The total duration was expected to take just over a year at 377 days; from May 10, 2010 to June 8, 2008. This time does not include the structural steel fabrication, which was assumed to take place off site.

4.3.2 Reinforced Concrete Schedule

The redesigned reinforced concrete placement schedule (including gravity and lateral systems) can be found in Appendix B. The total duration was expected to take a total of 54.4 weeks, or 381 days; from May 10, 2007 to May 23, 2008.

4.4 Comparison and Conclusions

The structural redesign in reinforced concrete is expected to save roughly $687,800.00, which constitutes approximately 0.4% of the total project cost.

The structural erection sequence takes approximately 4 days longer for the concrete system. This additional scheduled time could be reduced with the addition of more crews, prefabrication of standard formwork, or acceleration in the concrete curing time with additives.

Overall, the system is not only feasible by a cost and scheduling perspective; it represents a significant cost savings for a similar construction schedule. The system should be presented as a cost savings to the owner.

Chapter 5

Landscape Architecture Breadth: Designing for Force Protection

5.1 Overview and Design Objectives

The landscape architecture breadth was devised to investigate security and force protection design. It is based on the premise that SSM St. Clare Health Center has become an United States military-occupied facility and provides care for military affiliated and high-profile political patients.

As such, the site and building must be secured and constructed according to U.S. Department of Defense (DoD) Unified Facilities Criteria(UFC). The goal of design is to mitigate risk to building occupants and damage to the building in the event of an attack through alterations to the site. The following sections provide a background on UFC criteria, the redesign of SSM St. Clare Health Center's site, and investigations into the effectiveness of the redesign to mitigate blast damage to the building facade.

5.2 Literature Review of Force Protection Design Criteria

Security and force protection design is a general topic that refers to any design which serves to secure a facility against damage or casualties due to an act of aggression. UFC design criteria represent one of the most thorough, but certainly not the only, set of criteria on the topic. UFC is an aggregate of standards that provide guidance in planning, designing, constructing, and maintaining DoD facilities. UFC documents pertaining to force protection fall under the umbrella of UFC 4-010-01 ”DoD Minimum Antiterrorism Standards for Buildings.”

UFC 4-010-01 was created with the intent to ”minimize mass casualties in buildings or portions of buildings owned, leased, privatized, or otherwise occupied, managed, or controlled by or for the DoD in the event of a terrorist attack.” The document provides the minimum antiterrorism protection standards for DoD facilities, recognizing that high levels of protection are often prohibitively expensive or technically unobtainable. The document references other UFC documents, which provide further detail on topics ranging from glazing design to chemical weaponry resistance design.

Subsidiary reference documents utilized in this report include those pertaining to site, landscape, and facade design. These include:

- UFC 4-010-02 ”DoD Minimum Antiterrorism Standoff Distances for Buildings”
- UFC 4-022-01 ”Security Engineering: Entry Control Facilities / Access Control Points”
- UFC 4-022-03 ”Security Fences and Gates”

UFC 4-010-01 also references several ASTM standards which govern the testing and design of facade components. These standards include:

- ASTM F1642 ”Standard Test Method for Glazing Systems Subject to Airblast Loadings”
- ASTM F2927 ”Standard Test Method for Door Systems Subject to Airblast Loadings”
- ASTM F2912 ”Standard Specification for Glazing and Glazing Systems Subject to Airblast Loading”

Additional resources related to the design of building enclosure systems for blast loading include recommendations on glazing design in Norville and Conrath, ”Simplified Design Procedure for Blast Resistant Glazing” and on airblast response limits of conventional steel stud walls, including:

- Godhinho, Gallant, Quiter, ”Design & Detailing of Metal Stud Wall Systems in Response to Air-Blast Loading and Effects”
- PDC-TR 06-08, ”Single Degree of Freedom Structural Response Limits for Antiterrorism Design”

Several other security and force protection design criteria have been reviewed, including United States Army PDC Technical Report 10-01, ”Conventional Construction Standoff Distances for the Low and Very Low Levels of Protection”; however, the standards are not as complete or generally adopted within the AEC industry. UFC criteria have the widest acceptance and most plausible applicability to SSM St. Clare Health Center.

5.3 UFC Site Planning Requirements

Site planning incorporates security requirements into the placement of the building, roadways, parking, and landscaping on a site. The site plan presented in the next section reflects the highest level of minimum protection defined in UFC 4-010-01.

5.3.1 Explosive Weights

UFC 4-010-01 specifies standards for site planning which ”address vehicle borne and hand placed explosive threats.” These threats are classified as explosive weights I and II. The exact TNT equivalent weight of the threats is withheld for security reasons, but they are described as a truck or car threat (I) and ”consistent with a brief case or satchel sized object” (II). Figure 5.1 from FEMA 428, ”Primer for Design Safe Schools Projects in Case of Terrorist Attacks,” shows typical ranges for explosive weights. The range of hand-carried explosive weights extends from 30 to 100 pounds of TNT. The exact weight used in the following analyses will not be disclosed for security reasons.

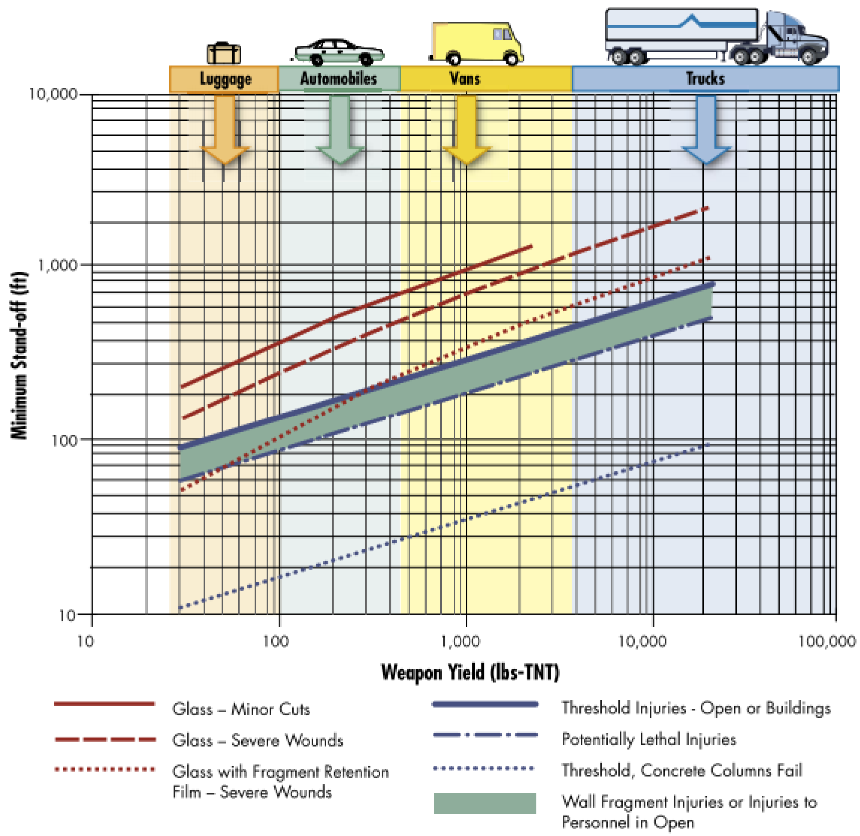


Figure 5.1: Spectrum of blast weights by delivery method

5.3.2 Standard Standoff Distances

To mitigate the two threat levels, UFC 4-010-01 identifies standard construction standoff distances, past which the given threats cause minimal injury or destruction. The standard allows for reduction of threats to level II within a controlled perimeter (CP), assuming that security at the perimeter would detect explosive weight I threats and prevent them from entering. Table B-2 in the document defines the standard construction standoff for a primary gathering (PG) facility, subject to explosive weight I, and with metal stud and brick veneer enclosure as 207 ft. This setback was used to establish the CP for the site redesign.

For explosive weight II, the minimum setback according to Table B-1 is 13 ft, while the standard construction standoff is 82 ft. The 82 ft. value was used to establish the ”unobstructed space”: a safety perimeter within which an explosive device of explosive weight II could easily be detected. Unobstructed means no obstructions that could conceal a device greater than six inches in height. Safe parking (B-1.1.6) and trash receptacle locations (B-1.1.14) are also required to be outside of the unobstructed space. No plants with foliage below 3 ft above the ground are permitted.

The standard standoff distances have been superimposed on a map of the site in Figure 5.2.

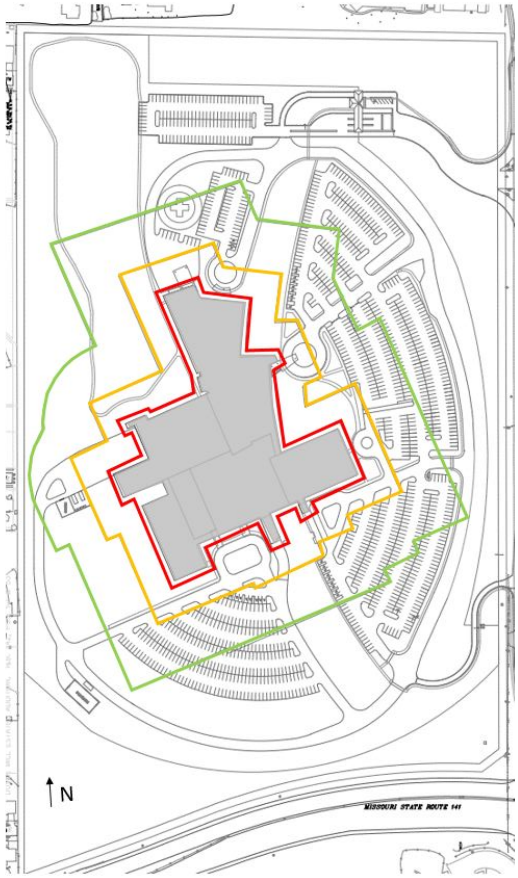


Figure 5.2: UFC standoff distances superimposed on site plan

5.4 Landscape Design

The landscape breadth focuses on two aspects of landscape design: the aesthetic design of spaces for occupant enjoyment, and the functional design of spaces for operation and logistical needs. The following sections present a garden design and site plan design, which fit the aforementioned categories and which meet the security requirements of UFC 04-010-01.

5.4.1 Garden Design

The first aspect of the landscape redesign was a micro-level redesign of the garden space within the unobstructed space (82 ft. setback line) on the east side of the building. Located at the base of a hill, the garden starts at ground level and climbs 16 ft. to the first story level.

The redesign requires the use of plants with foliage below 3 ft. and elements that cannot hide potential threats. A concept was created that incorporates a healing labyrinth surrounded by outdoor seating. The labyrinth fits the religious nature of the hospital, as well as provides a healing recreation for patients and a point of visual interest. An inspiration labyrinth is shown in Figure 5.3 below.

Figure 5.3: Inspiration healing labyrinth design

The seating and labyrinth were surrounded with flowering dogwood trees (Cornus florida L.), the state tree of Missouri. Flowering dogwoods bloom white or pink in the spring and turn hues of red and orange in the fall. They provide further visual interest, shade, and dynamic color to the landscape. Figure 5.4 shows a group of flowering dogwood trees.

Figure 5.4: A group of flowering dogwood trees (Cornus florida L.) in bloom

Figure 5.5 shows a plan of the garden design in its entirety.

Figure 5.5: Plan view of garden design

5.4.2 Site Design

On the master-planning scale, site design focused on meeting the setback requirements identified in UFC 4-010-01. In order to assume parking limits up to the standard construction setback (82 ft.), a control perimeter was established beyond the critical setback for explosive weight I (207 ft.)

A view of the control perimeter can be seen in Figure 5.6. Note the control access points at the North and South of the site. The north control access point allows for traffic flow both into and out of the site, while the south control point is only an exit. The flow allows for more security, and decreases the cost of additional facilities. The south control point contains only a guard house and barricade, while the north requires a full visitor and inspection center. The design of the control perimeter and guard facilities follows UFC 4-022-01, ”Security Engineering: Entry Control Facilities/Access Control Points.”

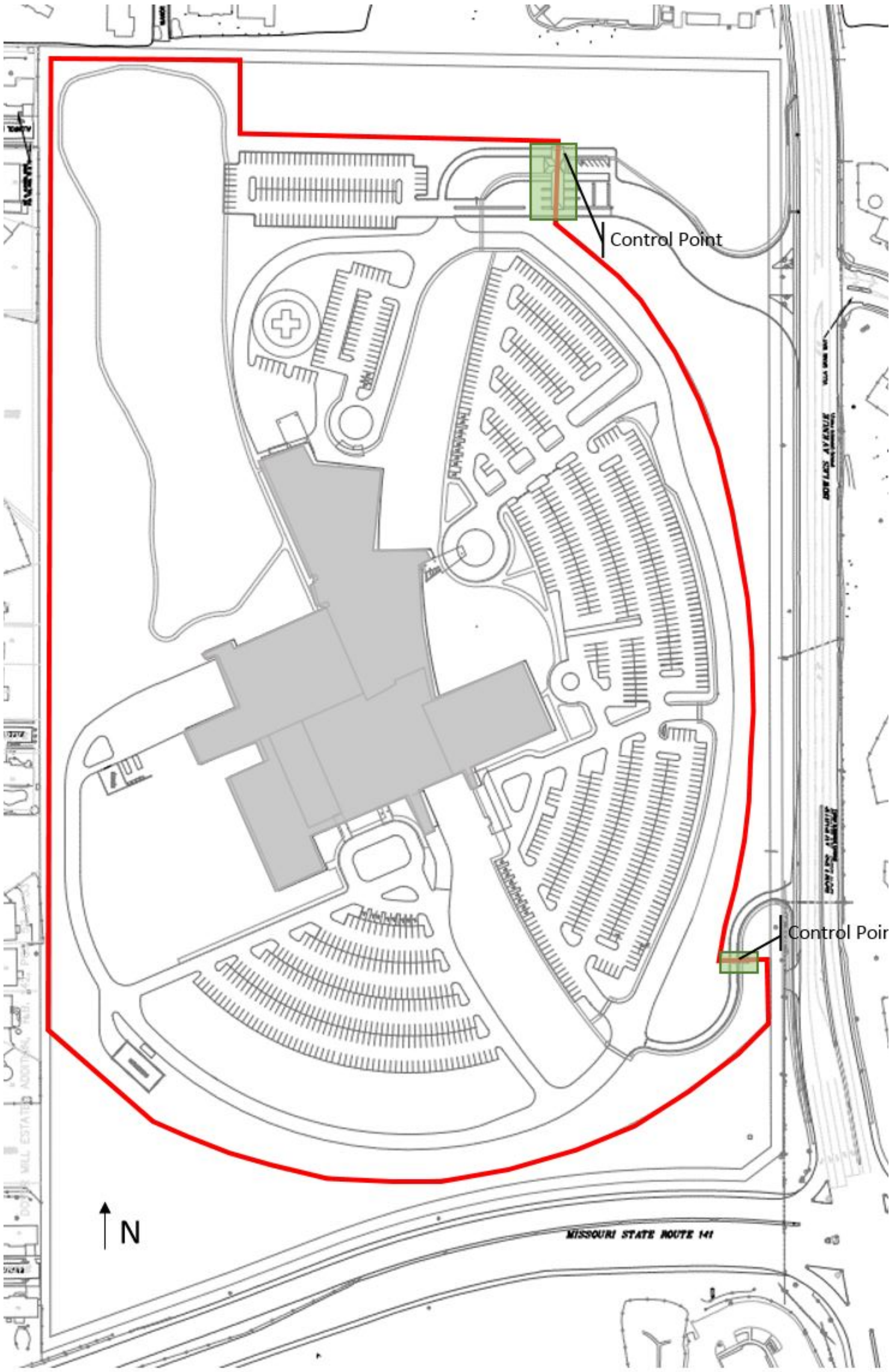


Figure 5.6: Plan view of control perimeter and locations of access control points

Guard Facilities

Site entry layout meets provisions of UFC 4-022-01 Section 6.2 "General Layout Requirements." This section details the requirements for the three protection zones for mobile threats: the approach zone, access control zone, and response zone. These zones are shown in Figure 5.7 for the north control access facility. The approach zone curves to slow traffic, with several speed bumps located before the access control zone to further slow mobile threats. The access control zone consists of a full visitor and inspection center. Private vehicles can be processed in three lanes, while commercial and delivery vehicles have a separate inspection lane at the rear of the facility. The lane nearest to SSM St. Clare Health Center is reserved for emergency vehicles and hospital personnel.

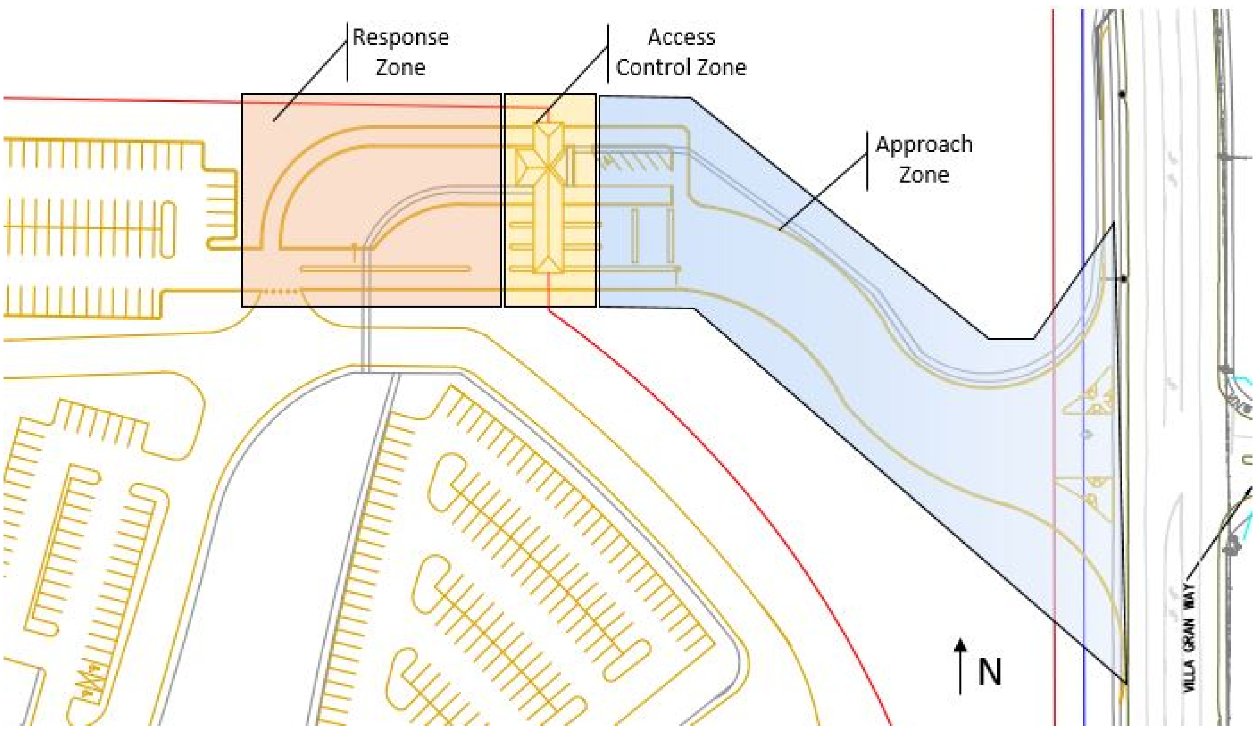


Figure 5.7: Plan view of access control facility

A final denial barrier of retractable bollards is located at the end of the response zone. The response zone is shorter than that required by the UFC requirements, so a full-stop checkpoint was added in the response zone to eliminate the threat of a high-speed attack.

The south control access point also contains three zones and similar design, including retractable bollards and stop checkpoint.

Site Alterations

Several site alterations were made to make the existing parking and trash receptacle locations UFC compliant. Figure 5.8 shows the standard UFC standoffs and highlights problem areas where parking or trash receptacles were relocated. The trash receptacles were placed outside of the standard construction standoff distance and enclosed by only two walls to avoid the need for full enclosure. Several rows of parking were added to the east parking lot to offset the parking lost to setback distances. The net number of parking spaces is greater than the original design (including the same number of ADA compliant spaces).

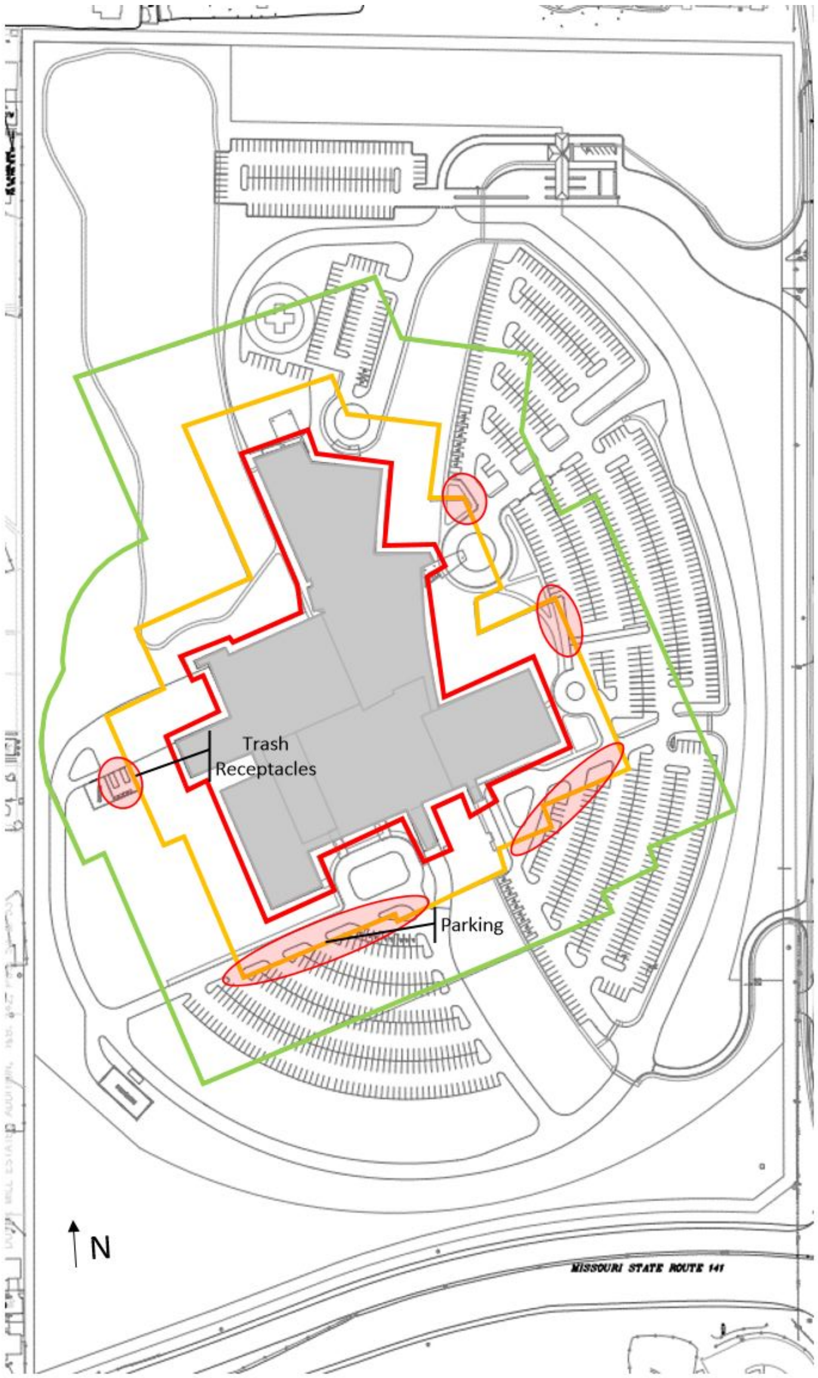


Figure 5.8: Plan view of site alterations to meet setback requirements

5.5 Effectiveness of Threat Mitigation

An analysis was conducted to verify the effectiveness of the new site design in mitigating standard threats. The analysis simplifies the building enclosure to a single-degree-of-freedom (SDOF) system determines deflections and rotations based on a given explosive weight and setback distance. The following sections present an overview of blast loading theory, the analysis methodology, and summary of results. The explosive weight used in the analysis will not be disclosed for security reasons.

5.5.1 Overview of Blast Loading

Blast loads are a function of air pressure changes on a building surface. After detonation, a shock-wave of high-pressure air forms and spreads outward from the energy source. The incidence of this pressure on the building is known as a disturbance or pressure pulse, and is a function of the distance from the building and the energy released in the explosion. As the pressure pulse moves past the building, the pressure changes from highly positive to slightly negative (suction), reversing the force on the enclosure. Figure 5.9 shows a typical pressure-time graph of an airblast at a given point of interest.

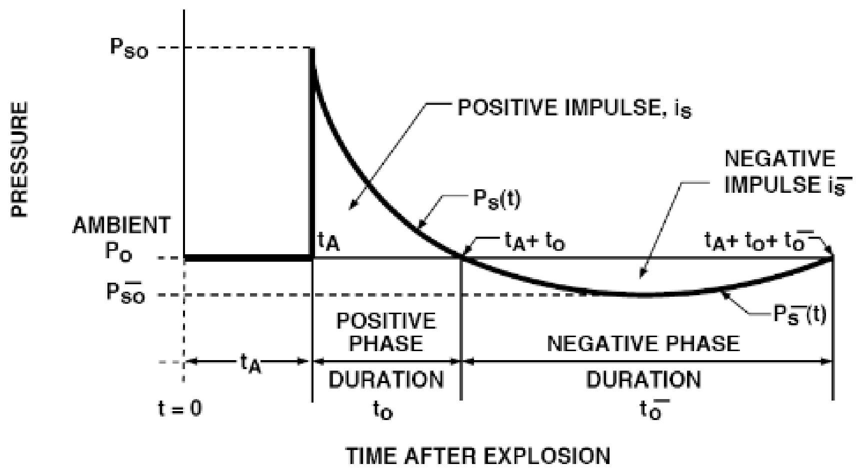


Figure 5.9: Typical pressure-time graph of an airblast at a given point of interest.

5.5.2 Overview of Existing Enclosure

A section of the existing cavity wall enclosure can be seen in Figure 5.10. The wall's structural system consists of eight inch, 800S162-54 steel studs spaced at 16 in. on center. The brick is 4 in. and assumed to have Portland cement/lime mortar, type M or S, with a solid unit flexural tensile capacity of 40 psi. Glazing systems were not evaluated as part of this general analysis.

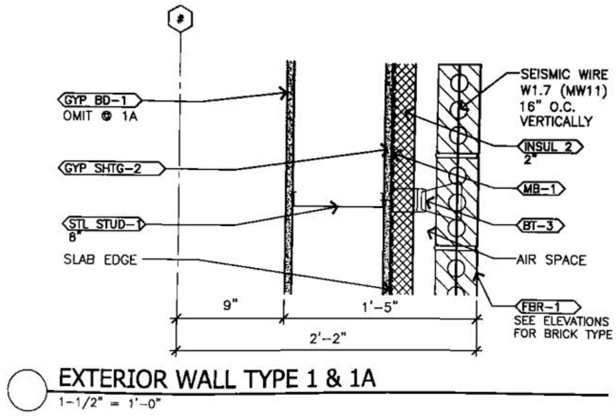


Figure 5.10: Typical steel stud cavity wall section

5.5.3 Analysis Methodology

The analysis was based on the assumption that standard construction standoff distances have been met, and thus the largest and closest possible threat was that of an explosive weight II device at 82 ft. The goal of the previously described site and landscape redesign was to ensure the validity of this assumption.

A copy of the Single Degree of Freedom Blast Design Spreadsheet (SBEDS) was obtained from the U.S. Army Corps of Engineers for this analysis. The spreadsheet was developed to reduce complex structural systems such as building enclosures into SDOF systems which could be easily analyzed. SBEDS is capable of analyzing metal stud cavity walls with brick veneers as SDOF components.

A list of modeling assumptions for SBEDS can be seen in Table 5.1.

Table 5.1: List of assumptions used in SBEDS modeling

Component	Element Properties	Assumptions
Steel Studs	800S162-54 Section	Bending about strong (X-X) axis
	A653, Grade 33 (cold-formed steel)	No Dynamic Axial Load
		Standard Web Punch Outs
		Simply supported
		Connected top and bottom
Veneer Wall	4 in. Brick	40 psi allowable tension stress
	S or M type mortar	
General Wall		32 ft. Tall
		100 ft. Wide
		Flexural and Tension Membrane
		1% Critical Damping

5.5.4 Results

A example charge weight-standoff diagram has been reproduced in Figure 5.11 from PDC TR-06-08. This diagram shows iso-damage lines for varying explosive weights and standoff distances (for a given set of damage criteria).

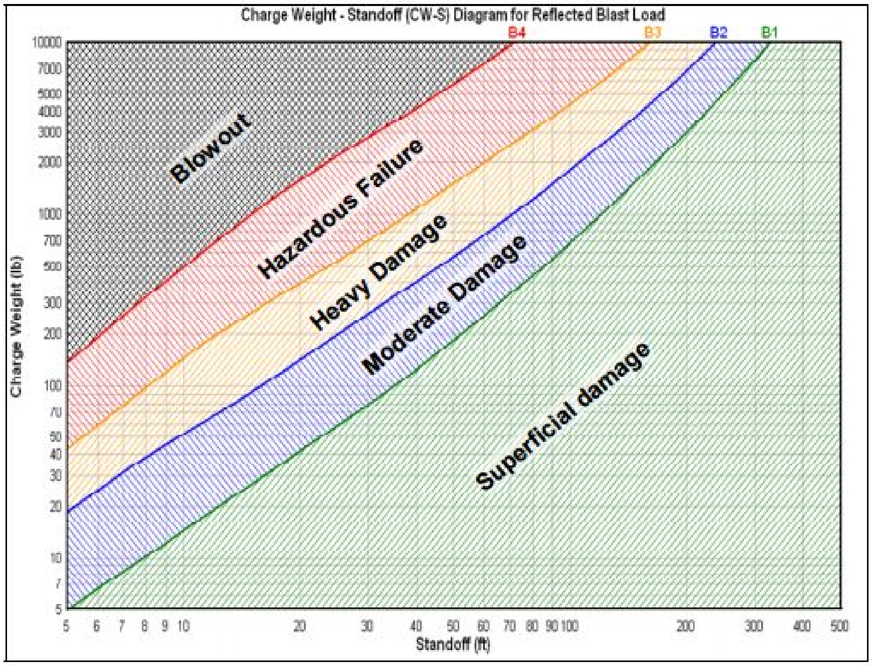


Figure 5.11: CW-S diagram for Reflected Blast Load

An SBEDS generated charge weight-standoff diagram is shown in Figure 5.12. This figure shows iso-damage lines for ”superficial damage” and ”moderate damage” based on response limits for steel stud walls from PDC TR-06-08,as well as those from an independent Simpson, Gumpertz, and Heger (SGH) investigation. The SGH results are plotted in red and light blue, while the PDC results are in purple and dark blue. Note that the PDC limits are significantly more stringent than the SGH limits for the same expected level of damage. The range of values indicated in red represent the range of hand-delivered threat weights at an 82 ft. standoff distance. It can be seen that these values are within the limits of moderate damage criteria established by both PDC and SGH.

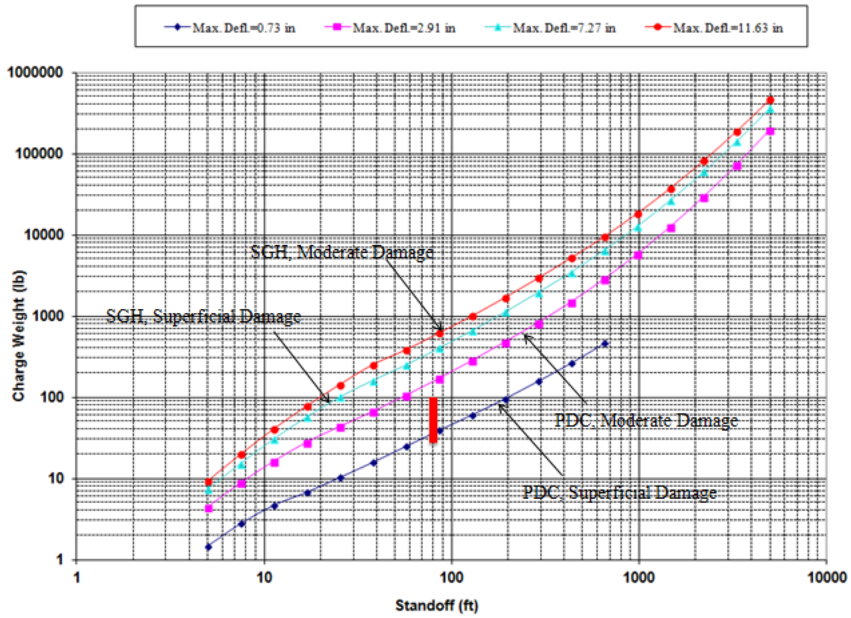


Figure 5.12: PDC and SGH CW-S Diagram for Reflected Blast Load

An SBEDS analysis of the wall showed a support rotation of -1.1 degree and a ductility ratio of 1.31. The maximum deflection was -1.9 in., meaning that the negative pressure portion of the blast history controlled both rotation and deflection. A full output report for SBEDS, including displacement and resistance graphs can be found in Appendix C.

Table 5.2 provides a summary of the PDC and SGH response limits as well as the theoretical wall response at the given loading and standoff.

Table 5.2: Summary of blast results

	Δ_{max}	μ_{max}	θ_{max}
	inch		degree
PDC	-	0.5	-
SGH	H/30 = 6.4	5	7
Theoretical	-1.9	1.31	-1.1

5.5.5 Conclusion

The enclosure does not meet PDC TR-06-08 superficial damage criteria for rotation and ductility at an 82 ft. standoff; however it does meet the moderate damage PDC criteria and superficial damage criteria based on SGH study values (Figure 5.2). By these criteria, the wall is subject to only superficial damage at the analyzed standoff and explosive weight. Should a higher explosive weight be used, the wall would sustain greater damage, but would have additional capacity to protect against ultimate failure and loss of life.

Appendix A

Structural Depth References

A.1 Slab References

DDM CHECK

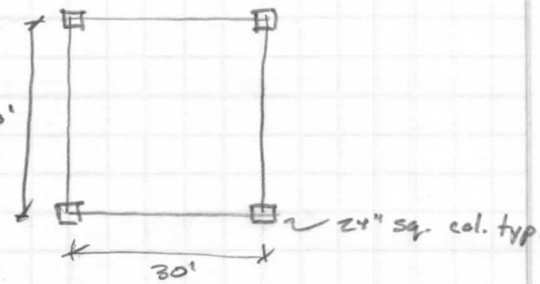
spans: 30' typ.

h_f : 10.5"

q_u : 303.5 psf

M_o : $\dfrac{(0.3035)(30)(28)^2}{8}$

: 892.29 k ft



SLAB INTERIOR

M_u^- : $0.65 M_o$ = -580.0 k ft
M_u^+ : $0.35 M_o$ = 312.3 k ft

COLUMN - MIDDLE STRIPS

$\alpha_{f_1} = 1$

$\dfrac{\ell_2}{\ell_1} = 1$

$M_{u\,col}^-$ = 0.9 (580) = -522 k ft
$M_{u\,col}^+$ = 0.9 (312.3) = 281 k ft
$M_{u\,mid}^-$ = 0.1 (580) = -58 k ft
$M_{u\,mid}^+$ = 0.1 (312.3) = 31.23 k ft

TYPICAL MAT CHECK

$d = 10.5 - 0.75 - (5/8)(0.5) = 9.4375$
$\;\; = 10.5 - 0.75 - (5/8)(1.5) = 8.8125$

$a = \dfrac{8(0.31)(60)}{0.85(4)(96)}$

$\;\; = 0.456$ in

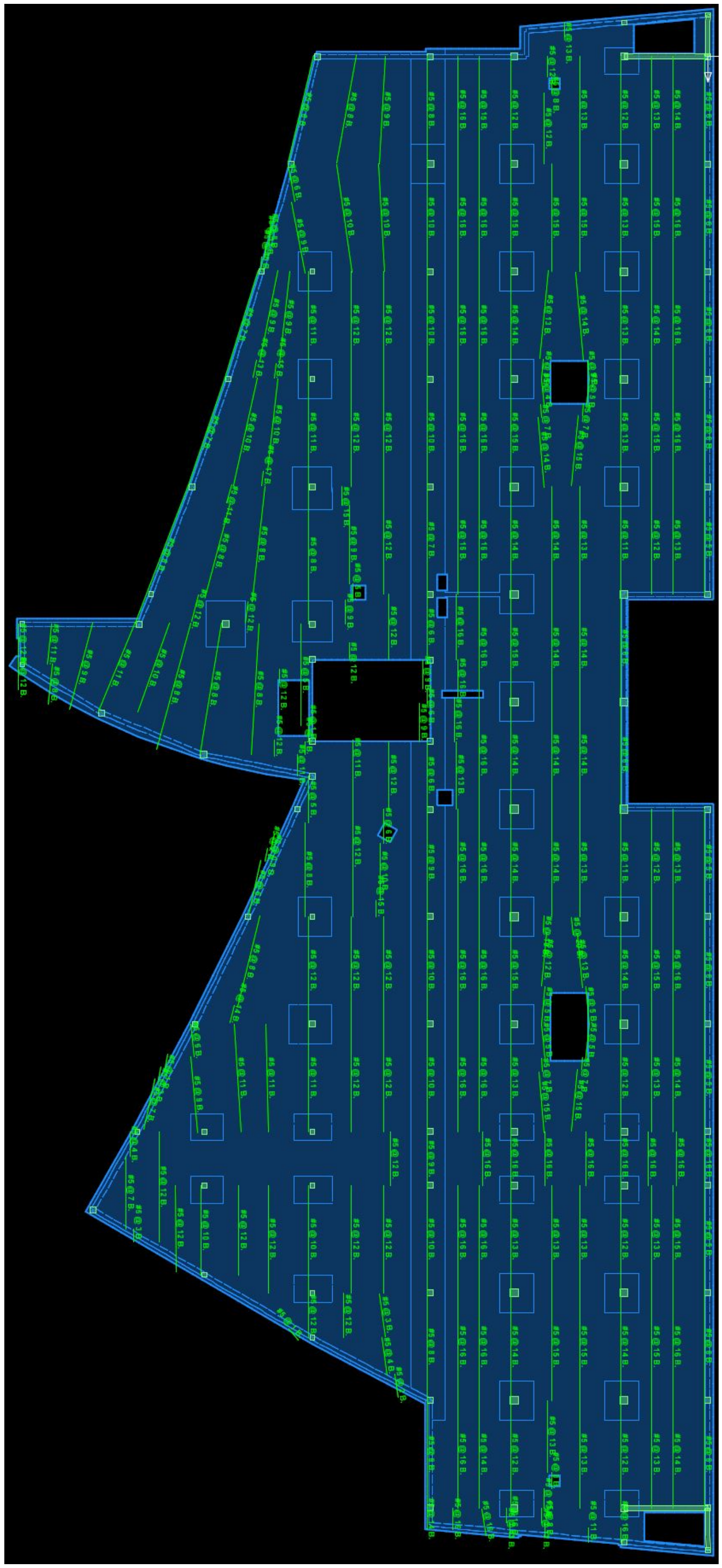
$\beta_1 = 0.85$

$c = 0.536$

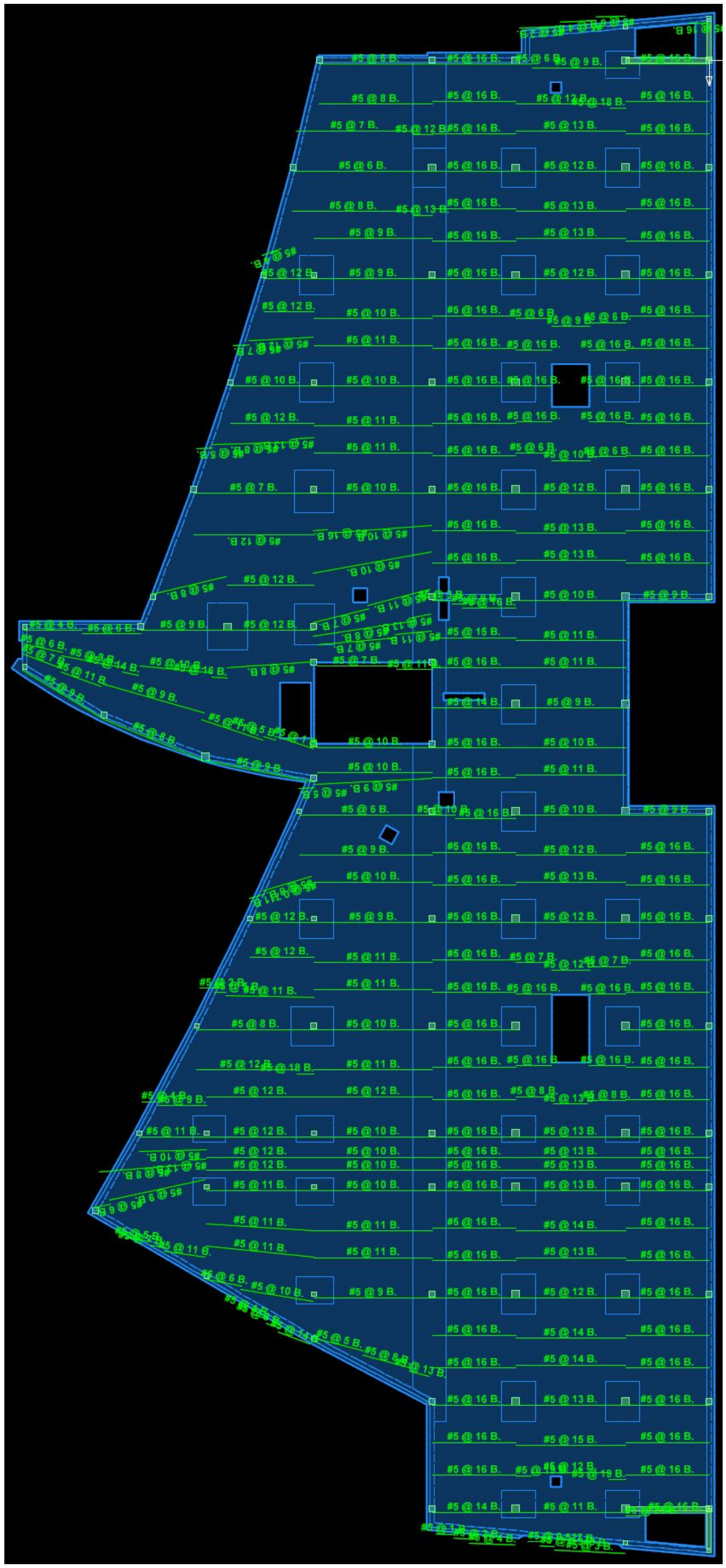
$96" = \underbrace{1.5(24)(2) + 24}_{\text{COL TRANSFER ZONE}}$

$M_n = 8(0.31)(60)\left(8.8125 - \dfrac{0.456}{2}\right)$
$\;\; = 1255$ k ft

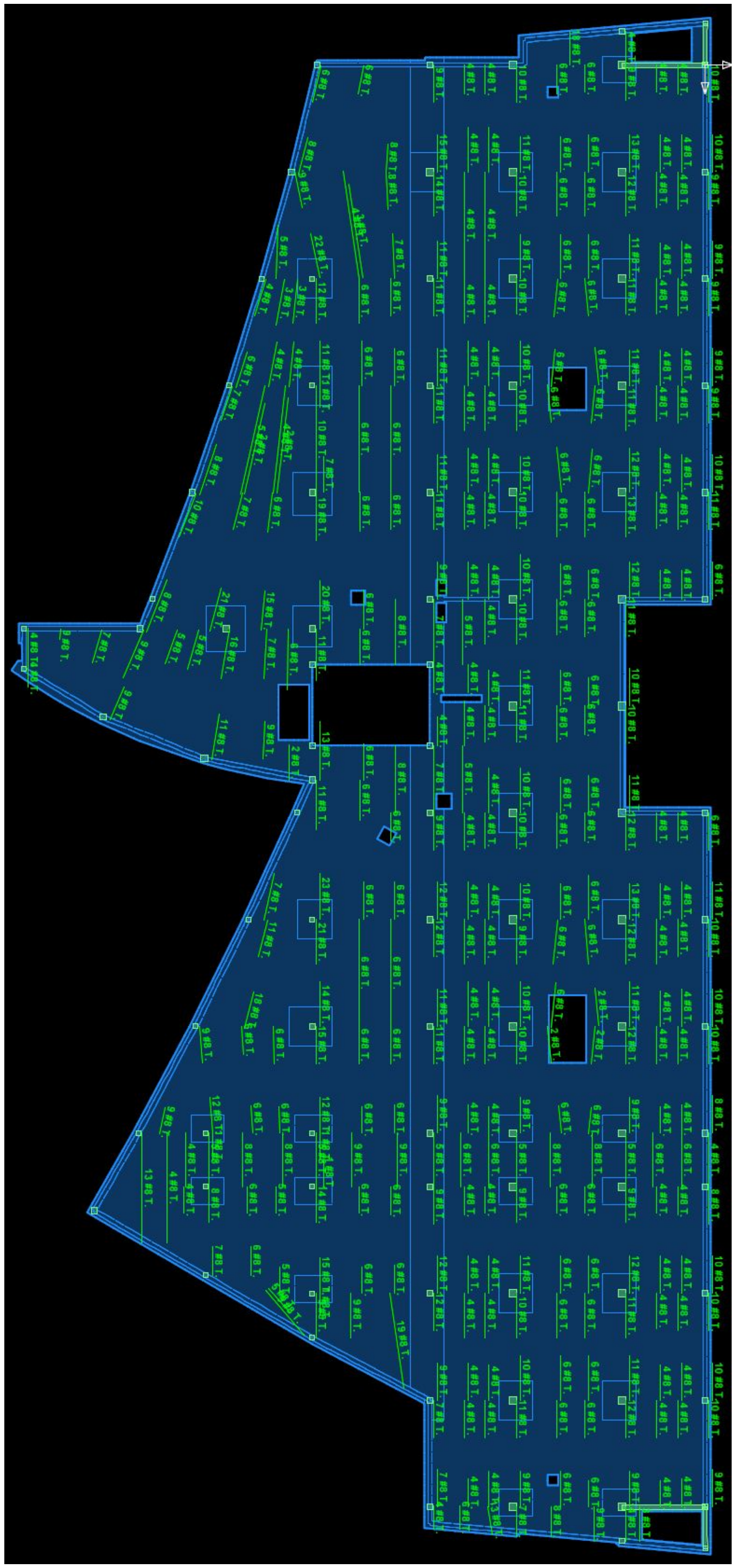
$\phi M_n = 1129$ k ft > 281 ✓



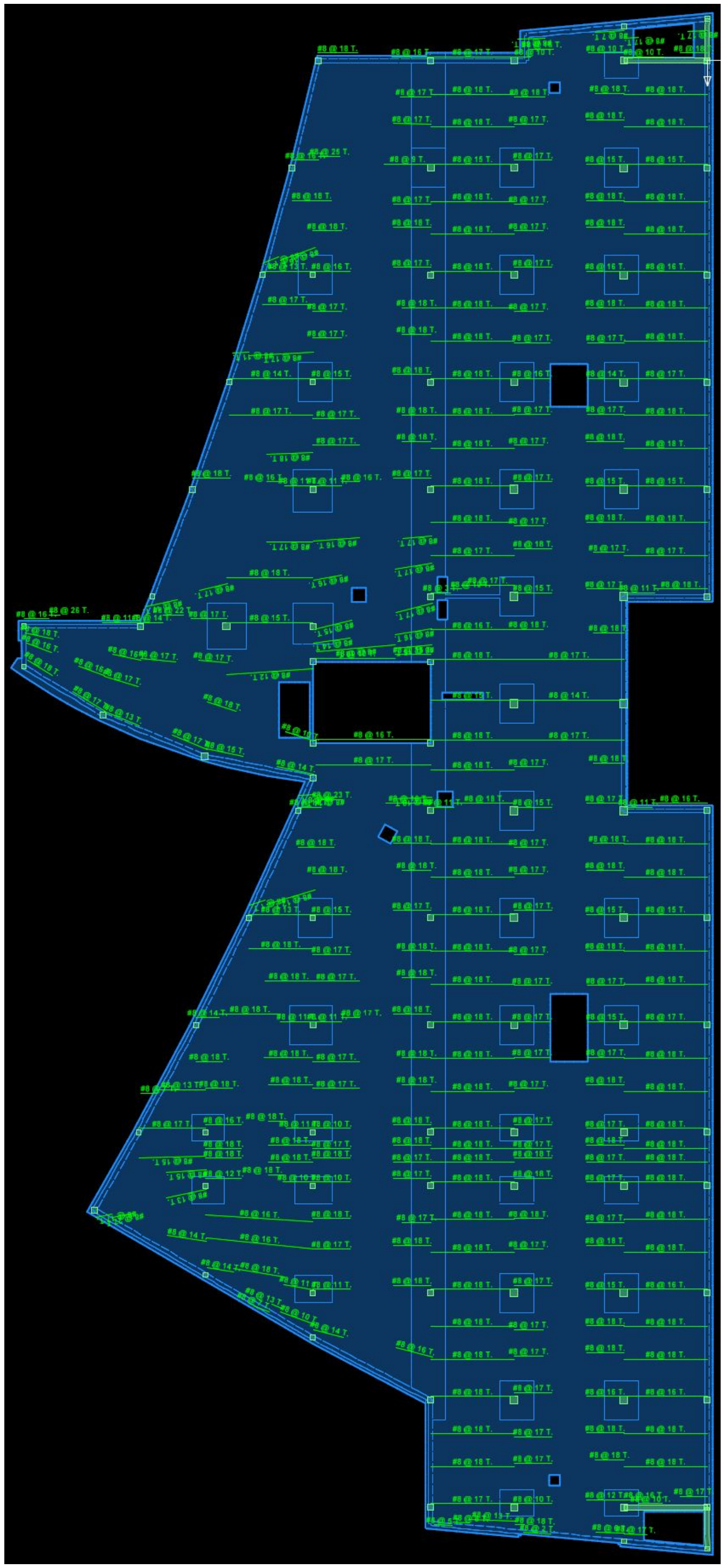
Typical Reinforcement Plan: Lower Level Latitudinal Bottom



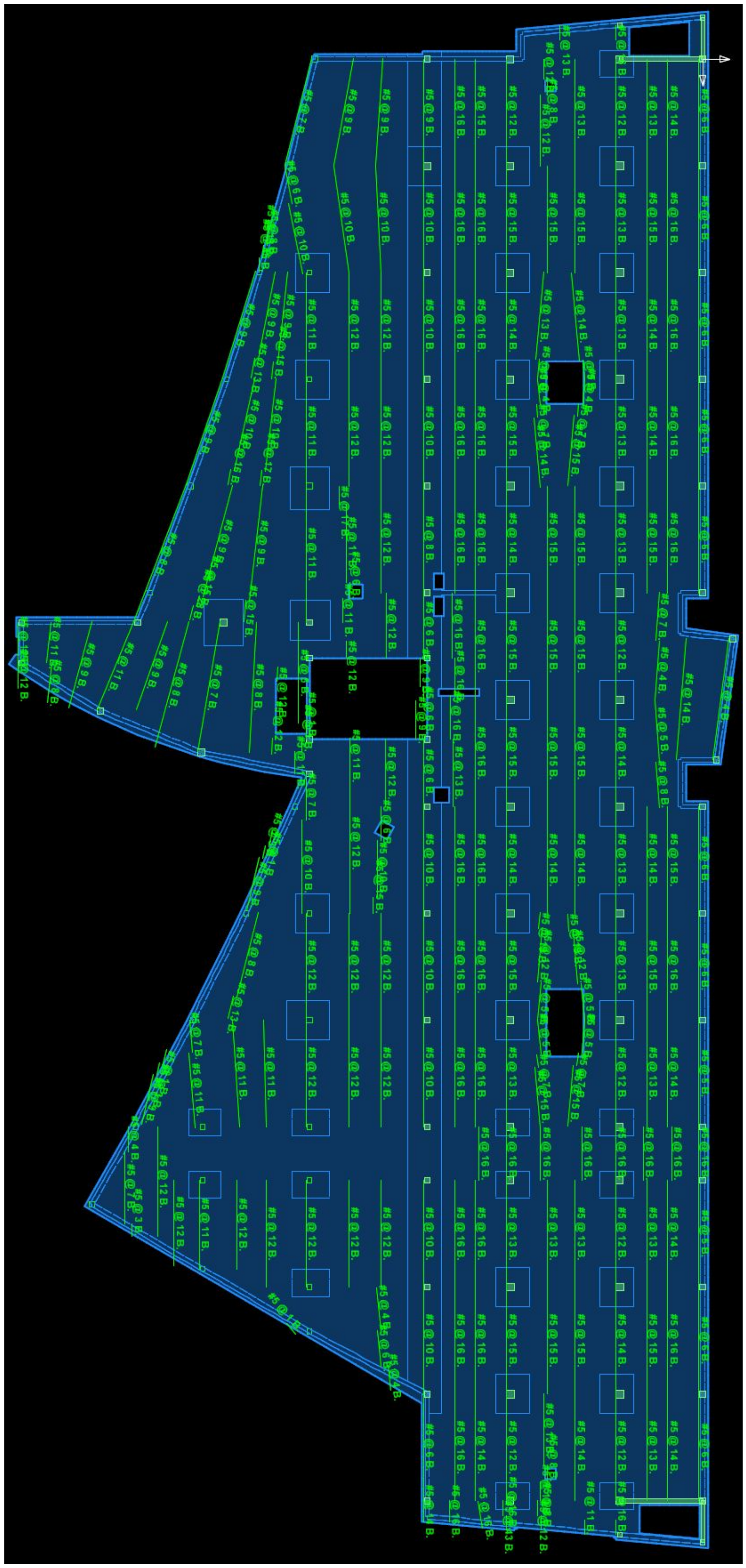
Typical Reinforcement Plan: Lower Level Longitudinal Bottom



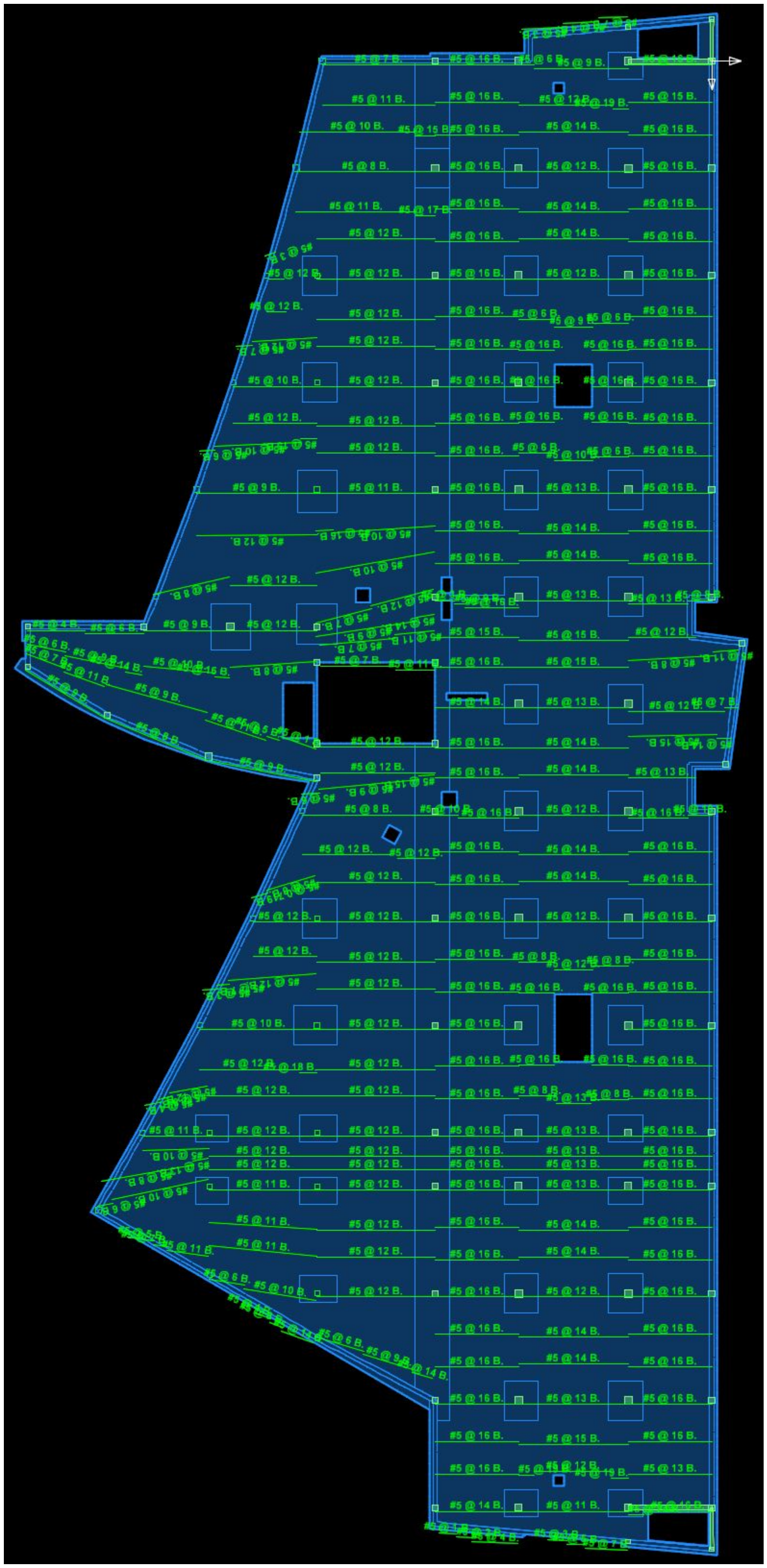
Typical Reinforcement Plan: Lower Level Latitudinal Top



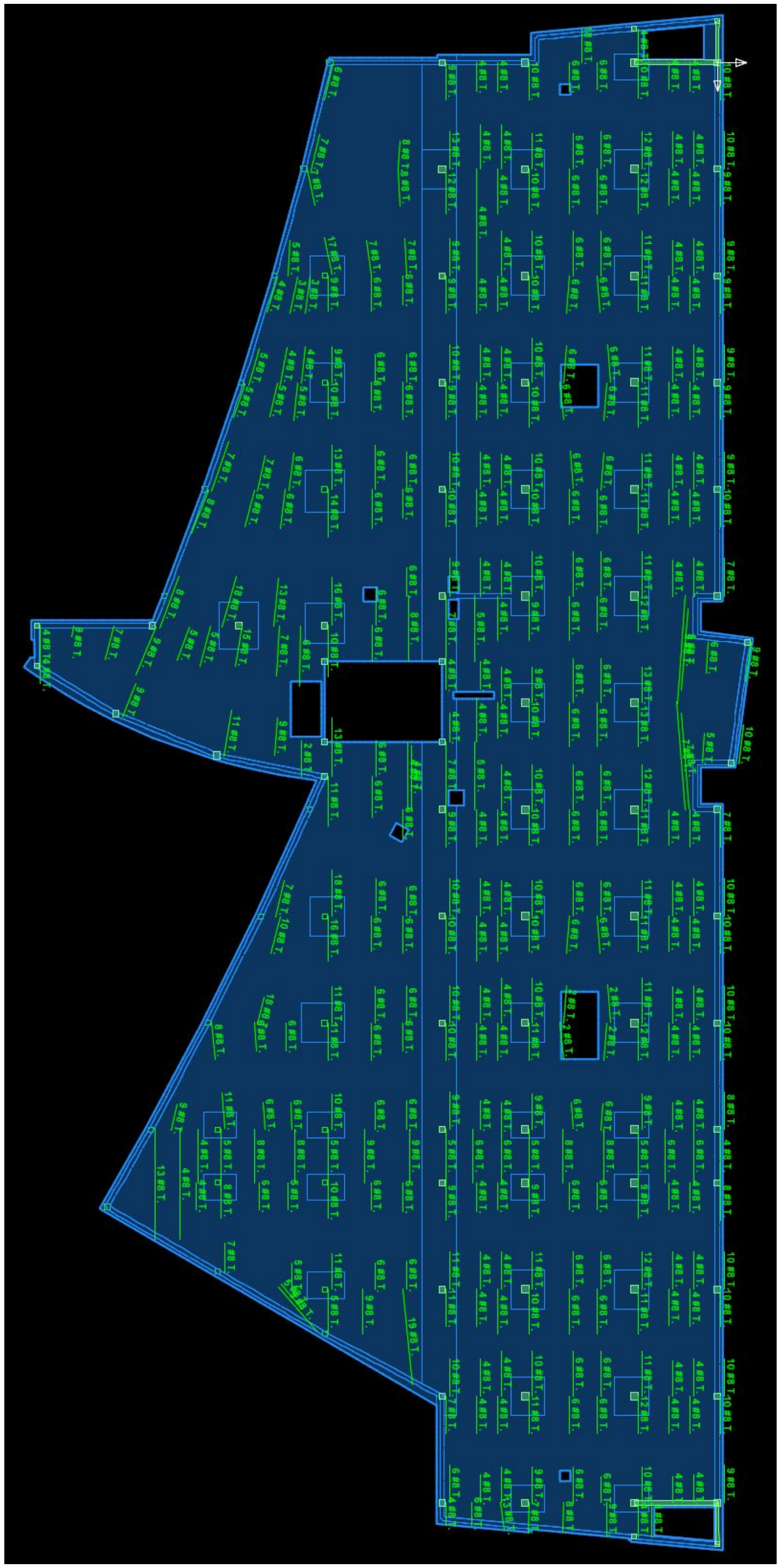
Typical Reinforcement Plan: Lower Level Longitudinal Top



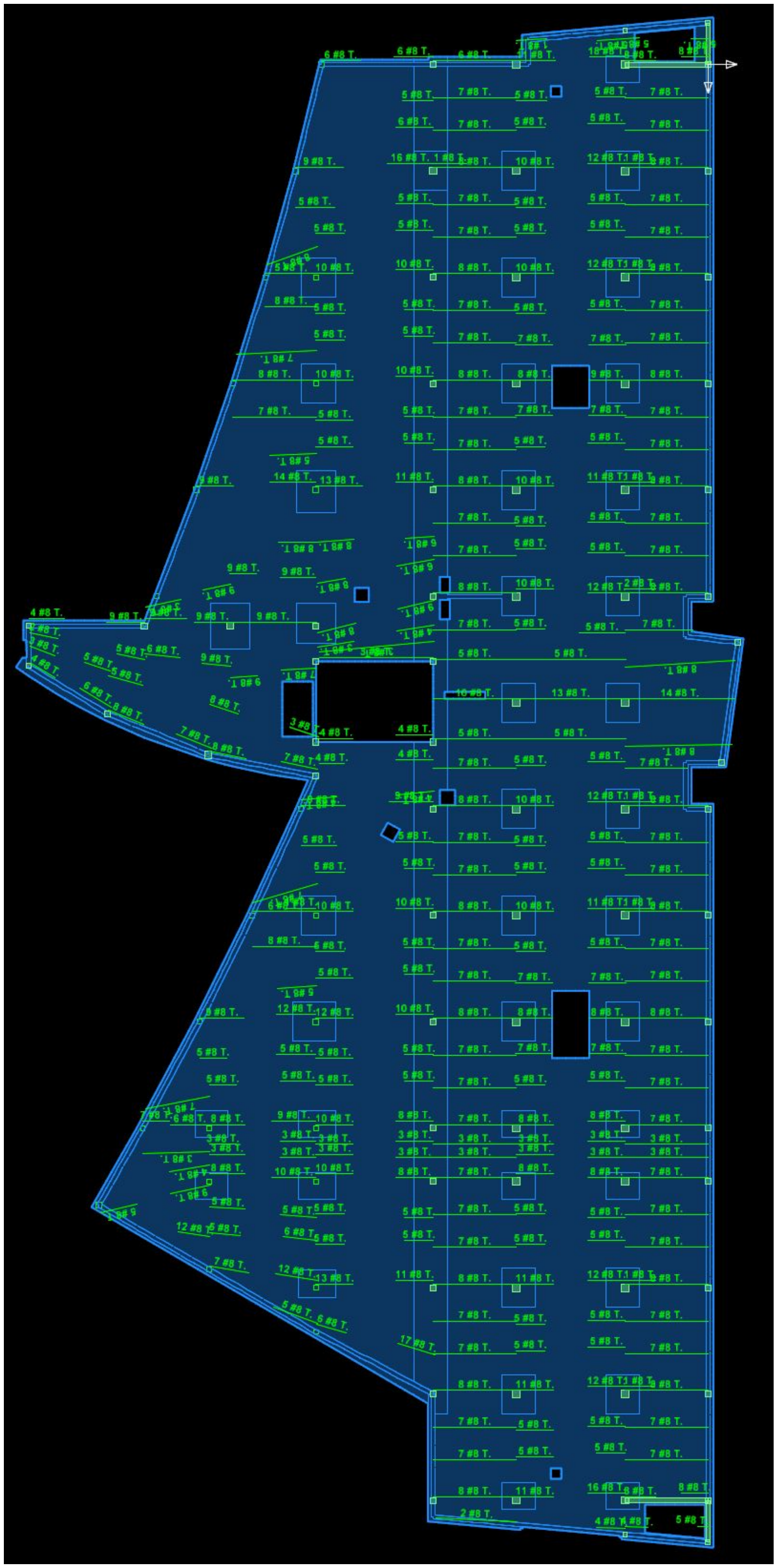
Typical Reinforcement Plan: Lower Level Roof Latitudinal Bottom



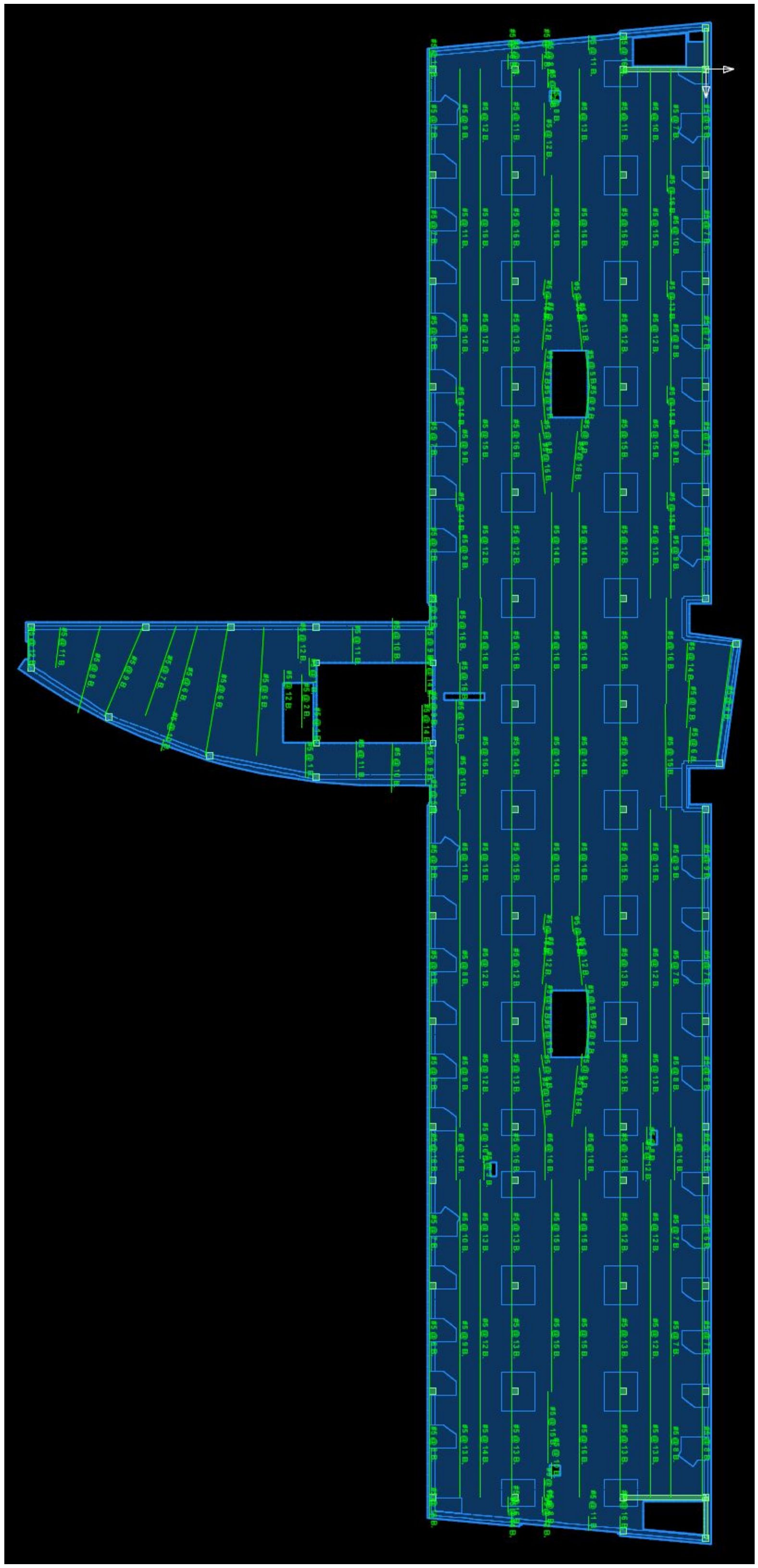
Typical Reinforcement Plan: Lower Level Roof Longitudinal Bottom



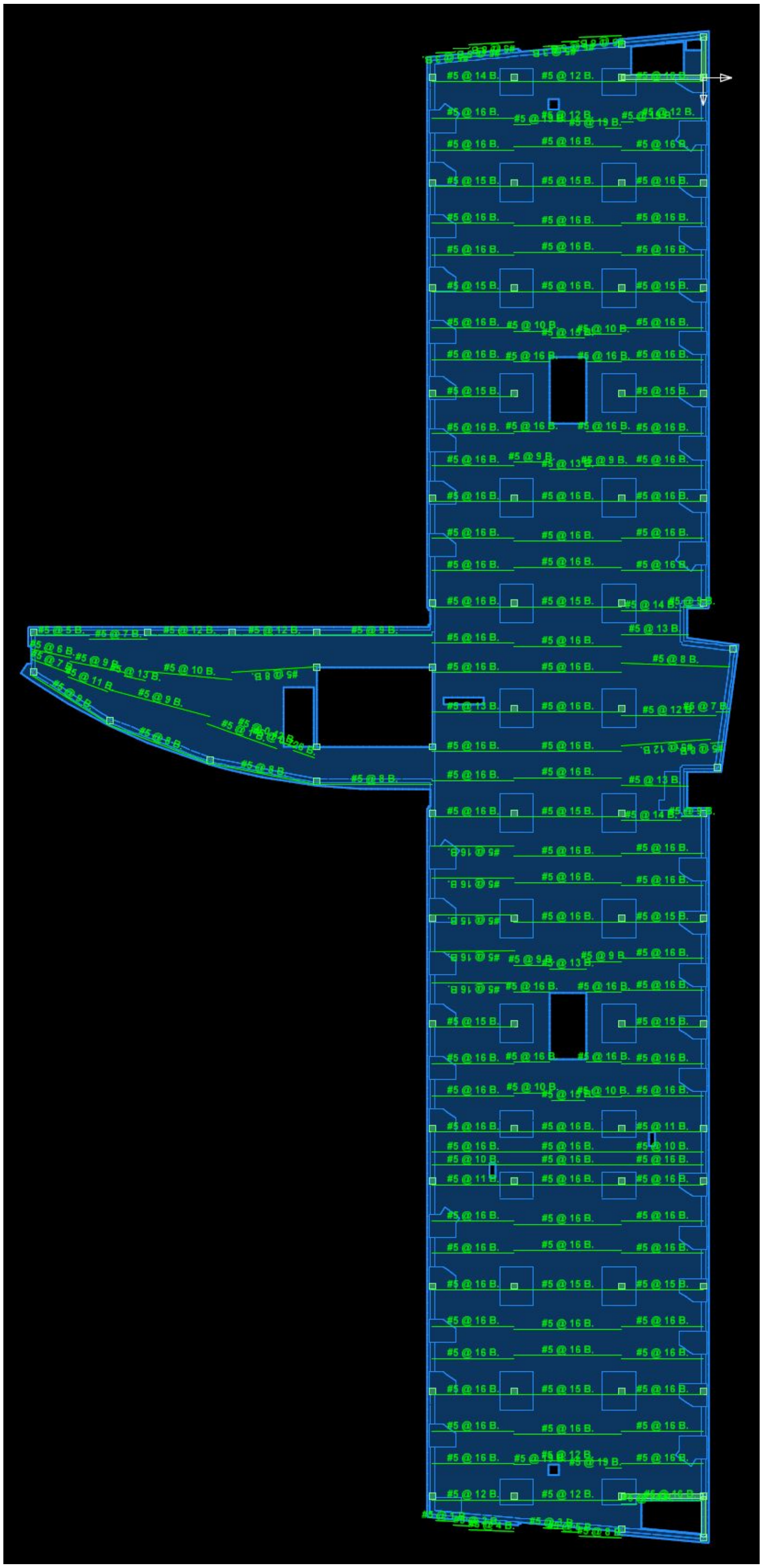
Typical Reinforcement Plan: Lower Level Roof Latitudinal Top



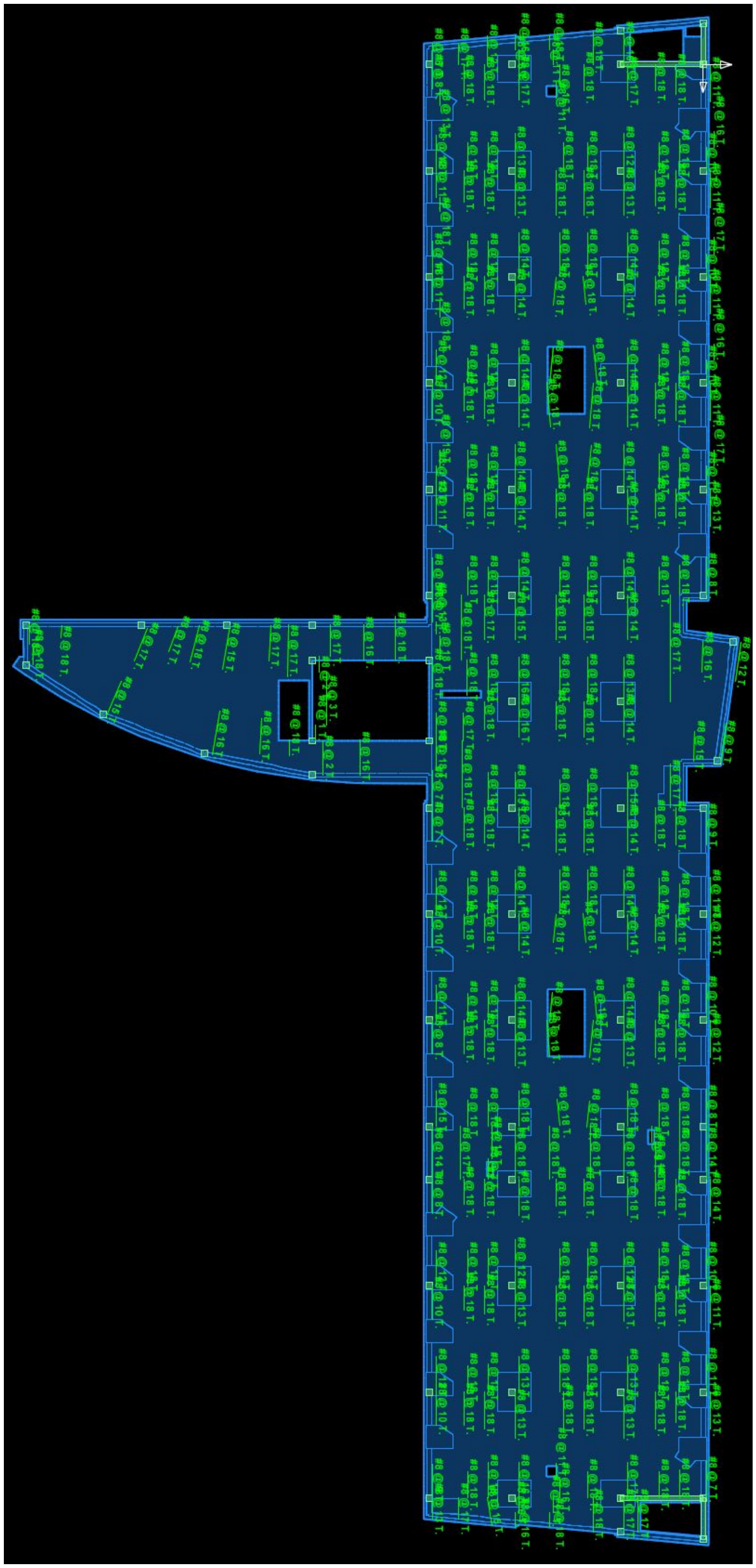
Typical Reinforcement Plan: Lower Level Roof Longitudinal Top



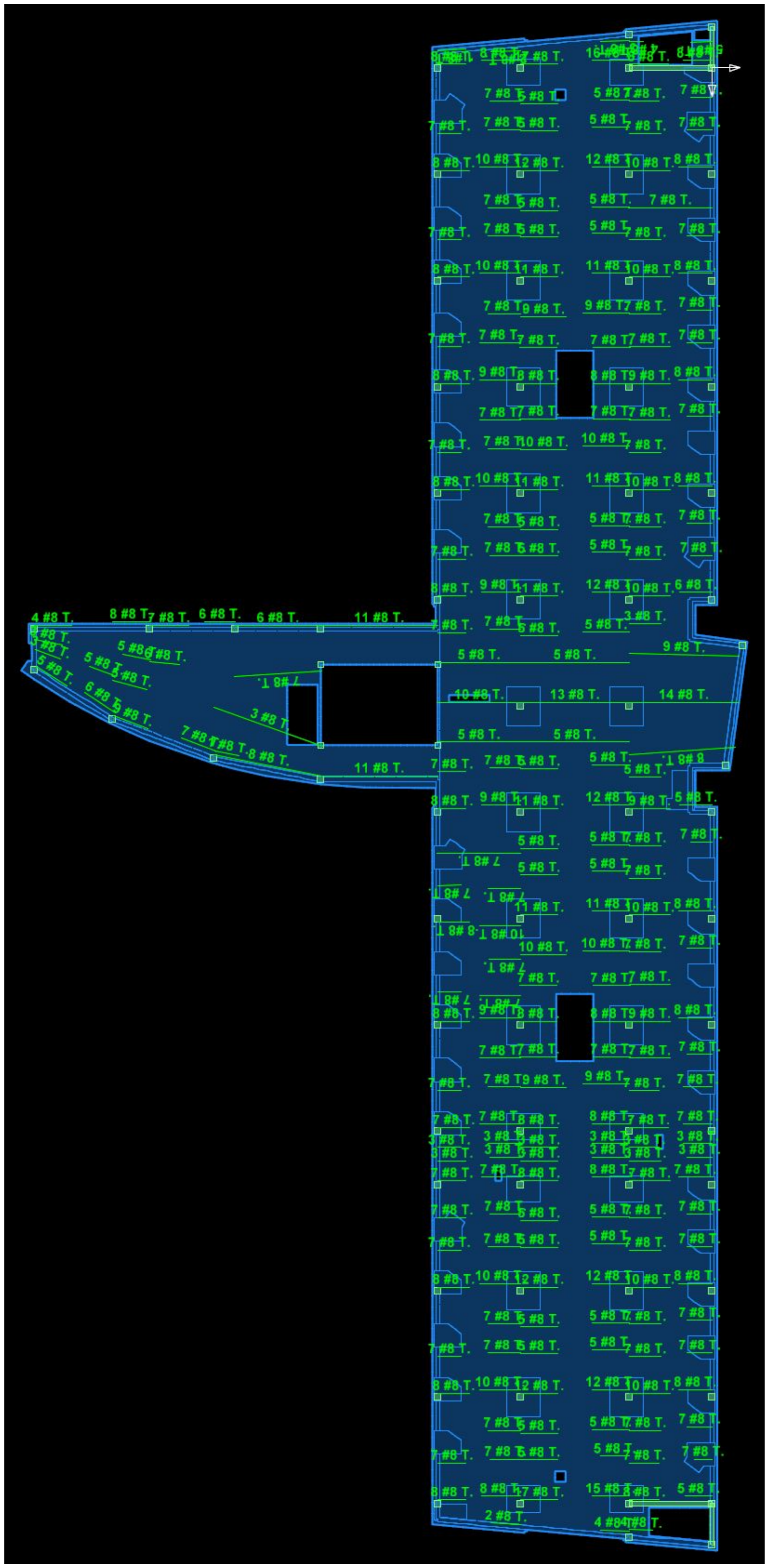
Typical Reinforcement Plan: Upper Level Latitudinal Bottom



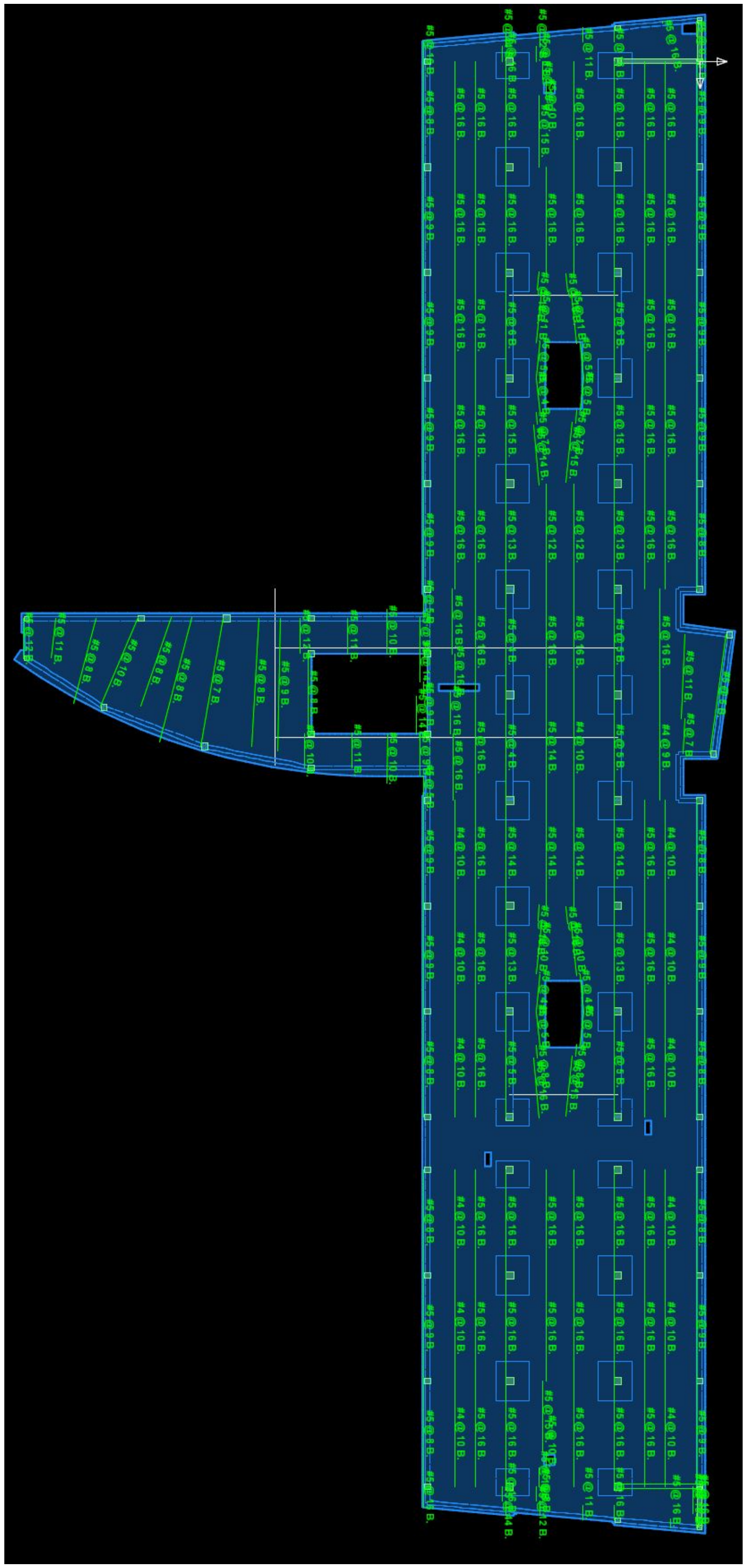
Typical Reinforcement Plan: Upper Level Longitudinal Bottom



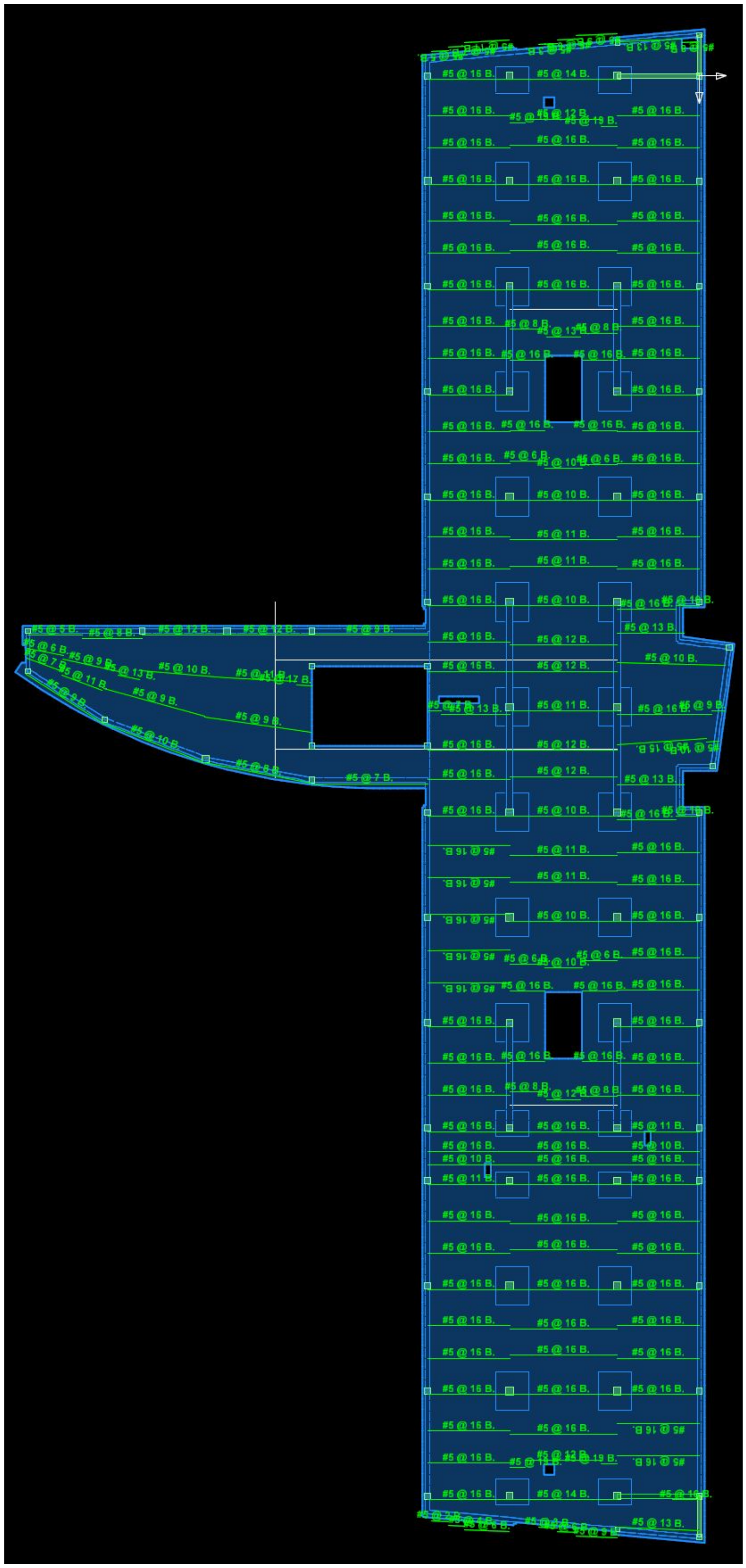
Typical Reinforcement Plan: Upper Level Latitudinal Top



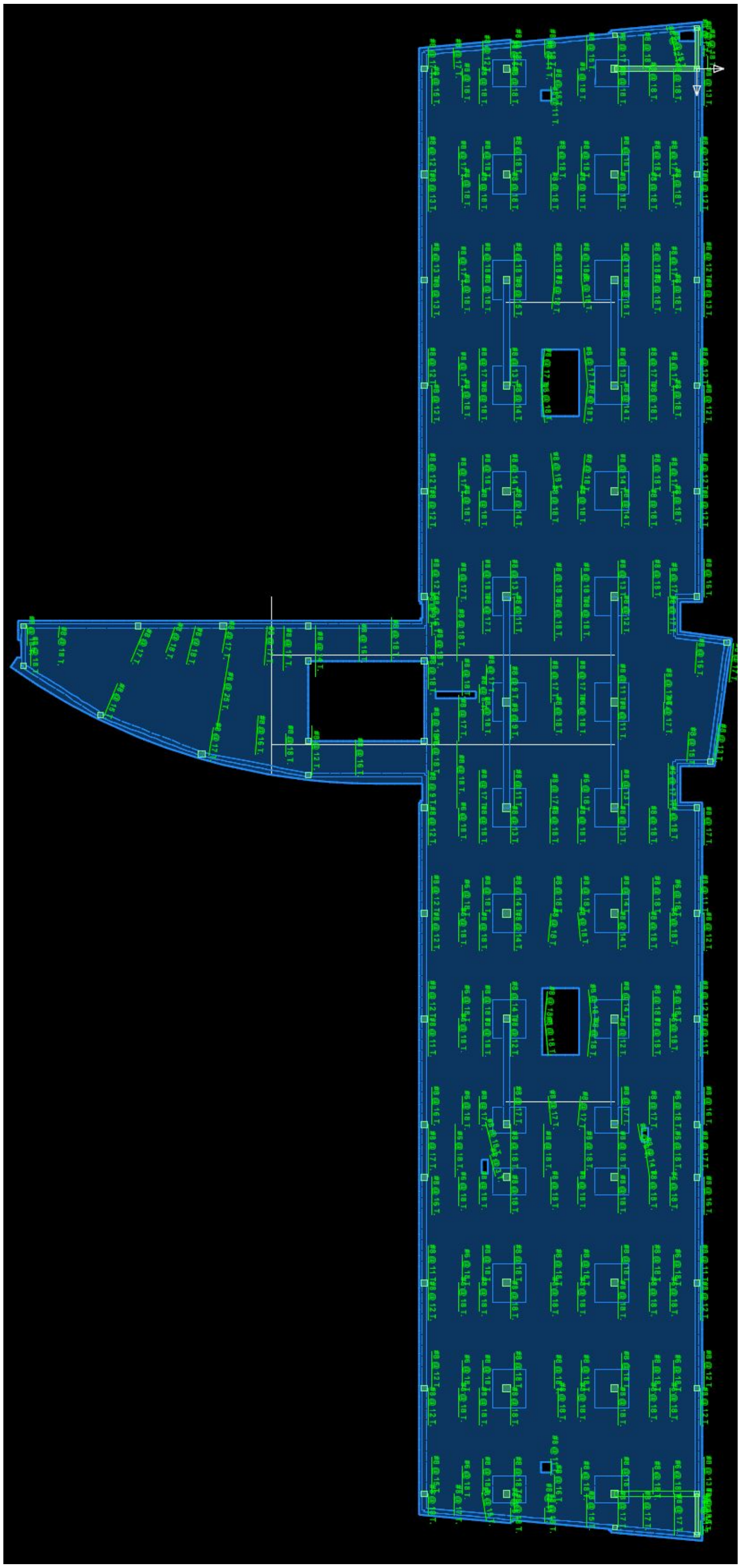
Typical Reinforcement Plan: Upper Level Longitudinal Top



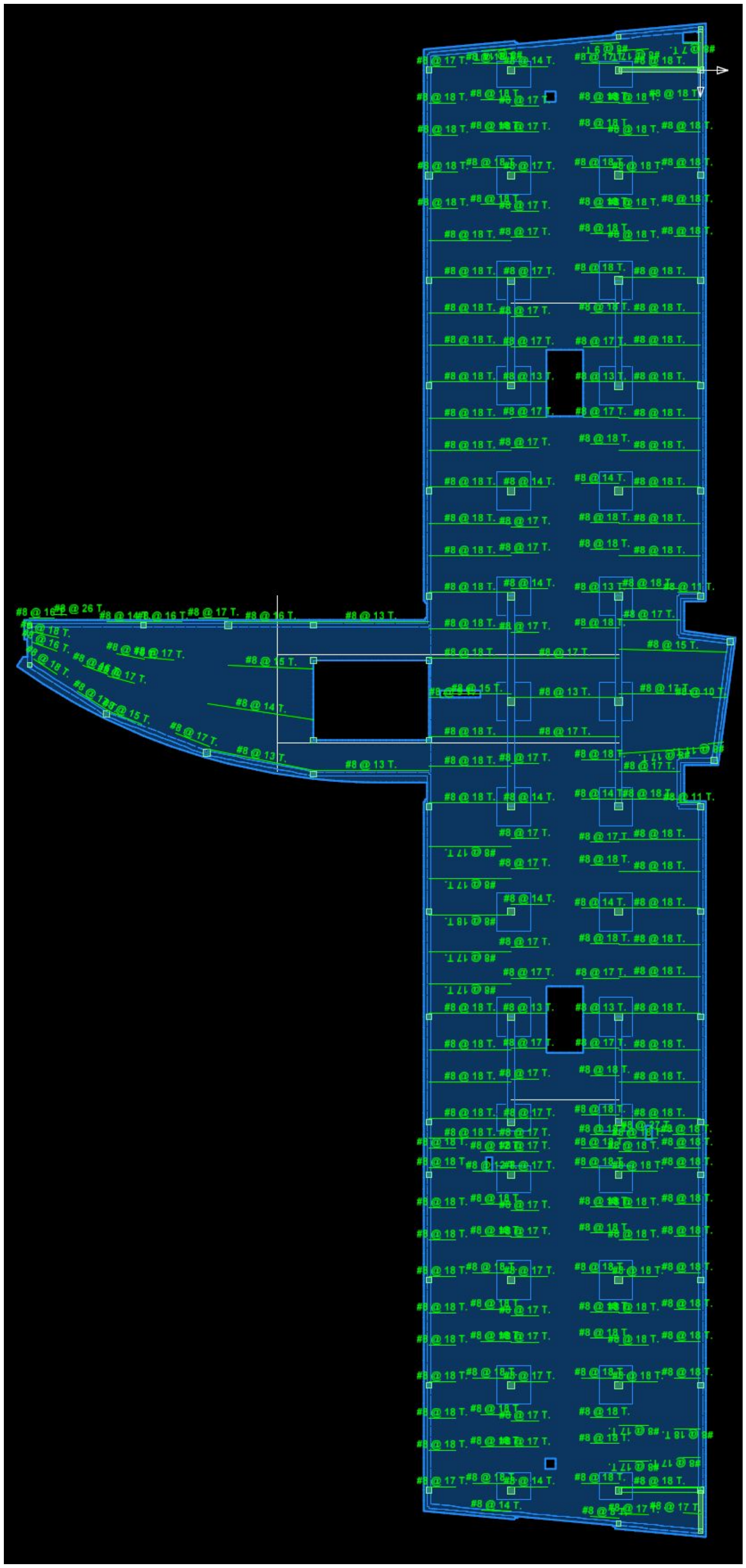
Typical Reinforcement Plan: Upper Level Roof Latitudinal Bottom



Typical Reinforcement Plan: Upper Level Roof Longitudinal Bottom



Typical Reinforcement Plan: Upper Level Roof Latitudinal Top

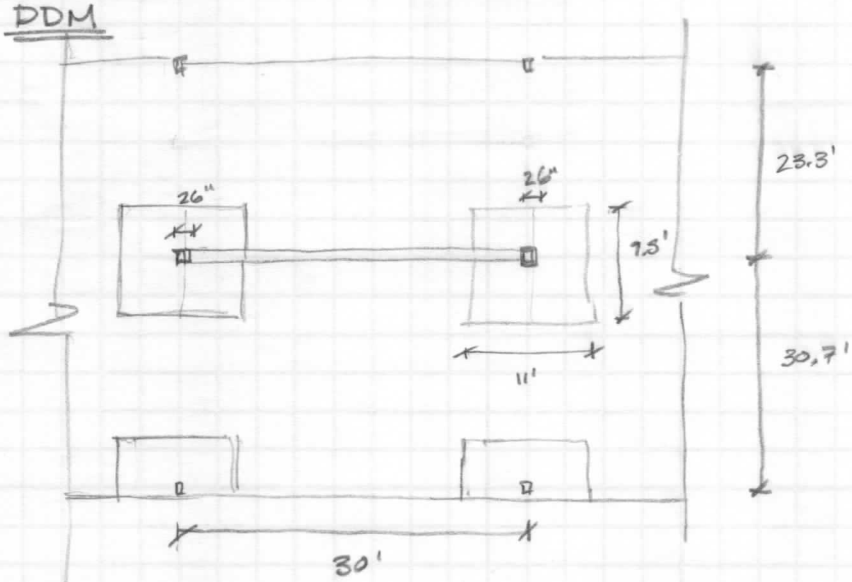


Typical Reinforcement Plan: Upper Level Roof Longitudinal Top

A.2 Beam References

BEAM DESIGN (PENTHOUSE SUPPORT)

DDM



TYP. DROP = 16.5" THICK
SLAB = 10.5" THICK

$l_2 = 27'$
$l_1 = 30'$
$l_n = 27.83$

$$b_{eff} = \begin{cases} \frac{1}{4}(30)(12) = 90 \text{ in} \\ 8(10.5)(2) = 168 \\ \frac{1}{2}(30(12)-26)(2) = 334 \end{cases}$$

$$q_u = 1.2\left(\frac{10.5}{12}(150)+15\right)+1.6(80)$$

$$= 303.5 \text{ psf}$$

$$M_o = \frac{0.3035(27)(27.83)^2}{8}$$

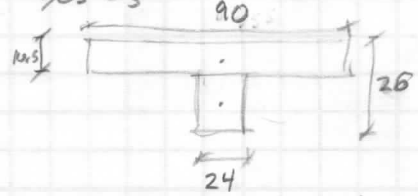
$$= 793.3 \text{ k ft}$$

DISTRIBUTE MOMENTS

$$\begin{cases} 0.65M_o = -515.67 \text{ kft} \\ 0.35M_o = +277.67 \text{ kft} \end{cases}$$

$$\alpha = \frac{\cancel{E_{cb}} I_b}{\cancel{E_{cs}} I_s}$$

$I_b =$



$$c = \frac{24(15.5)7.75 + 90(10.5)(20.75)}{24(15.5)+90(10.5)}$$

$$= \frac{22491.75}{1317}$$

$$\frac{90(10.5)^3}{12} + (90)(10.5)(20.75-17.07)^2 \quad = 17.07$$

$$+ \frac{24(15.5)^3}{12} + (24)(15.5)(17.07-7.75)^2$$

$$= 61240.3 \text{ in}^4$$

$$I_s = \frac{27(12)(10.5)^3}{12}$$

$$= 31255.8$$

$$\alpha_{f1} = 1.959$$

$$\frac{\alpha l_2}{l_1} = \frac{1.959(27)}{30}$$
$$= 1.76 \geq 1.0$$

$$\frac{l_2}{l_1} = \frac{27}{30} = 0.9$$

INTERPOLATION

$$\frac{0.9-1.0}{0.5-1.0} = \frac{x-75}{100-75}$$
$$5 = x-75$$
$$85 = x$$

$$\frac{0.9-1}{0.5-1.0} = \frac{x-75}{90-75}$$

$$78 = x$$

DISTRIBUTE TO COLUMN STRIP

$$M_u^- = 0.78(-515.67) = -402.2$$
$$M_u^+ = 0.78(277.67) = 216.6$$

DISTRIBUTE TO BEAM IN COLUMN STRIP

$$M_u^- = 0.85(-402.2) = -341.87$$
$$M_u^+ = 0.85(216.6) = 184.11$$

EDGE BEAM WORST CASE SIZING: 10.5" SLAB

Span: 30.0'

Hf : 10.5"

q_u = 303.5 psf

$$M_o = \frac{(0.3035)(30)(30)^2}{8}$$

= 1024.3 kft

$$b_{eff} = 14 + \min\left\{\begin{matrix} 8(10.5) \\ \frac{1}{2}(30.67(12)-20) \end{matrix}\right\} + 18 = 116$$

$$= \min\left\{\begin{matrix} 0.25(30.67)(12) \\ 116 \text{ in} \end{matrix}\right\} = 92"$$

DISTRIBUTE MOMENT

SLAB w/ BEAM ON ONLY EXTERIOR

M_u^- int = 0.7 M_o = -717.0 kft

M_u^- ext = 0.3 M_o = -307.3 kft

M_u^+ = 0.5 M_o = -512.2 kft

SLAB INTERIOR

M_u^- = 0.65 M_o = 665.8 kft

M_u^+ = 0.35 M_o = 358.5 kft

DISTRIBUTE TO COL. STRIPS.

$$\text{centroid} = \frac{14(9.5)(4.75) + 92(10.5)(14.75)}{14(9.5) + 92(10.5)} = 13.54 \text{ in}$$

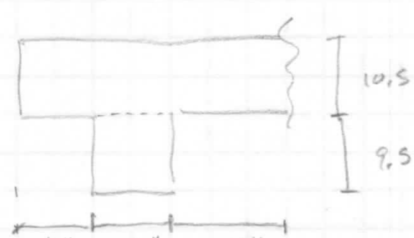
$$I_b = \frac{92(10.5)^3}{12} + 92(10.5)(20-14.75)^2 + \frac{14(9.5)^3}{12} + 14(9.5)(14.75-4.75)^2$$

= 49800.77 in^4

$$C = \Sigma\left(1 - \frac{0.63x}{y}\right)\left(\frac{x^3y}{3}\right)$$

$$= \left(1 - \frac{0.63(9.5)}{14}\right)\left(\frac{9.5^3(14)}{3}\right) + \left(1 - \frac{0.63(10.5)}{92}\right)\left(\frac{10.5^3(92)}{3}\right)$$

= 21153.31



$$I_s = \frac{198(12)(10.5)^3}{12}$$

= 229209.75 in^4

α_{f_1} = 0.2173

$$\beta_T = \frac{C}{2I_s} = 0.046 \approx 0$$

$$\frac{\alpha l_2}{l_1} = \frac{0.217(16.5)}{30.67} = 0.117$$

$$\frac{l_2}{l_1} = \frac{16.5}{30.67} = 0.538$$

SLAB @ EXTERIOR

COL $M_u^-{}_{int} = 0.76(-717.0) = -544.9$ kft
$M_u^-{}_{ext} = 1.0(-307.3) = -307.3$
$M_u^+ = 0.63(512.2) = 322.7$
MID $M_u^-{}_{ext} = 0$

SLAB @ INTERIOR

COL $M_u^- = 0.76(665.8) = -506.0$ kft
$M_u^+ = 0.63(358.5) = 225.9$
MID $M_u^- = 0.24(665.8) = 159.8$
$M_u^+ = 0.37(358.5) = 132.6$

INTERPOLATION

$$\frac{(1-0.117)}{(1-0)} = \frac{(90-x)}{90-75}$$
$x = 76.8$

$$\frac{1-0.117}{1-0} = \frac{90-x}{90-60}$$
$x = 63.51$

$$\frac{1-0.117}{1-0} = \frac{75-x}{75-60}$$
$x = 61.75$

$$\frac{0.5-0.54}{0.5-1} = \frac{63.51-x}{63.51-61.75}$$
$x = 63.4$

DISTRIBUTE TO BEAMS

$0.85 M_u$

SLAB @ EXTERIOR

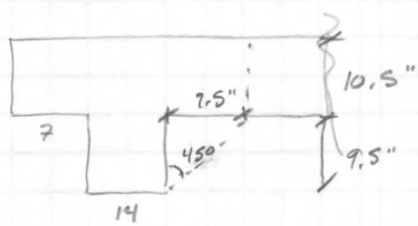
$M_u^-{}_{int} = -0$ kft
$M_u^-{}_{ext} = -222.02$ kft
$M_u^+ = 0$

SLAB @ INTERIOR
$M_u^- = -430.1$
$M_u^+ = 192.015$

TORSION:

USE COMPATIBILITY TORSION

$$T_u = \phi 4 \sqrt{f'c}\left(\frac{A_{cp}^2}{p_{cp}}\right)$$



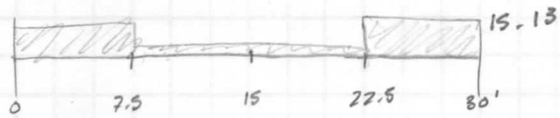
$A_{cp} = 453.25$
$P_{cp} = 101$

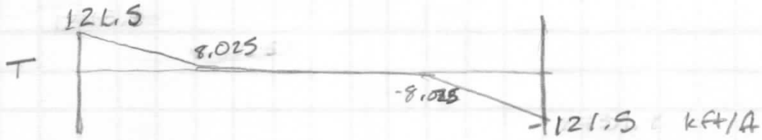
$$T_u = (0.75)(4)\sqrt{4000}\left(\frac{(453.25)^2}{101}\right)$$
$= 385927$ in lbs
$= 32.16$ ft k

TORSION IN EDGE BEAMS

$$COL: \quad -225.9 - \frac{51(14)(1.5)}{1000} = -226.9$$

$$MID: \quad 0 - \frac{51(14)(1.5)}{1000} = -1.071$$





32.16 kft/ft < 1709.8 kft/ft NEED ADDITIONAL REINF.

$$\frac{A_t}{s} = \frac{T_n}{2A_o f_y \cos\theta}$$

$$= \frac{1458000}{2(200.8)(60000)(\cot(45))}$$

$$= 0.085 \text{ in}^2/\text{in for one leg}$$

$$A_{oh} = (10.5)(22.5)$$
$$= 236.25$$
$$A_o = 0.85(236.25)$$
$$= 200.8$$

SHEAR REINFORCEMENT:

$$V_c = 2\sqrt{4000}(14)(23.5)$$
$$= 41.6 \text{ k}$$

$$V_u = \left[\frac{51(14)(30)}{2(1000)} + \frac{\frac{41.5}{12}(0.3035)(30)}{2}\right]$$

$$= 10.71 + 15.744$$
$$= 26.454 \text{ k}$$

$$26.454 \text{ k} < 0.5\phi V_c$$
$$< 15.6 \quad \times$$

$$V_s = \frac{26.5 - (0.75)(41.6)}{0.75}$$
$$= 6.26 \text{ k}$$

$$\frac{A_v}{s} = \frac{6.26}{60(23.5)}$$

$$= 0.0044 \text{ in}^2/\text{in}$$

TOTAL WEB REINF.

$$\frac{2A_t}{s} + \frac{A_v}{s} = 2(0.085) + (0.0044) = 0.1744 \text{ in}^2/\text{in for 2 legs}$$

USE #4 BAR $A_s = 0.2 \text{ in}^2$, 2 legs

MAX SPACING §11.5.6.1

$$\begin{cases} \frac{P_n}{8}'' = \frac{(24+10.5)2}{8} = 8.625 \leftarrow \text{CONTROLS} \\ 12'' = 12'' \end{cases}$$

$$S = \frac{2(0.2)}{0.1744} = 2.29''$$

USE 3 Legs

$$s = \frac{3(0.2)}{(0.1744)} = 3.44 \text{ in}$$

MINIMUM AREA OF STEEL =

$$\begin{cases} 0.75\sqrt{4000}\left(\frac{14(3)}{60000}\right) = 0.033 \leftarrow \text{CONTROLS} \\ \frac{50(14)(3)}{60\,000} = 0.035 \end{cases}$$

USE #4 (3 legs) @ 3" O.C. (0 - 4) ft
#4 (3 legs) @ 6" O.C. (4 - 8) ft
NO TORSION/SHEAR REINF. (8 - 15) ft

LONGITUDINAL TORSION REINF.

$$A_\ell = \frac{A_t}{s} P_h \left(\frac{f_{yt}}{f_y}\right) \cot^2\theta$$

$$= 0.085(69)\left(\frac{60}{60}\right)(1.0)^2 = 5.865$$

$$\text{MINIMUM } A_\ell = \frac{5\sqrt{f'_c}\,A_{cp}}{f_y} - \frac{A_t}{s} P_h \frac{f_{yt}}{f_y}$$

$$= \frac{5\sqrt{4000}(45325)}{60000} - 0.085(69)(1)$$

$$= -3.476$$

$$\frac{A_t}{s} \geq \frac{25(14)}{60000} = 0.0058 < 0.085 \checkmark$$

NO ADDITIONAL REINF. NEEDED.

A.3 Column References

COLUMN SLENDERNESS CHECKS:

CHECK IF SWAY OR NON-SWAY

$$Q = \frac{\Sigma P_u \Delta_o}{V_{us} l_c} \le 0.05 \qquad \text{ACI 318-11 10.10.5.2}$$

$$\Sigma P_u \text{ @ 2nd FLOOR} = 1.2(65063 \text{ kips}) + 1.6(80)(214830 ft^2)\left(\frac{1}{1000}\right)$$

ΣDL @ 2nd $\qquad$ Σsf @ 2nd

$$= 105573.8 \text{ k}$$

$$V_u = 4573.18(0.85) \leftarrow \text{scaled ELF}$$
$$= 3887.2 \text{ k}$$
$$l_c = 32'$$
$$\Delta_o = 0.67''$$

$$Q = \frac{105573.8k(0.67'')}{3887.2k(32)(12)''} = 0.0336 < 0.05$$

THIS CHECK REPRESENTS THE CHECK FOR THE COLUMN MOST CRITICAL FOR SLENDERNESS.

$l_c = 32'$, DOUBLE STORY, NO INTERMEDIATE SUPPORTS

$$\frac{kl_u}{r} \le 34 - 12(M_1/M_2) \le 40$$

$$\frac{1(32)(12)}{\left(\frac{20}{\sqrt{12}}\right)} = 55.4 \quad \text{TOO LARGE} \times$$

$$I_s = \frac{(15)(12)(10.5)^3}{12} = 17364.4 \text{ in}^4$$

$$I_c = \frac{26(26)^3}{12} = 38081.3 \text{ in}^4$$

$$I_{EB} = 49800.77 \text{ in}^4$$

$$\frac{\frac{\Sigma EI_c}{l_c}}{\frac{\Sigma EI_s}{l}} = \frac{2\left(\frac{38081.3}{32}\right)}{\left(\frac{17364.4}{31}\right)\left(\frac{49800.8}{31}\right)} = 1.098$$

$K = 0.785 \qquad$ FIGURE R10.10.1.1 (a)

$$\frac{kl_u}{r} = \frac{0.785(32)(12)}{0.3(26)} = 38.65 < 40 \checkmark$$

General Information:
====================
File Name: X:\Thesis\Models\SP Column\Type_S_rev1.col
Project: SSM
Column: TEST Engineer: CJB
Code: ACI 318-11 Units: English

Run Option: Design Slenderness: Not considered
Run Axis: Biaxial Column Type: Structural

Material Properties:
====================
f'c = 4 ksi fy = 60 ksi
Ec = 3605 ksi Es = 29000 ksi
Ultimate strain = 0.003 in/in
Beta1 = 0.85

Section:
========
Rectangular: Width = 16 in Depth = 16 in

Gross section area, Ag = 256 in^2
Ix = 5461.33 in^4 Iy = 5461.33 in^4
rx = 4.6188 in ry = 4.6188 in
Xo = 0 in Yo = 0 in

Reinforcement:
==============
Bar Set: ASTM A615

Size	Diam (in)	Area (in^2)	Size	Diam (in)	Area (in^2)	Size	Diam (in)	Area (in^2)
# 3	0.38	0.11	# 4	0.50	0.20	# 5	0.63	0.31
# 6	0.75	0.44	# 7	0.88	0.60	# 8	1.00	0.79
# 9	1.13	1.00	# 10	1.27	1.27	# 11	1.41	1.56
# 14	1.69	2.25	# 18	2.26	4.00			

Bar selection: Minimum number of bars
Asmin = 0.01 * Ag = 2.56 in^2, Asmax = 0.08 * Ag = 20.48 in^2

Confinement: Tied; #3 ties with #10 bars, #4 with larger bars.
phi(a) = 0.8, phi(b) = 0.9, phi(c) = 0.65

Layout: Rectangular
Pattern: All Sides Equal (Cover to transverse reinforcement)
Total steel area: As = 10.16 in^2 at rho = 3.97%
Minimum clear spacing = 4.22 in

8 #10 Cover = 1.5 in

Factored Loads and Moments with Corresponding Capacities:
===
Design/Required ratio PhiMn/Mu >= 1.00

No.	Pu kip	Mux k-ft	Muy k-ft	PhiMnx k-ft	PhiMny k-ft	PhiMn/Mu	NA depth in	Dt depth in	eps_t	Phi
1	617.10	46.51	7.86	130.62	22.08	2.808	15.46	15.84	0.00007	0.650
2	611.00	36.34	15.38	116.97	49.50	3.219	16.68	17.76	0.00019	0.650
3	644.56	66.33	45.94	93.85	65.00	1.415	17.90	18.65	0.00012	0.650
4	655.17	71.43	58.87	85.24	70.25	1.193	18.39	18.94	0.00009	0.650
5	646.85	57.11	92.34	60.18	97.30	1.054	17.84	18.47	0.00011	0.650

*** End of output ***

General Information:
====================
File Name: X:\Thesis\Models\SP Column\Type_M_Rev1.col
Project: SSM
Column: 20x20 Engineer: CJB
Code: ACI 318-11 Units: English

Run Option: Design Slenderness: Not considered
Run Axis: Biaxial Column Type: Structural

Material Properties:
====================
f'c = 4 ksi fy = 60 ksi
Ec = 3605 ksi Es = 29000 ksi
Ultimate strain = 0.003 in/in
Beta1 = 0.85

Section:
========
Rectangular: Width = 20 in Depth = 20 in

Gross section area, Ag = 400 in^2
Ix = 13333.3 in^4 Iy = 13333.3 in^4
rx = 5.7735 in ry = 5.7735 in
Xo = 0 in Yo = 0 in

Reinforcement:
==============
Bar Set: ASTM A615

Size	Diam (in)	Area (in^2)	Size	Diam (in)	Area (in^2)	Size	Diam (in)	Area (in^2)
# 3	0.38	0.11	# 4	0.50	0.20	# 5	0.63	0.31
# 6	0.75	0.44	# 7	0.88	0.60	# 8	1.00	0.79
# 9	1.13	1.00	# 10	1.27	1.27	# 11	1.41	1.56
# 14	1.69	2.25	# 18	2.26	4.00			

Bar selection: Minimum number of bars
Asmin = 0.01 * Ag = 4.00 in^2, Asmax = 0.08 * Ag = 32.00 in^2

Confinement: Tied; #3 ties with #10 bars, #4 with larger bars.
phi(a) = 0.8, phi(b) = 0.9, phi(c) = 0.65

Layout: Rectangular
Pattern: All Sides Equal (Cover to transverse reinforcement)
Total steel area: As = 15.24 in^2 at rho = 3.81%
Minimum clear spacing = 3.72 in

12 #10 Cover = 1.5 in

Factored Loads and Moments with Corresponding Capacities:
===
Design/Required ratio PhiMn/Mu >= 1.00

No.	Pu kip	Mux k-ft	Muy k-ft	PhiMnx k-ft	PhiMny k-ft	PhiMn/Mu	NA depth in	Dt depth in	eps_t	Phi
1	223.70	180.40	205.20	248.30	282.43	1.376	13.05	24.64	0.00267	0.701
2	350.70	219.70	100.50	336.67	154.01	1.532	13.62	23.48	0.00217	0.659
3	360.30	293.20	15.50	434.57	22.97	1.482	10.54	18.58	0.00229	0.669
4	557.83	200.80	19.32	377.16	36.29	1.878	13.26	19.41	0.00139	0.650
5	562.87	133.70	130.90	233.99	229.09	1.750	16.74	24.64	0.00142	0.650
6	1101.90	110.20	48.02	174.39	75.99	1.582	23.35	22.58	-0.00010	0.650
7	1139.70	77.62	4.35	176.13	9.87	2.269	21.28	18.26	-0.00043	0.650

*** End of output ***

General Information:

File Name: X:\Thesis\Models\SP Column\Type_L_Rev1.col
Project: SSM
Column: 24x24 Engineer: CJB
Code: ACI 318-11 Units: English

Run Option: Design Slenderness: Not considered
Run Axis: Biaxial Column Type: Structural

Material Properties:

f'c = 4 ksi fy = 60 ksi
Ec = 3605 ksi Es = 29000 ksi
Ultimate strain = 0.003 in/in
Beta1 = 0.85

Section:

Rectangular: Width = 24 in Depth = 24 in

Gross section area, Ag = 576 in^2
Ix = 27648 in^4 Iy = 27648 in^4
rx = 6.9282 in ry = 6.9282 in
Xo = 0 in Yo = 0 in

Reinforcement:

Bar Set: ASTM A615

Size	Diam (in)	Area (in^2)	Size	Diam (in)	Area (in^2)	Size	Diam (in)	Area (in^2)
# 3	0.38	0.11	# 4	0.50	0.20	# 5	0.63	0.31
# 6	0.75	0.44	# 7	0.88	0.60	# 8	1.00	0.79
# 9	1.13	1.00	# 10	1.27	1.27	# 11	1.41	1.56
# 14	1.69	2.25	# 18	2.26	4.00			

Bar selection: Minimum number of bars
Asmin = 0.01 * Ag = 5.76 in^2, Asmax = 0.08 * Ag = 46.08 in^2

Confinement: Tied; #3 ties with #10 bars, #4 with larger bars.
phi(a) = 0.8, phi(b) = 0.9, phi(c) = 0.65

Layout: Rectangular
Pattern: All Sides Equal (Cover to transverse reinforcement)
Total steel area: As = 20.32 in^2 at rho = 3.53%
Minimum clear spacing = 3.47 in

16 #10 Cover = 1.5 in

Factored Loads and Moments with Corresponding Capacities:

Design/Required ratio PhiMn/Mu >= 1.00

No.	Pu kip	Mux k-ft	Muy k-ft	PhiMnx k-ft	PhiMny k-ft	PhiMn/Mu	NA depth in	Dt depth in	eps_t	Phi
1	1602.60	64.91	11.33	291.83	50.94	4.496	26.76	24.31	-0.00028	0.650
2	1595.90	98.89	22.14	292.64	65.52	2.959	27.18	25.08	-0.00023	0.650
3	1567.10	72.34	2.08	326.12	9.38	4.508	24.61	22.00	-0.00032	0.650
4	1472.30	2.99	18.39	60.92	375.08	20.396	24.85	24.51	-0.00004	0.650
5	753.00	3.51	245.70	9.68	678.39	2.761	14.48	21.86	0.00153	0.650
6	1299.70	48.45	212.90	102.82	451.81	2.122	23.33	26.04	0.00035	0.650
7	1360.60	281.10	36.97	437.61	57.55	1.557	23.10	24.33	0.00016	0.650

*** End of output ***

```
General Information:
====================
  File Name: X:\Thesis\Models\SP Column\Type_XL_Rev1.col
  Project:  SSM
  Column:   26x26                          Engineer: CJB
  Code:     ACI 318-11                     Units: English

  Run Option: Design                       Slenderness: Not considered
  Run Axis:   Biaxial                      Column Type: Structural

Material Properties:
====================
  f'c   = 4 ksi                            fy   = 60 ksi
  Ec    = 3605 ksi                         Es   = 29000 ksi
  Ultimate strain = 0.003 in/in
  Beta1 = 0.85

Section:
========
  Rectangular: Width = 26 in               Depth = 26 in

  Gross section area, Ag =  676 in^2
  Ix =  38081.3 in^4                       Iy =  38081.3 in^4
  rx =  7.50555 in                         ry =  7.50555 in
  Xo =  0 in                               Yo =  0 in

Reinforcement:
==============
  Bar Set: ASTM A615
  Size Diam (in) Area (in^2)   Size Diam (in) Area (in^2)   Size Diam (in) Area (in^2)
  ---- --------- -----------   ---- --------- -----------   ---- --------- -----------
  #  3      0.38        0.11   #  4      0.50        0.20   #  5      0.63        0.31
  #  6      0.75        0.44   #  7      0.88        0.60   #  8      1.00        0.79
  #  9      1.13        1.00   # 10      1.27        1.27   # 11      1.41        1.56
  # 14      1.69        2.25   # 18      2.26        4.00

  Bar selection: Minimum number of bars
  Asmin = 0.01 * Ag = 6.76 in^2,  Asmax = 0.08 * Ag = 54.08 in^2

  Confinement: Tied; #3 ties with #10 bars,  #4 with larger bars.
  phi(a) = 0.8,  phi(b) = 0.9,  phi(c) = 0.65

  Layout: Rectangular
  Pattern: All Sides Equal  (Cover to transverse reinforcement)
  Total steel area: As = 24.96 in^2 at rho = 3.69%
  Minimum clear spacing = 3.74 in

  16 #11   Cover = 1.5 in

Factored Loads and Moments with Corresponding Capacities:
=========================================================
  Design/Required ratio PhiMn/Mu >= 1.00
             Pu         Mux         Muy      PhiMnx      PhiMny PhiMn/Mu NA depth Dt depth    eps_t    Phi
  No.       kip        k-ft        k-ft        k-ft        k-ft              in       in
  --- ----------- ----------- ----------- ----------- ----------- -------- -------- -------- -------- ------
    1     1916.20      199.20        3.32      387.96        6.46    1.948    27.20    23.59 -0.00040  0.650
    2     1863.50       82.83       36.68      375.44      166.26    4.533    30.74    30.10 -0.00006  0.650
    3     1863.50       85.72       29.53      389.89      134.32    4.548    30.01    28.93 -0.00011  0.650
    4     1808.70      169.90        3.92      465.90       10.75    2.742    25.82    23.77 -0.00024  0.650

  *** End of output ***
```

A.4 Lateral System References

Project: SSM - St. Claire Health Center
Subject: Seismic Design Forces
CommNo: N/A
Name: Brandmeier Page:
Date: 4/6/2015 1/1

Design Parameters

Categories	Parameter	Value	Units	Description	Reference
Site Code Factors	Occ. Category	IV		Occupant Category	Table 1-1
	Site Class	D		Site Class (A, B, C, D, E, or F)	Chapter 20
	SDC	D		Seismic Design Category	11.6-11.7
	I_E	1.50		Seismic Importance Factor	Table 11.5-1
Seismic Response	S_S	0.414		Short Period MCE Spectral Response Acceleration (%g)	Figure 22-1
	S_1	0.163		One Second MCE Spectral Response Acceleration (%g)	Figure 22-1
	F_a	1.468		Site Coefficient at Short Periods	Table 11.4-1
	F_v	2.148		Site Coefficient at 1 Second Period	Table 11.4-2
Period	T_L	12.00	s	Long-period Transition Period	Figure 22-15
	T_b	0.84	s	Building Period determined from Modal Analysis	
	C_t	0.02		Building Period Coefficient	12.8.1.1
	x	0.75		Building Period Coefficient	
	h_n	118.00	ft	Height of building	
	C_u	1.47			
	N	0.00	#	Number of Stories (leave blank unless apprx Ta desired)	
SFRS Coefficients	R	6.00		Response Modification Coefficient	Table 12.2-1
	Ω	2.50		Overstrength Factor	Table 12.2-1
	C_d	5.00		Deflection Amplication Factor	Table 12.2-1
Shear Wall Data	Concrete/masonry shear walls?	NO			
	Direction	X		X or Y?	
	Ab	1200	sqft	Area of base of Structure	

Intermediate Calculations

Categories	Calculated Values	Value	Units	Description	Reference
Seismic Response	S_{MS}	0.608		Short Period MCE Spectral Response Acc., site adjusted	Eq. 11.4-1
	S_{M1}	0.350		One Second MCE Spectral Response Acc., site adjusted	Eq. 11.4-2
	S_{DS}	0.405		5% Damped Design Spectral Response Acc. at Short Periods	Eq. 11.4-3
	S_{D1}	0.233		5% Damped Design Spectral Response Acc. at 1 Second Period	Eq. 11.4-4
	S_a	3.941		Design Spectral Response Acceleration	11.4.5
Periods	T_a	0.72	s	Approximate Fundamental Period	12.8.2
	T_0	0.12	s		
	T_s	0.58	s		
	T	0.84	s	Period of the Structure	
Coefficients	C_w	0.00		Shear Wall Coefficient	12.8-10
	Cs	0.069		T<=TL	
	Cs	0.101		T>TL	
	Cs	0.101		S1>0.6g	
	$C_{s\ final}$	0.069		Seismic Response Coefficient	12.8.1.1
Base Shear	V	3410.25		Base Shear	

Project: SSM - St. Claire Health Center
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Story Data and Forces

Story	Dia.	Wx (kips)	Hx (ft)	k	Hx^k	$Wx*Hx^k$	Cvx	Fx	0.2SdsIwpx	0.4SdsIwpx	Fpx (diaph.)
First Floor	1	10650.95	16.00	1.17	25.74	274166.87	0.06	206.79	1294.63	2589.25	1294.63
Second Floor	2	10763.05	30.00	1.17	53.76	578606.05	0.13	436.42	1308.25	2616.51	1308.25
Third Floor	3	6975.92	44.00	1.17	84.20	587362.87	0.13	443.02	847.93	1695.85	847.93
Fourth Floor	4	6975.92	58.00	1.17	116.37	811815.94	0.18	612.32	847.93	1695.85	847.93
Fifth Floor	5	6975.92	72.00	1.17	149.92	1045843.49	0.23	788.84	847.93	1695.85	847.93
Sixth Floor	6	6283.78	90.00	1.17	194.71	1223533.84	0.27	922.86	763.80	1527.59	922.86
Penthouse Roof	7	640.00	108.00	1.17	241.08	154289.33	0.03	116.37	77.79	155.58	116.37
				1.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				1.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				1.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				1.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				1.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				1.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				1.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				1.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				1.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				1.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		49265.55	418.00	7.03	624.71	4521329.05	1.00	3410.25			6185.89

Shear Wall Data

				X	Y
Shear Wall	Direction	Height	Length	Σ(eq)	Σ(eq)
				0.00	0.00
				0.00	0.00
				0.00	0.00
				0.00	0.00
				0.00	0.00
				0.00	0.00
				0.00	0.00

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Design Parameters

Categories	Parameter	Value	Units	Description	Reference
Site Code Factors	Occ. Category	IV		Occupant Category	Table 1-1
	Site Class	D		Site Class (A, B, C, D, E, or F)	Chapter 20
	SDC	D		Seismic Design Category	11.6-11.7
	I_E	1.50		Seismic Importance Factor	Table 11.5-1
Seismic Response	S_S	0.414		Short Period MCE Spectral Response Acceleration (%g)	Figure 22-1
	S_1	0.163		One Second MCE Spectral Response Acceleration (%g)	Figure 22-1
	F_a	1.468		Site Coefficient at Short Periods	Table 11.4-1
	F_v	2.148		Site Coefficient at 1 Second Period	Table 11.4-2
Period	T_L	12.00	s	Long-period Transition Period	Figure 22-15
	T_b	0.54	s	Building Period determined from Modal Analysis	
	C_t	0.02		Building Period Coefficient	12.8.1.1
	x	0.75		Building Period Coefficient	
	h_n	118.00	ft	Height of building	
	C_u	1.47			
	N	0.00	#	Number of Stories (leave blank unless apprx Ta desired)	
SFRS Coefficients	R	6.00		Response Modification Coefficient	Table 12.2-1
	Ω	2.50		Overstrength Factor	Table 12.2-1
	C_d	5.00		Deflection Amplication Factor	Table 12.2-1
Shear Wall Data	Concrete/masonry shear walls?	NO			
	Direction	X		X or Y?	
	Ab	1200	sqft	Area of base of Structure	

Intermediate Calculations

Categories	Calculated Values	Value	Units	Description	Reference
Seismic Response	S_{MS}	0.608		Short Period MCE Spectral Response Acc., site adjusted	Eq. 11.4-1
	S_{M1}	0.350		One Second MCE Spectral Response Acc., site adjusted	Eq. 11.4-2
	S_{DS}	0.405		5% Damped Design Spectral Response Acc. at Short Periods	Eq. 11.4-3
	S_{D1}	0.233		5% Damped Design Spectral Response Acc. at 1 Second Period	Eq. 11.4-4
	S_a	9.713		Design Spectral Response Acceleration	11.4.5
Periods	T_a	0.72	s	Approximate Fundamental Period	12.8.2
	T_0	0.12	s		
	T_s	0.58	s		
	T	0.54	s	Period of the Structure	
Coefficients	C_w	0.00		Shear Wall Coefficient	12.8-10
	Cs	0.101		T<=TL	
	Cs	0.101		T>TL	
	Cs	0.101		S1>0.6g	
	$C_{s\ final}$	0.101		Seismic Response Coefficient	12.8.1.1
Base Shear	V	4990.21		Base Shear	

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CommNo: N/A
Name: Brandmeier Page:
Date: 4/6/2015 1/1

Story Data and Forces

Story	Dia.	Wx (kips)	Hx (ft)	k	Hx^k	$Wx*Hx^k$	Cvx	Fx	0.2SdsIwpx	0.4SdsIwpx	Fpx (diaph.)
First Floor	1	10650.95	16.00	1.02	16.84	179384.38	0.07	365.84	1294.63	2589.25	1294.63
Second Floor	2	10763.05	30.00	1.02	31.95	343861.39	0.14	701.28	1308.25	2616.51	1308.25
Third Floor	3	6975.92	44.00	1.02	47.19	329198.79	0.13	671.38	847.93	1695.85	847.93
Fourth Floor	4	6975.92	58.00	1.02	62.52	436167.29	0.18	889.53	847.93	1695.85	889.53
Fifth Floor	5	6975.92	72.00	1.02	77.93	543619.25	0.22	1108.67	847.93	1695.85	1108.67
Sixth Floor	6	6283.78	90.00	1.02	97.81	614634.43	0.25	1253.50	763.80	1527.59	1253.50
Penthouse Roof	7	640.00	108.00	1.02	117.77	75374.09	0.03	153.72	77.79	155.58	153.72
				1.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				1.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				1.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				1.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				1.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				1.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				1.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				1.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				1.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				1.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		49265.55	418.00	6.11	334.25	2446865.52	1.00	4990.21			6856.23

Shear Wall Data

				X	Y
Shear Wall	Direction	Height	Length	Σ(eq)	Σ(eq)
				0.00	0.00
				0.00	0.00
				0.00	0.00
				0.00	0.00
				0.00	0.00
				0.00	0.00
				0.00	0.00

Global Parameters

Step	Parameter	Symbol	Value
1	Risk Category	-	IV
2	Basic Wind Speed	V	115
3a	Wind Directionality Factor	K_d	0.85
3b	Exposure Category	-	B
3c	Topographical Factor	K_{zt}	See Table
3d	Gust Effect Factor	G	0.790231552
3e	Enclosure Classification	-	Enclosed
3f	Internal Pressure Coefficient	GC_{pi}	See Table
4a	Velocity pressure exposure coefficient	K_z	See Table
4b	Velocity pressure exposure coefficient	K_h	0.961202163
5a	Velocity Pressure	q_z	See Table
5b	Velocity Pressure	q_h	See Table
6a	External Pressure Coefficient	C_p	See Table
6b	External Pressure Coefficient	C_n	N/A
		h/L	1.173541963

Table 27.2-1 Steps to Determine MWFRS Wind Loads for Enclosed, Partially Enclosed and Open Buildings of All Heights

Step 1: Determine risk category of building or other structure, see Table 1.4-1

Step 2: Determine the basic wind speed, V, for the applicable risk category, see Figure 26.5-1A, B or C

Step 3: Determine wind load parameters:
- Wind directionality factor, K_d, see Section 26.6 and Table 26.6-1
- Exposure category, see Section 26.7
- Topographic factor, K_{zt}, see Section 26.8 and Table 26.8-1
- Gust Effect Factor, G, see Section 26.9
- Enclosure classification, see Section 26.10
- Internal pressure coefficient, (GC_{pi}), see Section 26.11 and Table 26.11-1

Step 4: Determine velocity pressure exposure coefficient, K_z or K_h, see Table 27.3-1

Step 5: Determine velocity pressure q_z or q_h Eq. 27.3-1

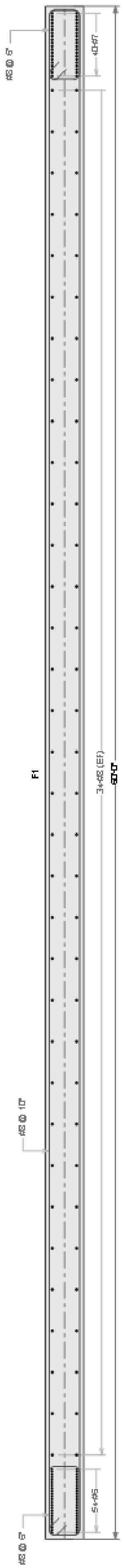
Step 6: Determine external pressure coefficient, C_p or C_N
- Fig. 27.4-1 for walls and flat, gable, hip, monoslope or mansard roofs
- Fig. 27.4-2 for domed roofs
- Fig. 27.4-3 for arched roofs
- Fig. 27.4-4 for monoslope roof, open building
- Fig. 27.4-5 for pitched roof, open building
- Fig. 27.4-6 for troughed roof, open building
- Fig. 27.4-7 for along-ridge/valley wind load case for monoslope, pitched or troughed roof, open building

Step 7: Calculate wind pressure, p, on each building surface
- Eq. 27.4-1 for rigid buildings
- Eq. 27.4-2 for flexible buildings
- Eq. 27.4-3 for open buildings

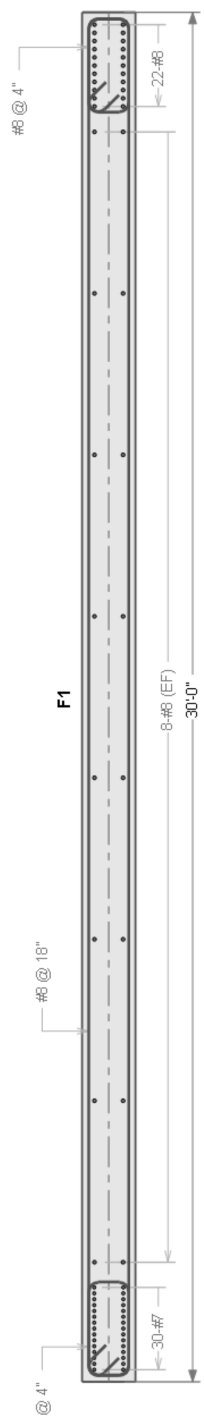
Supplemental Calculations

Geometry					
	mean roof height	h	90.75		
	horizontal building dimension parallel	L	77.33		
	horizontal building dimension normal	B	417		
K_{zt}	Descriptions				
	Height of hill	H	0		
	horizontal distance to half hill height	Lh	0		
	distance from crest to building	x	0		
	height above ground to building site	z	0		
	from Figure 26.8-1	$k1/(H/L_h)$	0		
	height attenuation factor	Gamma	0		
	horizontal attenuation factor	mu	0		
	from Figure 26.8-1	H/Lh	#DIV/0!		
G	Descriptions			Is the structure RIGID?	
		n_a	0.826446	1 for yes, 0 for no	0
	fundamental frequency	n_1	0.8333	Do you want to assume G=0.85 (RIGID)?	
	Table 26.9-1	Beta	0.05	1 for yes, 0 for no	0
	Table 26.9-1	b bar	0.45		
	Table 26.9-1	alpha bar	0.25		
		g_Q	3.4		
		g_v	3.4		
		g_R	4.145775		
	Table 26.9-1	c	0.3		
	Table 26.9-1	l	320		
	Table 26.9-1	Epsilon Bar	0.333333		
	Table 26.9-1	zmin	30		
		z bar	54.45		
		R	0.09518		
		Rn	0.061721		
		Rh	0.216723		
		Rb	0.052369		
		RL	0.248139		
		N1	3.662969		
		n sub h	4.043832		
		n sub b	18.58157		
		n sub L	3.445835		
		I_z	0.275978		
		Lz	378.133		
		Vz	86.02264		
		Q	0.754089		
		G_f	**0.790232**		
		G_r	**0.785183**		
K_z	Descriptions				
	3-sec gust speed power law exponent	alpha	7		
	nominal height of atmospheric boundary	z_g	1200		

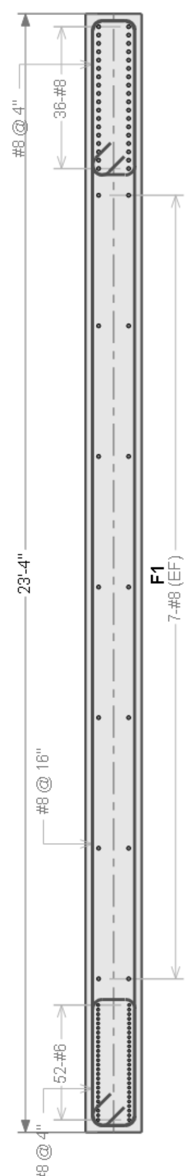
Location	z (ft)	Story Height (ft)	K_h	K_z	K_{zt}	q_z	q_h	Cp	q_zGC_p (psf)	GC_{pi}	q_hGC_{pi} (psf)	q_zGC_p-q_h(+GC_{pi})	q_zGC_p-q_h(-GC_{pi})	(ft^2)	Total (kips)
Windward	-16	16	0.96	0.57	1.00	16.54	27.66	0.8	10.46	0.18	4.98	5.48	15.43	3336.00	34.88
	0	16	0.96	0.57	1.00	16.54	27.66	0.8	10.46	0.18	4.98	5.48	15.43	6672.00	69.76
	16	14	0.96	0.59	1.00	16.85	27.66	0.8	10.65	0.18	4.98	5.67	15.63	6255.00	66.62
	30	14	0.96	0.70	1.00	20.16	27.66	0.8	12.75	0.18	4.98	7.77	17.72	5838.00	74.41
	44	14	0.96	0.78	1.00	22.49	27.66	0.8	14.22	0.18	4.98	9.24	19.20	5838.00	83.01
	58	14	0.96	0.85	1.00	24.34	27.66	0.8	15.39	0.18	4.98	10.41	20.37	5838.00	89.83
	72	18.75	0.96	0.90	1.00	25.89	27.66	0.8	16.37	0.18	4.98	11.39	21.35	6828.38	111.77
	90.75		0.96	0.96	1.00	27.66	27.66	0.8	17.49	0.18	4.98	12.51	22.47	3909.38	68.36
			0.00	0.00	1.00	0.00	0.00	0.8	0.00	0.18	0.00	0.00	0.00	0.00	0.00
Leeward	90.75	90.75	0.96	0.96	1.00	27.66	27.66	-0.5	-10.93	0.18	4.98	-15.91	-5.95	37842.75	-413.60
Sides	90.75	90.75	0.96	0.96	1.00	27.66	27.66	-0.7	-15.30	0.18	4.98	-20.28	-10.32	37842.75	-579.03
Parapet WW	93	2.166	0.96	0.97	1.00	27.86	27.66	1.5	33.02	1.5	41.49	-8.47	74.51	903.22	37.48
Parapet LW	93	2.166	0.96	0.97	1.00	27.86	27.66	1	22.01	-1	-27.66	49.67	-5.65	903.22	-24.98
Roof (0 to h/2)	90.75	45	0.96	0.96	1.00	27.66	27.66	-0.9	-19.67	0.18	4.98	-24.65	-14.69	18765.00	-369.16
Roof (h/2 to h)	90.75	90	0.96	0.96	1.00	27.66	27.66	-0.9	-19.67	0.18	4.98	-24.65	-14.69	37530.00	-738.32
Roof (h to 2h)	90.75	180	0.96	0.96	1.00	27.66	27.66	-0.5	-10.93	0.18	4.98	-15.91	-5.95	75060.00	-820.36
Roof (>2h)	90.75	393	0.96	0.96	1.00	27.66	27.66	-0.3	-6.56	0.18	4.98	-11.54	-1.58	163881.00	-1074.67
													Base Shear:		1074.70



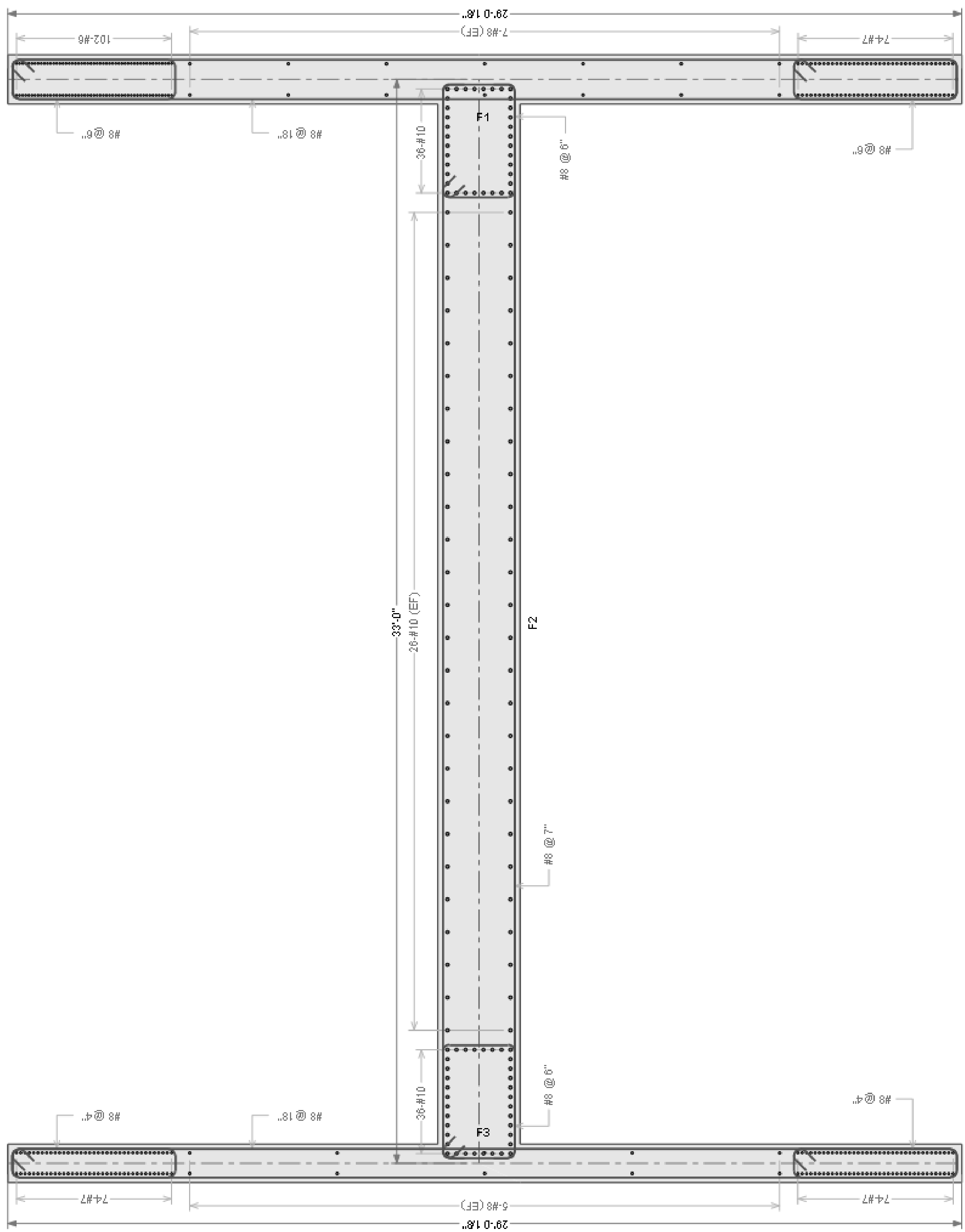
CW2 Section: A
(Scale 1/4 = 1'-0")



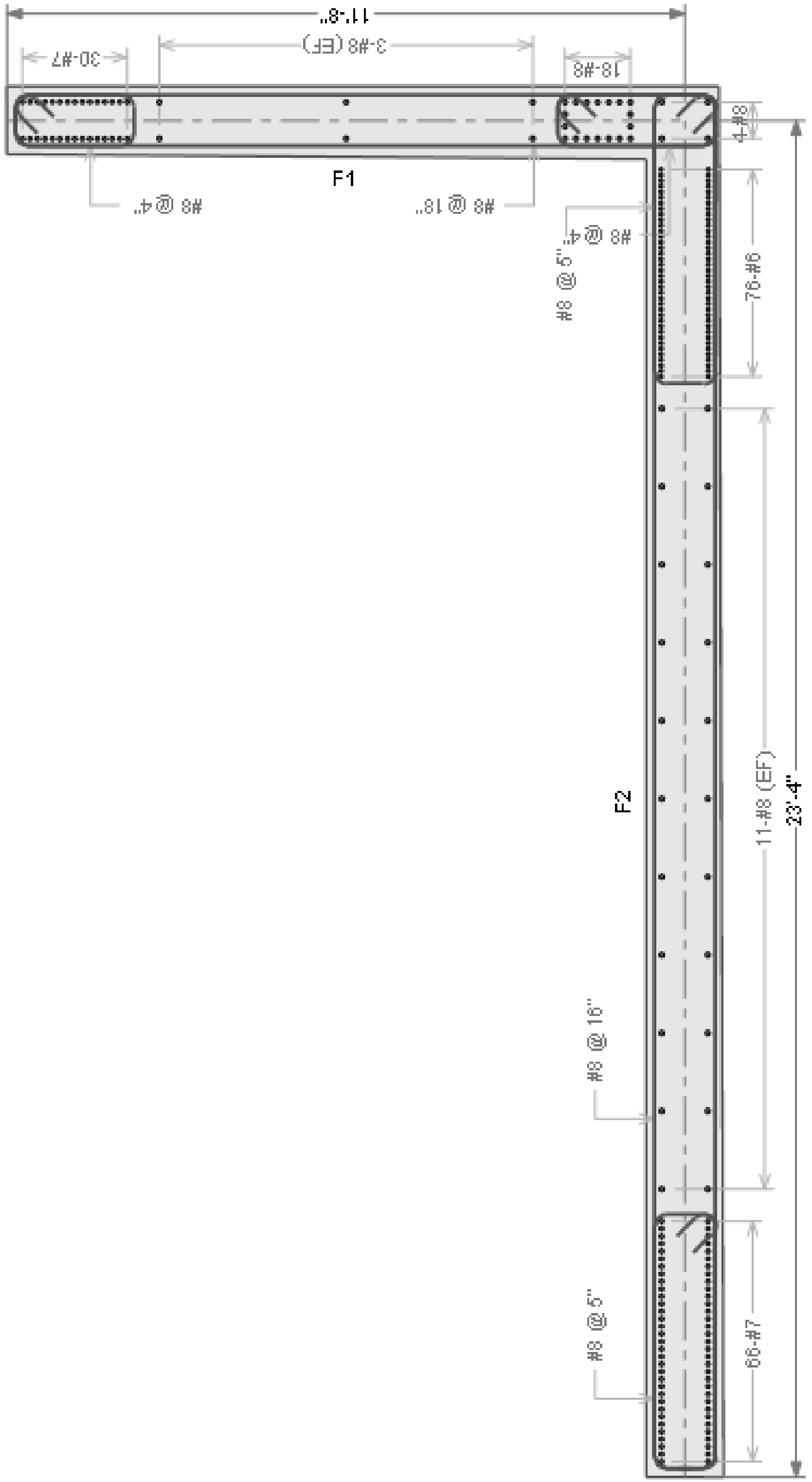
CW1 Section: A
(Scale 1/4 = 1'-0")



CW6 Section: A
(Scale 1/4 = 1'-0")



CW3 Section: A
(Scale 1/4 = 1'-0")



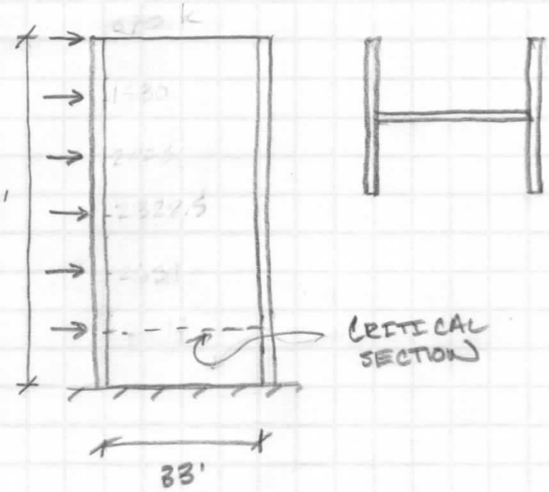
CW4 Section: A
(Scale 1/4 = 1'-0")

SHEAR WALL CHECK (Ha)

DESIGN FORCES:

546655
351783

$P_u = 572$ k
$M_u = 89337$ kft
$V_u = 3549.3$ k



Critical section

$$a = \min \begin{cases} \frac{h_w}{2} \\ \frac{l_w}{2} \\ \text{story height} \end{cases} = \begin{cases} 44' \\ 16.5' \\ 16' \text{ CONTROLS} \end{cases}$$

$$V_n = 10\sqrt{f'_c}\, h d$$
$$= 10\sqrt{4000}(30)(0.8)(33)[12]$$
$$= 6010.86 \text{ k} > 3549.3 \text{ k} \checkmark$$

$$V_c = 2\sqrt{4000}(30)(316.8)/1000$$
$$= 1202.17 \text{ k}$$

$$V_s = \frac{3549.3}{0.75} - 1202.17$$
$$= 3530.23$$

$$\frac{A_s}{s} = 0.186$$

USE #10 @ 12" O.C.

$$\frac{A_s}{s} = 0.211$$

$$C_v = \frac{P_u}{2} + \frac{M_u}{d}$$
$$= \frac{572}{2} + \frac{89374.5}{26.4}$$
$$= 3671.4 \text{ k}$$

$$A_g = 33\left(\frac{30}{12}\right) = 82.5 \text{ ft}^2$$

$$I_g = \frac{\left(\frac{30}{12}\right)(33)^3}{12} = 7486.9 \text{ ft}^4$$

$$f_c = \frac{572}{82.5} + \frac{89337\left(\frac{33}{2}\right)}{7486.9} = 203.81 \text{ ksf} = 1.41 \text{ ksi}$$

$1.41 > 0.2(4) = 0.8 \rightarrow$ NEED BOUNDARY ELEMENTS

DETERMINE LONGITUDINAL + TRANSVERSE REINF. § 21.9.2.2

$$V_u \geq 2 A_{cv} \sqrt{f'c}$$
$$\geq 2(33)(12)(30)\sqrt{4000}$$
$$\geq$$

2797.2k ≥ 1502.7 k → NEED 2 CURTAINS

$$\rho t = \frac{A_{sl}}{A_{cv}} \geq 0.0025$$

$$A_{cv} = 12(30) = 360 \text{ in}^2/\text{ft}$$
$$A_{sl\,req} = 0.0025(360) = 0.9 \text{ in}^2/\text{ft}$$

$$0.9 \text{ in}^2/\text{ft} < 2.54 \text{ in}^2/\text{ft} \checkmark$$

$$\rho l = 0.0025 + 0.5\left(2.5 - \frac{88}{33}\right)(0.186 - 0.0025)$$
$$= -0.0127$$
$$= 0.0025$$

USE #8 @ 7"

$$\frac{0.79 \text{ in}^2}{7 \text{ in}} = 1.354 \text{ in}^2/\text{ft}$$
$$\rho l = 0.00376 > 0.0025 \checkmark$$

CHECK BOUNDARY ELEMENT:

$$A_{st} = 36(1.27) = 45.72 \text{ in}^2$$
$$\rho_{st} = \frac{45.72}{30(45)} = 0.033$$
$$\rho_{min} = 0.01 < \rho_{st} = 0.033 < \rho_{max} = 0.06 \checkmark$$

AXIAL CAPACITY

$$\phi P_n = 0.8(0.65)[0.85(4)(1350 - 45.72) + 60(45.72)]$$
$$= 3732.43$$

$$3732.43 = \phi P_n > 3671.4 = P_{uBE} \checkmark$$

DETERMINE CONFINEMENT REINFORCEMENT:

$$S_{max} = \begin{cases} \frac{1}{4}(30) = 7.5'' \\ 6(1) = 6'' \\ S_o = 4 + \frac{14-24}{3} = 4.667 \rightarrow \text{use } 4'' \end{cases}$$

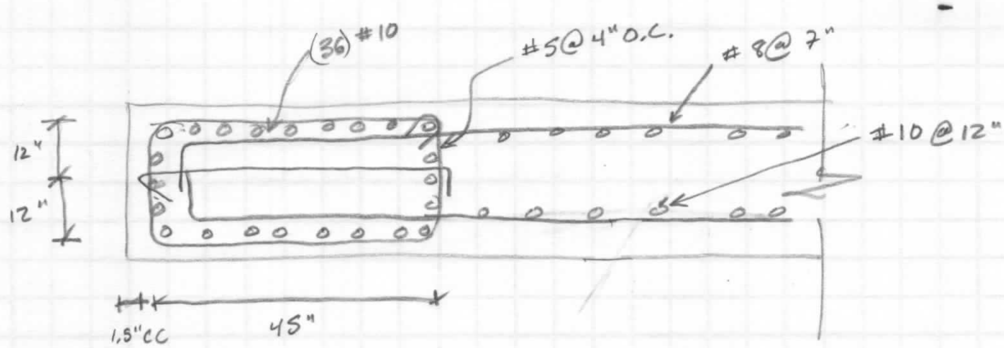
$$A_{sh} \geq \begin{cases} 0.09\frac{(s)(b_c)(f'c)}{f_{yt}} = \frac{0.09(6)(45)(4)}{60} = 1.62 \\ 0.3\frac{(6)(45)(4)}{60}\left(\frac{45(30)}{(39)(24)} - 1\right) = 2.388 \end{cases}$$

USE #8 @ 4" $\quad A_{sh} = 0.78(2)\left(\frac{12}{4}\right) = 4.68 \text{ in}^2/\text{ft}$

$4.68 \text{ in}^2/\text{ft} > 2.388 \text{ in}^2/\text{ft}$ ✓

RECOMMEND DOWNSIZING BAR TO #5 @4"

$0.31(3)\left(\frac{12}{4}\right) = 2.79 > 2.388 \text{ in}^2/\text{ft}$ ✓



Appendix B

Construction Breadth References

B.1 Estimate References

Alberici Constructors
AN ALBERICI ENTERPRISE

Financial Status Report

By Budget Code

05063 - St. Clare Health Center
1015 Bowles Avenue
Fenton, MO 63026

Project # 05063
Tel: 636-496-5985 Fax: 636-717-0100

Alberici Constructors, Inc.

ACI Code	Description	Original Budget	Approved Revs	Current Budget	Pending Revs	Approx Revs	Project'd Budget	Commit'd Costs	Uncommit Costs	Pending Commit	Forecast Cost	Project'd Cost	Project'd Over/Under
010000	General & Special Conditions	8,266,110	172,781	8,438,891	0	0	8,438,891	8,438,891	0	0	0	8,438,891	0
010105	Building Works Inc.	0	31,220	31,220	0	0	31,220	31,220	0	0	0	31,220	0
011500	Gateway Elevator	0	19,304	19,304	0	0	19,304	19,304	0	0	0	19,304	0
011510	Goedecke	0	17,979	17,979	0	0	17,979	17,979	0	0	0	17,979	0
012100	A.S.S. - Clean Up	417,208	121,846	539,054	0	0	539,054	539,054	0	0	0	539,054	0
012101	New Vision - Clean Up	0	66,636	66,636	0	0	66,636	66,636	0	0	0	66,636	0
012102	A.S.S. - Final Clean	0	58,370	58,370	0	0	58,370	58,370	0	0	0	58,370	0
012103	Wesco Hauling - Street Cleaning	0	0	0	0	0	0	0	0	0	0	0	0
012403	Hudson Services	0	221,303	221,303	0	0	221,303	221,303	0	0	0	221,303	0
012406	Industrial Steel Fab - Landing Platforms	0	196,682	196,682	0	0	196,682	196,682	0	0	0	196,682	0
012407	Industrial Steel - Install Main Entry Stair	0	31,351	31,351	0	0	31,351	31,351	0	0	0	31,351	0
017600	Pest Control	5,000	(5,000)	0	0	0	0	0	0	0	0	0	0
017610	Soil Treatment	12,700	(12,700)	0	0	0	0	0	0	0	0	0	0
040000	Bloomsdale Excavating	4,862,510	720,976	5,583,486	0	0	5,583,486	5,583,486	0	0	0	5,583,486	0
040001	Underground Location	0	460	460	0	0	460	460	0	0	0	460	0
040002	Sitework Allowance	0	0	0	0	0	0	0	0	0	0	0	0
040010	Hansen's Tree Service	0	6,475	6,475	0	0	6,475	6,475	0	0	0	6,475	0
040020	Site Grading Allowance	105,000	(105,000)	0	0	0	0	0	0	0	0	0	0
040030	JH Berra - Entrances and Roads	0	133,495	133,495	0	0	133,495	133,495	0	0	0	133,495	0
060000	Relocate Utilities/Sewers	662,376	(662,376)	0	0	0	0	0	0	0	0	0	0

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ACI Code	Description	Original Budget	Approved Revs	Current Budget	Pending Revs	Approx Revs	Project'd Budget	Commit'd Costs	Uncommit Costs	Pending Commit	Forecast Cost	Project'd Cost	Project'd Over/Under
060010	Relocate Utilities	0	329,575	329,575	0	0	329,575	329,575	0	0	0	329,575	0
060020	Bates Utility - Off-Site Sewers	0	407,433	407,433	0	0	407,433	407,433	0	0	0	407,433	0
080000	Subsurface Constructors	1,282,405	39,591	1,321,996	0	0	1,321,996	1,321,996	0	0	0	1,321,996	0
090000	Apex Contracting - Asphalt Paving	1,105,438	220,616	1,326,054	0	0	1,326,054	1,326,054	0	0	0	1,326,054	0
090010	Parking Lot Striping	14,143	(14,143)	0	0	0	0	0	0	0	0	0	0
090020	TGA @ Bowles Avenue	430,605	(430,605)	0	0	0	0	0	0	0	0	0	0
100000	Collins & Hermann - Temporary Fencing	26,050	5,607	31,657	0	0	31,657	31,657	0	0	0	31,657	0
100010	Collins & Hermann - Permanent Fencing	0	0	0	0	0	0	0	0	0	0	0	0
110000	Landscaping Allowance	600,000	(600,000)	0	0	0	0	0	0	0	0	0	0
110010	Big Tree II, Inc.	0	0	0	0	0	0	0	0	0	0	0	0
110020	Site Specialties	39,773	(39,773)	0	0	0	0	0	0	0	0	0	0
110030	Retaining Walls	818,250	(818,250)	0	0	0	0	0	0	0	0	0	0
110040	Gartland Inc. - Irrigation	0	224,524	224,524	0	0	224,524	224,524	0	0	0	224,524	0
110050	Waldbart & Sons - Landscaping	0	342,982	342,982	0	0	342,982	342,982	0	0	0	342,982	0
110060	Brookside Contracting - Water Feature	0	138,063	138,063	0	0	138,063	138,063	0	0	0	138,063	0
120000	Kienlen Constructors	6,244,278	1,540,424	7,784,702	0	0	7,784,702	7,784,702	0	0	0	7,784,702	0
120010	Site Concrete	1,261,165	(1,261,165)	0	0	0	0	0	0	0	0	0	0
120020	Oreo & Botta	0	485,481	485,481	0	0	485,481	485,481	0	0	0	485,481	0
120030	Concrete Coring - Elevator Pit Drilling	0	1,411	1,411	0	0	1,411	1,411	0	0	0	1,411	0
120031	Concrete Coring - Elevator Pit Drilling	0	8,527	8,527	0	0	8,527	8,527	0	0	0	8,527	0
140000	Vee-Jay Cement	1,409,724	929,351	2,339,075	0	0	2,339,075	2,339,075	0	0	0	2,339,075	0
140010	Cement Flatwork	808,410	(808,410)	0	0	0	0	0	0	0	0	0	0
180000	John Smith Masonry	2,765,000	505,217	3,270,217	0	0	3,270,217	3,270,217	0	0	0	3,270,217	0
190000	Hammert's Iron Works	8,294,992	489,156	8,784,148	0	0	8,784,148	8,784,148	0	0	0	8,784,148	0
190010	Structural Steel Allowance	2,291,608	(2,291,608)	0	0	0	0	0	0	0	0	0	0

ACI Code	Description	Original Budget	Approved Revs	Current Budget	Pending Revs	Approx Revs	Project'd Budget	Commit'd Costs	Uncommit Costs	Pending Commit	Forecast Cost	Project'd Cost	Project'd Over/Under
200000	Imperial Ornamental Metal	653,321	787,246	1,440,567	0	0	1,440,567	1,440,567	0	0	0	1,440,567	0
200010	Mays-Maune - Ornamental Railing	0	352,648	352,648	0	0	352,648	352,648	0	0	0	352,648	0
200020	Custom Fabrications - Misc. Steel	0	14,183	14,183	0	0	14,183	14,183	0	0	0	14,183	0
230000	Expansion Joint Covers	192,700	(192,700)	0	0	0	0	0	0	0	0	0	0
240000	Rough Carpentry	1,275,308	(1,275,308)	0	0	0	0	0	0	0	0	0	0
240010	Nystrom - Access Panels	60,000	(31,275)	28,725	0	0	28,725	28,725	0	0	0	28,725	0
240020	Bilco - Sidewalk Door	0	985	985	0	0	985	985	0	0	0	985	0
260000	Architectural Woodwork - Furnish Millwork	3,000,000	367,967	3,367,967	0	0	3,367,967	3,367,967	0	0	0	3,367,967	0
260010	Waterhout - Install Millwork	784,461	1,169,727	1,954,188	0	0	1,954,188	1,954,188	0	0	0	1,954,188	0
260020	Cabinet Masters	0	23,850	23,850	0	0	23,850	23,850	0	0	0	23,850	0
270000	Lindberg Waterproofing	51,084	3,765	54,849	0	0	54,849	54,849	0	0	0	54,849	0
270010	Venetian Terrazzo	40,585	(40,585)	0	0	0	0	0	0	0	0	0	0
270020	Missouri Terrazzo - Stair Treads	0	55,782	55,782	0	0	55,782	55,782	0	0	0	55,782	0
270030	Western Waterproofing	0	40,504	40,504	0	0	40,504	40,504	0	0	0	40,504	0
280000	Bi-State Roof Systems	1,244,558	(123,035)	1,121,523	0	0	1,121,523	1,121,523	0	0	0	1,121,523	0
290000	Kuenz Sheet Metal	1,911,923	61,693	1,973,616	0	0	1,973,616	1,973,616	0	0	0	1,973,616	0
310000	Staat Tuckpointing - Joint Sealants	93,253	(30,484)	62,769	0	0	62,769	62,769	0	0	0	62,769	0
310010	McDonnell & Sons - Site Caulking	0	56,897	56,897	0	0	56,897	56,897	0	0	0	56,897	0
330000	Negwer Materials - Doors, Frames and Hardware	1,675,364	(44,634)	1,630,730	0	0	1,630,730	1,630,730	0	0	0	1,630,730	0
330010	Negwer Materials - Incidentals	24,636	(24,636)	0	0	0	0	0	0	0	0	0	0
350000	Missouri Valley Glass	4,200,000	987,309	5,187,309	0	0	5,187,309	5,187,309	0	0	0	5,187,309	0
350010	Int. Glass & Glazing	551,485	(551,485)	0	0	0	0	0	0	0	0	0	0
350020	Stanley Access - Auto Sliding Doors	0	194,023	194,023	0	0	194,023	194,023	0	0	0	194,023	0

ACI Code	Description	Original Budget	Approved Revs	Current Budget	Pending Revs	Approx Revs	Project'd Budget	Commit'd Costs	Uncommit Costs	Pending Commit	Forecast Cost	Project'd Cost	Project'd Over/Under
370000	Zumwalt - Overhead Doors	118,300	(16,709)	101,592	0	0	101,592	101,592	0	0	0	101,592	0
370010	Won-Door Corp.	0	28,536	28,536	0	0	28,536	28,536	0	0	0	28,536	0
390000	Fire Stop Technologies	0	4,415	4,415	0	0	4,415	4,415	0	0	0	4,415	0
390010	Firestoppers	0	524,398	524,398	0	0	524,398	524,398	0	0	0	524,398	0
400000	Niehaus Constr. Services	9,853,577	2,576,012	12,429,589	0	0	12,429,589	12,429,589	0	0	0	12,429,589	0
420000	ICS - Ceramic Tile	1,000,000	(105,165)	894,835	0	0	894,835	894,835	0	0	0	894,835	0
420100	Desco - Epoxy Flooring	0	162,045	162,045	0	0	162,045	162,045	0	0	0	162,045	0
440000	Golterman & Sabo - Fabric-Wrapped Inserts	30,000	231,751	261,751	0	0	261,751	261,751	0	0	0	261,751	0
450000	CI Select - Resilient Flooring & Carpet	1,523,686	(4,475)	1,519,211	0	0	1,519,211	1,519,211	0	0	0	1,519,211	0
450010	Recessed Floor Mat	0	0	0	0	0	0	0	0	0	0	0	0
450020	Bick Group - Access Flooring	0	7,532	7,532	0	0	7,532	7,532	0	0	0	7,532	0
460000	Painting Solutions - Garden Level & 1st Fl.	648,184	(152,330)	495,854	0	0	495,854	495,854	0	0	0	495,854	0
460001	Jos. Ward Painting - 2nd Fl. to Penthouse	0	305,316	305,316	0	0	305,316	305,316	0	0	0	305,316	0
460002	Runge Painting - Material Invoices	0	767	767	0	0	767	767	0	0	0	767	0
460003	Voorhees Painting - Exterior Painting	0	10,293	10,293	0	0	10,293	10,293	0	0	0	10,293	0
470000	Milmar Sales - Toilet Partitions	36,320	(9,699)	26,622	0	0	26,622	26,622	0	0	0	26,622	0
480000	ROM3 - Toilet Accessories	154,092	(10,976)	143,116	0	0	143,116	143,116	0	0	0	143,116	0
500100	Chalk & Tackboards	92,194	(92,194)	0	0	0	0	0	0	0	0	0	0
500110	Inpro - Cubicle Track/Wall Prot	21,291	237,572	258,863	0	0	258,863	258,863	0	0	0	258,863	0
500120	Wall Protection	233,763	(233,763)	0	0	0	0	0	0	0	0	0	0
500130	Baldwin/Priesmeyer - Flagpoles	16,500	(2,681)	13,819	0	0	13,819	13,819	0	0	0	13,819	0
500140	Signage	23,000	(23,000)	0	0	0	0	0	0	0	0	0	0
500150	Warehouse Design - Lockers	208,103	(84,993)	123,110	0	0	123,110	123,110	0	0	0	123,110	0
500160	FireSafety - Fire Extinguishers	10,000	2,025	12,025	0	0	12,025	12,025	0	0	0	12,025	0

ACI Code	Description	Original Budget	Approved Revs	Current Budget	Pending Revs	Approx Revs	Project'd Budget	Commit'd Costs	Uncommit Costs	Pending Commit	Forecast Cost	Project'd Cost	Project'd Over/Under
500170	Wire Mesh Partitions	2,925	(2,925)	0	0	0	0	0	0	0	0	0	0
500180	Ravensberg - Folding Partitions	119,980	(50,932)	69,048	0	0	69,048	69,048	0	0	0	69,048	0
500190	Telephone Enclosures	9,100	(9,100)	0	0	0	0	0	0	0	0	0	0
500200	Window Washing Anchors	87,126	(87,126)	0	0	0	0	0	0	0	0	0	0
500210	Projection Screens	59,600	(59,600)	0	0	0	0	0	0	0	0	0	0
500220	Modular Services Co.	0	4,117	4,117	0	0	4,117	4,117	0	0	0	4,117	0
500230	Jurgiel & Associates	0	13,785	13,785	0	0	13,785	13,785	0	0	0	13,785	0
500240	St. Louis Testing	0	2,300	2,300	0	0	2,300	2,300	0	0	0	2,300	0
500250	Knox Boxes	0	7,563	7,563	0	0	7,563	7,563	0	0	0	7,563	0
500260	Window Bullet Resistant	0	482	482	0	0	482	482	0	0	0	482	0
500270	Cath Managers	0	9,596	9,596	0	0	9,596	9,596	0	0	0	9,596	0
510100	Parking Equipment	25,000	(25,000)	0	0	0	0	0	0	0	0	0	0
510110	Roberts Loading Dock	24,900	12,290	37,190	0	0	37,190	37,190	0	0	0	37,190	0
510120	Medical Equipment	24,513	(24,513)	0	0	0	0	0	0	0	0	0	0
510130	Pharmacy Equipment	21,000	(21,000)	0	0	0	0	0	0	0	0	0	0
530100	Glen Alspaugh - Metal Casework	150,400	(29,541)	120,859	0	0	120,859	120,859	0	0	0	120,859	0
530110	Window Treatment	613,543	(613,543)	0	0	0	0	0	0	0	0	0	0
540000	Interior Finish Allowance	301,860	(301,860)	0	0	0	0	0	0	0	0	0	0
540010	Radiation Protection	495,000	(495,000)	0	0	0	0	0	0	0	0	0	0
540020	IMEDCO - RF Shielding	65,000	67,450	132,450	0	0	132,450	132,450	0	0	0	132,450	0
540030	Servco - Foodservice Equipment	0	1,271,601	1,271,601	0	0	1,271,601	1,271,601	0	0	0	1,271,601	0
540040	Unistrut Corp. - RF Shielding Support	0	13,366	13,366	0	0	13,366	13,366	0	0	0	13,366	0
550000	Otis Elevator	1,500,000	(51,695)	1,448,305	0	0	1,448,305	1,448,305	0	0	0	1,448,305	0
550001	Gateway Elevator	0	0	0	0	0	0	0	0	0	0	0	0
550010	Midwest Elevator	0	3,825	3,825	0	0	3,825	3,825	0	0	0	3,825	0
560000	Murphy Company	31,210,880	5,448,054	36,658,934	0	0	36,658,934	36,658,934	0	0	0	36,658,934	0
560010	TempAir - Temporary Cooling and Dehumidification	0	40,771	40,771	0	0	40,771	40,771	0	0	0	40,771	0

Financial Status Report
By Budget Code

ACI Code	Description	Original Budget	Approved Revs	Current Budget	Pending Revs	Approx Revs	Project'd Budget	Commit'd Costs	Uncommit Costs	Pending Commit	Forecast Cost	Project'd Cost	Project'd Over/Under
560020	Commercial Aquatic - Waterwall	0	105,837	105,837	0	0	105,837	105,837	0	0	0	105,837	0
580000	SLASCO	3,940,776	(623,180)	3,317,596	0	0	3,317,596	3,317,596	0	0	0	3,317,596	0
600000	Guarantee Electrical Co.	20,754,973	5,095,027	25,850,000	0	0	25,850,000	25,850,000	0	0	0	25,850,000	0
600010	Gerstner Electric - Traffic Signals	0	174,293	174,293	0	0	174,293	174,293	0	0	0	174,293	0
800000	Allowance - Full OB Build Out	0	0	0	0	0	0	0	0	0	0	0	0
800010	Allowance - 2nd OP CT Build Out	0	0	0	0	0	0	0	0	0	0	0	0
800020	Allowance - Full OR Build Out	0	0	0	0	0	0	0	0	0	0	0	0
800030	Allowance - Increase Coffee/Gift Shop Work	0	0	0	0	0	0	0	0	0	0	0	0
800040	Allowance - Add (7) ED Exam Rooms	0	0	0	0	0	0	0	0	0	0	0	0
870000	McGrath Inc.	0	316,210	316,210	0	0	316,210	316,210	0	0	0	316,210	0
870010	Stock & Associates	0	147,434	147,434	0	0	147,434	147,434	0	0	0	147,434	0
870020	Preconstruction	312,500	0	312,500	0	0	312,500	312,500	0	0	0	312,500	0
870030	Lean Project Consulting	97,000	13,112	110,112	0	0	110,112	110,112	0	0	0	110,112	0
870040	K.H. Lemp Elevator Consultant, Inc.	0	14,820	14,820	0	0	14,820	14,820	0	0	0	14,820	0
870050	Heitmann & Associates	0	26,935	26,935	0	0	26,935	26,935	0	0	0	26,935	0
910001	Insurance	1,129,163	(47,646)	1,081,517	0	0	1,081,517	1,081,517	0	0	0	1,081,517	0
920000	Bonds	970,556	(967,872)	2,684	0	0	2,684	2,684	0	0	0	2,684	0
930000	Permits	1,281,521	(506,858)	774,663	0	0	774,663	774,663	0	0	0	774,663	0
930010	Land Disturb Escrow	0	0	0	0	0	0	0	0	0	0	0	0
970000	Construction Contingency	1,498,775	(1,498,775)	0	0	0	0	0	0	0	0	0	0
970010	Overtime & Escalation	1,200,000	(1,200,000)	0	0	0	0	0	0	0	0	0	0
970020	Owner Contingency	0	0	0	0	0	0	0	0	0	0	0	0
980000	Fee	3,743,489	(500,000)	3,243,489	0	0	3,243,489	3,243,489	0	0	0	3,243,489	0
Grand Totals:		**141,090,013**	**11,247,623**	**152,337,636**	**0**	**0**	**152,337,636**	**152,337,636**	**0**	**0**	**0**	**152,337,636**	**0**

Forms in Place

Section			Activity	Floor	Total	Unit Value	Crew	Daily Output	Labor Hour	Unit	Material	Labor	Equipment	Total	Incl. O&P	Crews	Task Durati	Cost	Historical C	Location fa	Factored Cost
031113	20	1100	Exterior spandrel, job-built plywood, 18" wide, 3 use	TOTAL	17271.08		C-2	305.00	0.16	SFCA	1.07	7.05		8.12	12.05	1.00	0.00	$208,116.48	0.83	1.03	$176,759.37
				LL		3423.15	C-2	305.00	0.16	SFCA	1.07	7.05		8.12	12.05	3.00	3.74	$0.00	0.83	1.03	$0.00
				LR		3373.54	C-2	305.00	0.16	SFCA	1.07	7.05		8.12	12.05	3.00	3.69	$0.00	0.83	1.03	$0.00
				UL		3383.13	C-2	305.00	0.16	SFCA	1.07	7.05		8.12	12.05	3.00	3.70	$0.00	0.83	1.03	$0.00
				UR		325.00	C-2	305.00	0.16	SFCA	1.07	7.05		8.12	12.05	3.00	0.36	$0.00	0.83	1.03	$0.00
031114	20	2500	Interior beam, job-built plywood, 24" wide, 1 use	TOTAL	987.50		C-2	320.00	0.15	SFCA	2.52	6.70		9.22	13.10	1.00	0.00	$12,936.25	0.83	1.03	$10,987.13
				LL		81.25	C-2	305.00	0.16	SFCA	1.07	7.05		8.12	12.05	1.00	0.27	$0.00	0.83	1.03	$0.00
				LR		81.25	C-2	305.00	0.16	SFCA	1.07	7.05		8.12	12.05	1.00	0.27	$0.00	0.83	1.03	$0.00
				UL		0.00	C-2	305.00	0.16	SFCA	1.07	7.05		8.12	12.05	1.00	0.00	$0.00	0.83	1.03	$0.00
				UR		825.00	C-2	305.00	0.16	SFCA	1.07	7.05		8.12	12.05	1.00	2.70	$0.00	0.83	1.03	$0.00
031116	25	6500	Job-built plywood, 24"x24" columns, 3 use	TOTAL	50181.34		C-1	230.00	0.14	SFCA	1.15	6.05		7.20	10.60	1.00	0.00	$531,922.20	0.83	1.03	$451,776.95
				LL		10698.67	C-1	305.00	0.16	SFCA	1.07	7.05		8.12	12.05	5.00	7.02	$0.00	0.83	1.03	$0.00
				LR		10698.67	C-1	305.00	0.16	SFCA	1.07	7.05		8.12	12.05	5.00	7.02	$0.00	0.83	1.03	$0.00
				UL		7196.00	C-1	305.00	0.16	SFCA	1.07	7.05		8.12	12.05	5.00	4.72	$0.00	0.83	1.03	$0.00
				UR		7196.00	C-1	305.00	0.16	SFCA	1.07	7.05		8.12	12.05	5.00	4.72	$0.00	0.83	1.03	$0.00
031117	35	2150	Flat slab, drop panels, job-built plywood, to 15' high, 4 use	TOTAL	17400.00		C-2	544.00	0.88	SF	1.37	3.94		5.31	7.60	1.00	0.00	$132,240.00	0.83	1.03	$112,315.27
				LL		3900.00	C-2	544.00	0.88	SF	1.37	3.94		5.31	7.60	1.00	7.17	$0.00	0.83	1.03	$0.00
				LR		3900.00	C-2	544.00	0.88	SF	1.37	3.94		5.31	7.60	1.00	7.17	$0.00	0.83	1.03	$0.00
				UL		2400.00	C-2	544.00	0.88	SF	1.37	3.94		5.31	7.60	1.00	4.41	$0.00	0.83	1.03	$0.00
				UR		2400.00	C-2	544.00	0.88	SF	1.37	3.94		5.31	7.60	1.00	4.41	$0.00	0.83	1.03	$0.00
031118	35	2250	Flat slab, drop panels, job-built plywood, to 15-20' high, 4 use	TOTAL	2800.00		C-2	480.00	0.10	SF	2.43	4.47		6.90	9.55	1.00	0.00	$26,740.00	0.83	1.03	$22,711.06
				LL		1000.00	C-2	480.00	0.10	SF	2.43	4.47		6.90	9.55	1.00	2.08	$0.00	0.83	1.03	$0.00
				LR		1000.00	C-2	480.00	0.10	SF	2.43	4.47		6.90	9.55	1.00	2.08	$0.00	0.83	1.03	$0.00
				UL		200.00	C-2	480.00	0.10	SF	2.43	4.47		6.90	9.55	1.00	0.42	$0.00	0.83	1.03	$0.00
				UR		200.00	C-2	480.00	0.10	SF	2.43	4.47		6.90	9.55	1.00	0.42	$0.00	0.83	1.03	$0.00
031119	35	7070	Edge forms 7" to 12" high, 3 use	TOTAL	6468.39		C-1	222.00	0.14	SFCA	0.45	6.30		6.75	10.20	1.00	0.00	$65,977.53	0.83	1.03	$56,036.63
				LL		1089.18	C-1	222.00	0.14	SFCA	0.45	6.30		6.75	10.20	1.00	4.91	$0.00	0.83	1.03	$0.00
				LR		1073.40	C-1	222.00	0.14	SFCA	0.45	6.30		6.75	10.20	1.00	4.84	$0.00	0.83	1.03	$0.00
				UL		1076.45	C-1	222.00	0.14	SFCA	0.45	6.30		6.75	10.20	1.00	4.85	$0.00	0.83	1.03	$0.00
				UR		1076.45	C-1	222.00	0.14	SFCA	0.45	6.30		6.75	10.20	1.00	4.85	$0.00	0.83	1.03	$0.00
031120	35	7500	Depressed area forms to 12" high, 4 use	TOTAL	2580.00		C-1	300.00	0.11	LF	0.92	4.65		5.57	8.15	1.00	0.00	$21,027.00	0.83	1.03	$17,858.84
				LL		0.00	C-1	300.00	0.11	LF	0.92	4.65		5.57	8.15	1.00	0.00	$0.00	0.83	1.03	$0.00
				LR		0.00	C-1	300.00	0.11	LF	0.92	4.65		5.57	8.15	1.00	0.00	$0.00	0.83	1.03	$0.00
				UL		860.00	C-1	300.00	0.11	LF	0.92	4.65		5.57	8.15	1.00	2.87	$0.00	0.83	1.03	$0.00
				UR		0.00	C-1	300.00	0.11	LF	0.92	4.65		5.57	8.15	1.00	0.00	$0.00	0.83	1.03	$0.00
031121	35	8000	Perimeter deck and rail for elevated slabs, straight	TOTAL	7392.44		C-1	90.00	0.36	LF	12.00	15.50		27.50	37.00	1.00	0.00	$273,520.28	0.83	1.03	$232,308.71
				LL		1244.78	C-1	90.00	0.36	LF	12.00	15.50		27.50	37.00	1.00	13.83	$0.00	0.83	1.03	$0.00
				LR		1226.74	C-1	90.00	0.36	LF	12.00	15.50		27.50	37.00	1.00	13.63	$0.00	0.83	1.03	$0.00
				UL		1230.23	C-1	90.00	0.36	LF	12.00	15.50		27.50	37.00	1.00	13.67	$0.00	0.83	1.03	$0.00
				UR		1230.23	C-1	90.00	0.36	LF	12.00	15.50		27.50	37.00	1.00	13.67	$0.00	0.83	1.03	$0.00
031124	65	3050	Slab on grade, edge forms, wood, 7" to 12" high	TOTAL	7392.44		C-1	435.00	0.07	SFCA	0.77	3.20		3.97	5.80	1.00	0.00	$42,876.15	0.83	1.03	$36,415.96
				LL		1244.78	C-1	435.00	0.07	SFCA	0.77	3.20		3.97	5.80	1.00	2.86	$0.00	0.83	1.03	$0.00
				LR		1226.74	C-1	435.00	0.07	SFCA	0.77	3.20		3.97	5.80	1.00	2.82	$0.00	0.83	1.03	$0.00
				UL		1230.23	C-1	435.00	0.07	SFCA	0.77	3.20		3.97	5.80	1.00	2.83	$0.00	0.83	1.03	$0.00
				UR		1230.23	C-1	435.00	0.07	SFCA	0.77	3.20		3.97	5.80	1.00	2.83	$0.00	0.83	1.03	$0.00
031125	85	2400	Wall, job-built plywood, 8' to 16' high, 3 use	TOTAL	42808.00		C-2	375.00	0.13	SFCA	0.90	5.70		6.59	9.75	1.00	0.00	$417,378.00	0.83	1.03	$354,491.24
				LL		9616	C-2	375.00	0.13	SFCA	0.90	5.70		6.59	9.75	4.00	6.41	$0.00	0.83	1.03	$0.00
				LR		9616	C-2	375.00	0.13	SFCA	0.90	5.70		6.59	9.75	4.00	6.41	$0.00	0.83	1.03	$0.00
				UL		5894	C-2	375.00	0.13	SFCA	0.90	5.70		6.59	9.75	3.00	5.24	$0.00	0.83	1.03	$0.00
				UR		5894	C-2	375.00	0.13	SFCA	0.90	5.70		6.59	9.75	1.00	15.72	$0.00	0.83	1.03	$0.00
																					$1,471,661.15

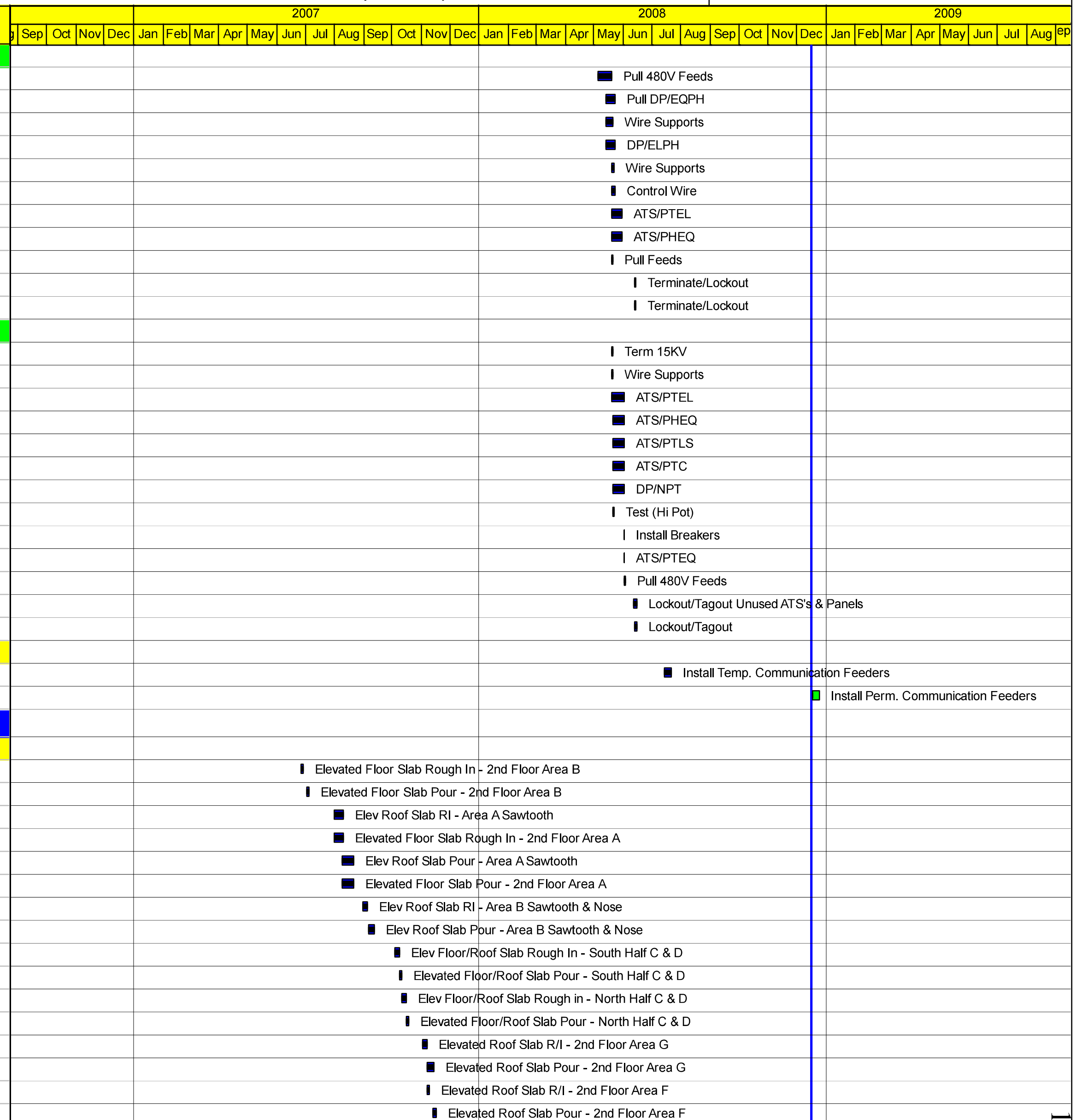
Shores																					
Section			Activity		SF	SFCA	Crew	Daily Output	Labor Hour	Unit	Material	Labor	Equipment	Total	Incl. O&P	Crews	Task Durati	Cost	Historical	Location factor	
031505	70	3000	Rent for job duration, aluminum joist @ 2' O.C., per mo.	TOTAL	53767.85					SF Flr	0.39			0.39	0.43	1.00		$23,120.18	0.83	1.03	$19,636.64
				LL		53767.85				SF Flr	0.39			0.39	0.43	1.00		$0.00	0.83	1.03	$0.00
				LR		0				SF Flr	0.39			0.39	0.43	1.00		$0.00	0.83	1.03	$0.00
				UL		0				SF Flr	0.39			0.39	0.43	1.00		$0.00	0.83	1.03	$0.00
				UR		0				SF Flr	0.39			0.39	0.43	1.00		$0.00	0.83	1.03	$0.00
031506	70	3600	#3 post shore, 8'-10" to 16'-1" high, 3800# capacity	TOTAL	2150.71					Ea	187.00			187.00	206.00	1.00		$443,047.08	0.83	1.03	$376,292.74
				LL		2150.71				Ea	187.00			187.00	206.00	1.00		$0.00	0.83	1.03	$0.00
				LR		0.00				Ea	187.00			187.00	206.00	1.00		$0.00	0.83	1.03	$0.00
				UL		0.00				Ea	187.00			187.00	206.00	1.00		$0.00	0.83	1.03	$0.00
				UR		0.00				Ea	187.00			187.00	206.00	1.00		$0.00	0.83	1.03	$0.00
031506	70	1500	Reshoring	TOTAL	219080.38		2 Carp	1400.00	0.01	SF	0.58	0.52		1.10	1.45	1.00	0.00	$317,666.55	0.83	1.03	$269,803.41
				LL		53767.85	2 Carp	1400.00	0.01	SF	0.58	0.52		1.10	1.45	1.00	38.41	$0.00	0.83	1.03	$0.00
				LR		55273.4	2 Carp	1400.00	0.01	SF	0.58	0.52		1.10	1.45	5.00	7.90	$0.00	0.83	1.03	$0.00
				UL		36679.71	2 Carp	1400.00	0.01	SF	0.58	0.52		1.10	1.45	1.00	26.20	$0.00	0.83	1.03	$0.00
				UR		0	2 Carp	1400.00	0.01	SF	0.58	0.52		1.10	1.45	1.00	0.00	$0.00	0.83	1.03	$0.00
																					$665,732.79
Expansion Joints																					
Section			Activity		SF	SFCA	Crew	Daily Output	Labor Hour	Unit	Material	Labor	Equipment	Total	Incl. O&P	Crews	Task Durati	Cost	Historical	Location factor	
031516	30	3800	Expansion Joint, polyurethane foam, regular, closed cell, 1"x12"	TOTAL	496.00		1 Carp	300.00	0.27	LF	3.00	1.22		4.22	5.20	1.00		$2,579.20	0.83	1.03	$2,190.59
				LL		248.00	1 Carp	300.00	0.27	LF	3.00	1.22		4.22	5.20	2.00		$0.00	0.83	1.03	$0.00
				LR		248.00	1 Carp	300.00	0.27	LF	3.00	1.22		4.22	5.20	3.00		$0.00	0.83	1.03	$0.00
				UL		0.00	1 Carp	300.00	0.27	LF	3.00	1.22		4.22	5.20	4.00		$0.00	0.83	1.03	$0.00
				UR		0.00	1 Carp	300.00	0.27	LF	3.00	1.22		4.22	5.20	5.00		$0.00	0.83	1.03	$0.00
																					$2,190.59
Rebar Accessories																					
Section			Activity		SF	SFCA	Crew	Daily Output	Labor Hour	Unit	Material	Labor	Equipment	Total	Incl. O&P	Crews	Task Durati	Cost	Historical	Location factor	
032105	75	1500	Bar Chair (BC), 1-1/2" high, plain steel	TOTAL	639.40					C	36.00			36.00	39.50	1.00		$25,256.31	0.83	1.03	$21,450.92
				LL		134.42				C	36.00			36.00	39.50	1.00		$0.00	0.83	1.03	$0.00
				LR		138.18				C	36.00			36.00	39.50	1.00		$0.00	0.83	1.03	$0.00
				UL		91.70				C	36.00			36.00	39.50	1.00		$0.00	0.83	1.03	$0.00
				UR		91.70				C	36.00			36.00	39.50	1.00		$0.00	0.83	1.03	$0.00
032111	60	0150	beams and girders #8-#18	TOTAL	125.77		4 Rodm	2.70	11.85	Ton	1000.00	600.00		1600.00	2050.00	1.00	0.00	$257,837.01	0.83	1.03	$218,988.45
				LL		21.18	4 Rodm	2.70	11.85	Ton	1000.00	600.00		1600.00	2050.00	2.00	3.92	$0.00	0.83	1.03	$0.00
				LR		20.87	4 Rodm	2.70	11.85	Ton	1000.00	600.00		1600.00	2050.00	2.00	3.87	$0.00	0.83	1.03	$0.00
				UL		20.93	4 Rodm	2.70	11.85	Ton	1000.00	600.00		1600.00	2050.00	2.00	3.88	$0.00	0.83	1.03	$0.00
				UR		20.93	4 Rodm	2.70	11.85	Ton	1000.00	600.00		1600.00	2050.00	2.00	3.88	$0.00	0.83	1.03	$0.00
032111	60	0250	columns #8-#28	TOTAL	212.55		4 Rodm	2.30	13.91	Ton	1000.00	705.00		1705.00	2200.00	1.00	0.00	$467,608.85	0.83	1.03	$397,153.76
				LL		44.28	4 Rodm	2.30	13.91	Ton	1000.00	705.00		1705.00	2200.00	3.00	6.42	$0.00	0.83	1.03	$0.00
				LR		44.28	4 Rodm	2.30	13.91	Ton	1000.00	705.00		1705.00	2200.00	3.00	6.42	$0.00	0.83	1.03	$0.00
				UL		31.00	4 Rodm	2.30	13.91	Ton	1000.00	705.00		1705.00	2200.00	3.00	4.49	$0.00	0.83	1.03	$0.00
				UR		31.00	4 Rodm	2.30	13.91	Ton	1000.00	705.00		1705.00	2200.00	3.00	4.49	$0.00	0.83	1.03	$0.00
032111	60	0400	elevated slabs #4-#7	TOTAL	813.20		4 Rodm	2.90	11.03	Ton	1000.00	560.00		1560.00	1975.00	1.00	0.00	$1,606,070.00	0.83	1.03	$1,364,081.83
				LL		170.4	4 Rodm	2.90	11.03	Ton	1000.00	560.00		1560.00	1975.00	10.00	5.88	$0.00	0.83	1.03	$0.00
				LR		174.4	4 Rodm	2.90	11.03	Ton	1000.00	560.00		1560.00	1975.00	10.00	6.01	$0.00	0.83	1.03	$0.00
				UL		116.5	4 Rodm	2.90	11.03	Ton	1000.00	560.00		1560.00	1975.00	6.00	6.70	$0.00	0.83	1.03	$0.00
				UR		118.9	4 Rodm	2.90	11.03	Ton	1000.00	560.00		1560.00	1975.00	6.00	6.83	$0.00	0.83	1.03	$0.00
032111	60	0700	walls #3-#7	TOTAL	30.00		4 Rodm	3.00	10.67	Ton	1000.00	540.00		1540.00	1950.00	1.00	0.00	$58,500.00	0.83	1.03	$49,685.75
				LL		5	4 Rodm	3.00	10.67	Ton	1000.00	540.00		1540.00	1950.00	1.00	1.67	$0.00	0.83	1.03	$0.00
				LR		5	4 Rodm	3.00	10.67	Ton	1000.00	540.00		1540.00	1950.00	1.00	1.67	$0.00	0.83	1.03	$0.00
				UL		5	4 Rodm	3.00	10.67	Ton	1000.00	540.00		1540.00	1950.00	1.00	1.67	$0.00	0.83	1.03	$0.00
				UR		5	4 Rodm	3.00	10.67	Ton	1000.00	540.00		1540.00	1950.00	1.00	1.67	$0.00	0.83	1.03	$0.00
032111	60	0750	walls #8-#18	TOTAL	160.00		4 Rodm	4.00	8.00	Ton	1000.00	405.00		1405.00	1725.00	1.00	0.00	$276,000.00	0.83	1.03	$234,414.80
				LL		30.00	4 Rodm	4.00	8.00	Ton	1000.00	405.00		1405.00	1725.00	1.00	7.50	$0.00	0.83	1.03	$0.00
				LR		30.00	4 Rodm	4.00	8.00	Ton	1000.00	405.00		1405.00	1725.00	1.00	7.50	$0.00	0.83	1.03	$0.00
				UL		25.00	4 Rodm	4.00	8.00	Ton	1000.00	405.00		1405.00	1725.00	1.00	6.25	$0.00	0.83	1.03	$0.00
				UR		25.00	4 Rodm	4.00	8.00	Ton	1000.00	405.00		1405.00	1725.00	1.00	6.25	$0.00	0.83	1.03	$0.00
032111	60	2200	Crane cost for handling, 90 picks/day, up to 1.5 tons/bundle	TOTAL	1341.52		C-5	135.00	0.42	Ton		20.50	5.55	26.05	38.00	1.00	0.00	$50,977.90	0.83	1.03	$43,297.01
				LL		270.86	C-5	135.00	0.42	Ton		20.50	5.55	26.05	38.00	1.00	2.01	$0.00	0.83	1.03	$0.00
				LR		274.55	C-5	135.00	0.42	Ton		20.50	5.55	26.05	38.00	1.00	2.03	$0.00	0.83	1.03	$0.00
				UL		198.43	C-5	135.00	0.42	Ton		20.50	5.55	26.05	38.00	1.00	1.47	$0.00	0.83	1.03	$0.00
				UR		200.83	C-5	135.00	0.42	Ton		20.50	5.55	26.05	38.00	1.00	1.49	$0.00	0.83	1.03	$0.00
																					$2,329,072.51

Placing Concrete																					
Section			Activity		SF	SFCA	Crew	Daily Output	Labor Hour	Unit	Material	Labor	Equipment	Total	Incl. O&P	Crews	Task Durati	Cost	Historical C	Location fa	Fact
033113	35	0150	Heavyweight concrete, ready mix, 3000 psi	TOTAL	12875.25					CY	93.00			93.00	102.00	1.00		$1,313,275.25	0.83	1.03	$1,115,402.76
				LL		2816.97				CY	93.00			26.05	38.00	1.00		$0.00	0.83	1.03	$0.00
				LR		2872.35				CY	93.00			26.05	38.00	1.00		$0.00	0.83	1.03	$0.00
				UL		1784.48				CY	93.00			26.05	38.00	1.00		$0.00	0.83	1.03	$0.00
				UR		1832.48				CY	93.00			26.05	38.00	1.00		$0.00	0.83	1.03	$0.00
033113	70	0050	Beams, elevated, small beams, pumped	TOTAL	252.88		C-20	60.00	1.07	CY		42.00	12.95	54.95	78.50	1.00	0.00	$19,851.02	0.83	1.03	$16,860.05
				LL		42.58	C-20	60.00	1.07	CY		42.00	12.95	54.95	78.50	1.00	0.71	$0.00	0.83	1.03	$0.00
				LR		41.96	C-20	60.00	1.07	CY		42.00	12.95	54.95	78.50	1.00	0.70	$0.00	0.83	1.03	$0.00
				UL		42.08	C-20	60.00	1.07	CY		42.00	12.95	54.95	78.50	1.00	0.70	$0.00	0.83	1.03	$0.00
				UR		42.08	C-20	60.00	1.07	CY		42.00	12.95	54.95	78.50	1.00	0.70	$0.00	0.83	1.03	$0.00
033113	70	0800	columns, 24" thick, pumped	TOTAL	865.87		C-20	92.00	0.70	CY		27.50	8.45	35.95	51.50	1.00	0.00	$44,592.22	0.83	1.03	$37,873.46
				LL		179.63786	C-20	92.00	0.70	CY		27.50	8.45	35.95	51.50	1.00	1.95	$0.00	0.83	1.03	$0.00
				LR		179.63786	C-20	92.00	0.70	CY		27.50	8.45	35.95	51.50	1.00	1.95	$0.00	0.83	1.03	$0.00
				UL		126.64815	C-20	92.00	0.70	CY		27.50	8.45	35.95	51.50	1.00	1.38	$0.00	0.83	1.03	$0.00
				UR		126.64815	C-20	92.00	0.70	CY		27.50	8.45	35.95	51.50	1.00	1.38	$0.00	0.83	1.03	$0.00
033113	70	1500	elevated slabs, 6" to 10", pumped	TOTAL	9592.00		C-20	160.00	0.40	CY		15.75	4.85	20.60	29.50	1.00	0.00	$282,964.00	0.83	1.03	$240,329.53
				LL		2144	C-20	160.00	0.40	CY		15.75	4.85	20.60	29.50	4.00	3.35	$0.00	0.83	1.03	$0.00
				LR		2200	C-20	160.00	0.40	CY		15.75	4.85	20.60	29.50	4.00	3.44	$0.00	0.83	1.03	$0.00
				UL		1300	C-20	160.00	0.40	CY		15.75	4.85	20.60	29.50	3.00	2.71	$0.00	0.83	1.03	$0.00
				UR		1348	C-20	160.00	0.40	CY		15.75	4.85	20.60	29.50	3.00	2.81	$0.00	0.83	1.03	$0.00
033113	70	5050	Walls, 12" thick, pumped	TOTAL	2164.50		C-20	110.00	0.58	CY		23.00	7.05	30.05	43.00	1.00	0.00	$93,073.50	0.83	1.03	$79,050.02
				LL		450.75	C-20	110.00	0.58	CY		23.00	7.05	30.05	43.00	1.00	4.10	$0.00	0.83	1.03	$0.00
				LR		450.75	C-20	110.00	0.58	CY		23.00	7.05	30.05	43.00	1.00	4.10	$0.00	0.83	1.03	$0.00
				UL		315.75	C-20	110.00	0.58	CY		23.00	7.05	30.05	43.00	1.00	2.87	$0.00	0.83	1.03	$0.00
				UR		315.75	C-20	110.00	0.58	CY		23.00	7.05	30.05	43.00	1.00	2.87	$0.00	0.83	1.03	$0.00
033513	30	0125	Bull float and manual float	TOTAL	255760.09		C-10	2000.00	0.01	SF		0.50		0.50	0.75	1.00	0.00	$191,820.07	0.83	1.03	$162,918.35
				LL		53767.85	C-10	2000.00	0.01	SF		0.50		0.50	0.75	1.00	26.88	$0.00	0.83	1.03	$0.00
				LR		55273.40	C-10	2000.00	0.01	SF		0.50		0.50	0.75	1.00	27.64	$0.00	0.83	1.03	$0.00
				UL		36679.71	C-10	2000.00	0.01	SF		0.50		0.50	0.75	1.00	18.34	$0.00	0.83	1.03	$0.00
				UR		36679.71	C-10	2000.00	0.01	SF		0.50		0.50	0.75	1.00	18.34	$0.00	0.83	1.03	$0.00
																					$1,652,434.17

Project Total: $6,121,091.20

B.2 Schedule References

Act ID	Activity Name	Orig Dur	Start	Finish
SWB/PTEM		29	05-May-08 A	13-Jun-08 A
PP.5010	Pull 480V Feeds	11	05-May-08 A	19-May-08 A
PP.5050	Pull DP/EQPH	8	14-May-08 A	23-May-08 A
PP.5060	Wire Supports	5	14-May-08 A	20-May-08 A
PP.5090	DP/ELPH	8	14-May-08 A	23-May-08 A
PP.5100	Wire Supports	3	19-May-08 A	21-May-08 A
PP.5020	Control Wire	4	20-May-08 A	23-May-08 A
PP.5030	ATS/PTEL	8	20-May-08 A	30-May-08 A
PP.5040	ATS/PHEQ	8	20-May-08 A	30-May-08 A
PP.5080	Pull Feeds	2	20-May-08 A	21-May-08 A
PP.5070	Terminate/Lockout	1	13-Jun-08 A	13-Jun-08 A
PP.5110	Terminate/Lockout	1	13-Jun-08 A	13-Jun-08 A
USS/PT		19	20-May-08 A	16-Jun-08 A
PP.5510	Term 15KV	2	20-May-08 A	21-May-08 A
PP.5580	Wire Supports	2	20-May-08 A	21-May-08 A
PP.5610	ATS/PTEL	9	20-May-08 A	02-Jun-08 A
PP.5590	ATS/PHEQ	8	21-May-08 A	02-Jun-08 A
PP.5600	ATS/PTLS	8	21-May-08 A	02-Jun-08 A
PP.5620	ATS/PTC	8	21-May-08 A	02-Jun-08 A
PP.5640	DP/NPT	8	21-May-08 A	02-Jun-08 A
PP.5520	Test (Hi Pot)	2	21-May-08 A	22-May-08 A
PP.5540	Install Breakers	1	02-Jun-08 A	02-Jun-08 A
PP.5630	ATS/PTEQ	1	02-Jun-08 A	02-Jun-08 A
PP.5560	Pull 480V Feeds	2	02-Jun-08 A	03-Jun-08 A
PP.5550	Lockout/Tagout Unused ATS's & Panels	3	12-Jun-08 A	16-Jun-08 A
PP.5530	Lockout/Tagout	2	13-Jun-08 A	16-Jun-08 A
Communication Feeders		114	15-Jul-08 A	24-Dec-08
CC.1000	Install Temp. Communication Feeders	6	15-Jul-08 A	22-Jul-08 A
CC.1010	Install Perm. Communication Feeders	6	17-Dec-08*	24-Dec-08
Structural Steel / Concrete Decks		377	02-Jan-07 A	20-Jun-08 A
2nd Floor		102	26-Jun-07 A	16-Nov-07 A
2005	Elevated Floor Slab Rough In - 2nd Floor Area B	4	26-Jun-07 A	29-Jun-07 A
2010	Elevated Floor Slab Pour - 2nd Floor Area B	3	02-Jul-07 A	05-Jul-07 A
2063X	Elev Roof Slab RI - Area A Sawtooth	8	01-Aug-07 A	10-Aug-07 A
2020X	Elevated Floor Slab Rough In - 2nd Floor Area A	8	01-Aug-07 A	10-Aug-07 A
2073X	Elev Roof Slab Pour - Area A Sawtooth	8	09-Aug-07 A	21-Aug-07 A
2050X	Elevated Floor Slab Pour - 2nd Floor Area A	8	09-Aug-07 A	21-Aug-07 A
2052X	Elev Roof Slab RI - Area B Sawtooth & Nose	2	31-Aug-07 A	04-Sep-07 A
2053X	Elev Roof Slab Pour - Area B Sawtooth & Nose	4	06-Sep-07 A	11-Sep-07 A
535	Elev Floor/Roof Slab Rough In - South Half C & D	3	04-Oct-07 A	08-Oct-07 A
570	Elevated Floor/Roof Slab Pour - South Half C & D	3	09-Oct-07 A	11-Oct-07 A
760	Elev Floor/Roof Slab Rough in - North Half C & D	3	11-Oct-07 A	15-Oct-07 A
770	Elevated Floor/Roof Slab Pour - North Half C & D	3	16-Oct-07 A	18-Oct-07 A
780	Elevated Roof Slab R/I - 2nd Floor Area G	3	02-Nov-07 A	06-Nov-07 A
790	Elevated Roof Slab Pour - 2nd Floor Area G	5	07-Nov-07 A	14-Nov-07 A
800	Elevated Roof Slab R/I - 2nd Floor Area F	3	07-Nov-07 A	09-Nov-07 A
810	Elevated Roof Slab Pour - 2nd Floor Area F	4	13-Nov-07 A	16-Nov-07 A



Act ID	Activity Name	Orig Dur	Start	Finish
Envelope		259	02-Jan-07 A	07-Jan-08 A
065	Structural Steel Fabrication	67	02-Jan-07 A	04-May-07 A
123	Steel Erection - Area B, Levels 1 & 2 South	19	10-May-07 A	11-Jun-07 A
45	Steel Erection - Area B, Levels 1 & 2 North	13	21-May-07 A	11-Jun-07 A
67	Steel Erection - Area B, Levels 3 & 4 South	17	29-May-07 A	22-Jun-07 A
89	Steel Erection - Area B, Levels 3 & 4 North	14	01-Jun-07 A	22-Jun-07 A
1011	Steel Erection - Area B, Levels 5 and Roof S	21	07-Jun-07 A	09-Jul-07 A
1213	Steel Erection - Area B, Levels 5 and Roof N	20	08-Jun-07 A	09-Jul-07 A
1415X	Steel Erection - Area A, Levels 1 and 2 Sawtooth	30	15-Jun-07 A	31-Jul-07 A
1617X	Steel Erection - Area A, Levels 1 and 2 South	27	20-Jun-07 A	31-Jul-07 A
1819X	Steel Erection - Area A, Levels 1 and 2 North	25	25-Jun-07 A	31-Jul-07 A
2021X	Steel Erection - Area A, Levels 3 & 4 South	30	02-Jul-07 A	14-Aug-07 A
2223X	Steel Erection - Area A, Levels 3 & 4 North	26	09-Jul-07 A	14-Aug-07 A
2425X	Steel Erection - Area A, Levels 5 and Roof South	27	12-Jul-07 A	21-Aug-07 A
2627X	Steel Erection - Area A, Levels 5 and Roof North	27	12-Jul-07 A	21-Aug-07 A
2831X	Steel Erection - Nose, Levels 1 thru 4	29	20-Jul-07 A	30-Aug-07 A
6162X10	Stair Delivery	1	23-Jul-07 A	23-Jul-07 A
3233X	Steel Erection - Nose, Levels 5 and Roof	26	25-Jul-07 A	30-Aug-07 A
3435X	Steel Erection - Area B Sawtooth	25	26-Jul-07 A	30-Aug-07 A
SS3	Erect & Pour Stair 3	32	30-Jul-07 A	14-Sep-07 A
33AX	Set Emergency Generators in Area D Mech Rm.	1	31-Jul-07 A	31-Jul-07 A
56X	Steel Erection - Area D, Level 1 South	34	06-Aug-07 A	21-Sep-07 A
5758X	Steel Erection - Area D, Levels 1N & Roof S	31	09-Aug-07 A	21-Sep-07 A
5960X	Steel Erection - Area D, Levels 2 & Roof N	39	13-Aug-07 A	05-Oct-07 A
5152X	Steel Erection - Area C, Levels 1 & 2 South	18	24-Aug-07 A	21-Sep-07 A
5354X	Steel Erection - Area C, Levels 1 & 2 North	15	29-Aug-07 A	21-Sep-07 A
SS2	Erect and Pour Stair 2	21	29-Aug-07 A	01-Oct-07 A
55X	Steel Erection - Area C, Roof North	23	30-Aug-07 A	05-Oct-07 A
6162X	Steel Erection - Area F, Levels 1 and Roof North	38	10-Sep-07 A	31-Oct-07 A
6364	Steel Erection - Area F, Levels 1 and Roof South	37	11-Sep-07 A	31-Oct-07 A
6566	Steel Erection - Area G, Levels 1 and Roof North	30	20-Sep-07 A	31-Oct-07 A
6768	Steel Erection - Area G, Levels 1 and Roof South	30	20-Sep-07 A	31-Oct-07 A
59F	Deliver AHU 3, 4 & 5 for Area F	1	27-Sep-07 A	27-Sep-07 A
SS1	Erect and Pour Stair 1	43	27-Sep-07 A	29-Nov-07 A
60F	Set AHU Units in Area F Mech Rm.	2	28-Sep-07 A	01-Oct-07 A
60A30	Beam Topping Out Event	1	03-Oct-07 A	03-Oct-07 A
60A20	Deliver AHU Area A & B	1	17-Oct-07 A	17-Oct-07 A
SS4	Erect and Pour Stair 4	28	27-Nov-07 A	07-Jan-08 A
1st Floor		97	25-Jun-07 A	08-Nov-07 A
1003	Elevated Floor Slab Rough In - 1st Flr, Area B	5	25-Jun-07 A	29-Jun-07 A
1005	Elevated Floor Slab Pour - 1st Floor, Area B	7	25-Jun-07 A	03-Jul-07 A
1010X	Elevated Floor Slab Rough In - Area A	3	26-Jul-07 A	30-Jul-07 A
1030X	Elevated Floor Slab RI - Area A Sawtooth	3	26-Jul-07 A	30-Jul-07 A
1025X	Elevated Floor Slab Pour - Area A	3	31-Jul-07 A	02-Aug-07 A
1050X	Elevated Flr Slab Pour - Area A Sawtooth	3	31-Jul-07 A	02-Aug-07 A
1052X	Elevated Floor Slab RI - Area B Sawtooth & Nose	6	31-Aug-07 A	11-Sep-07 A
1053	Elev Floor Slab Pour - Area B Sawtooth & Nose	5	12-Sep-07 A	18-Sep-07 A

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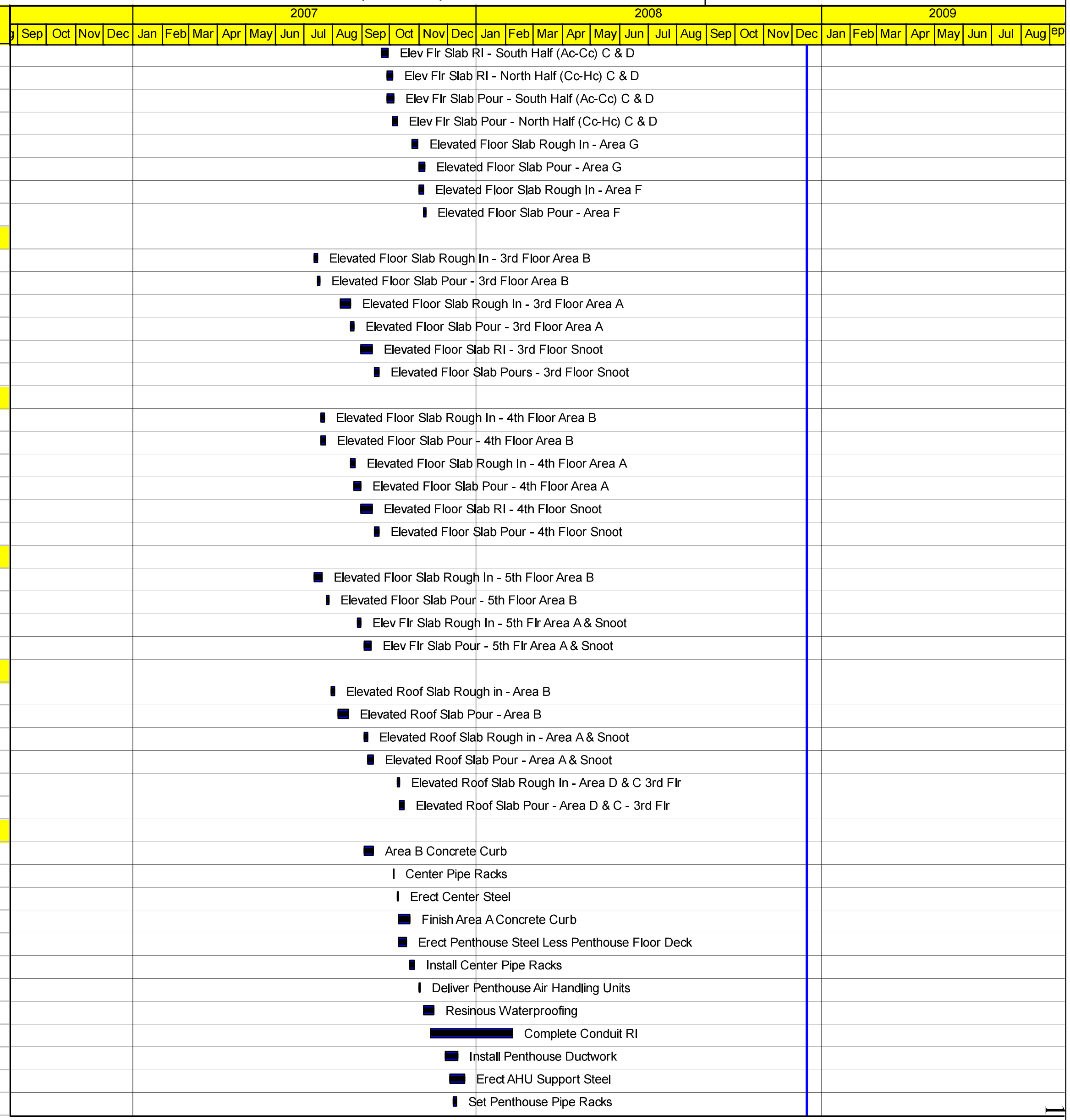
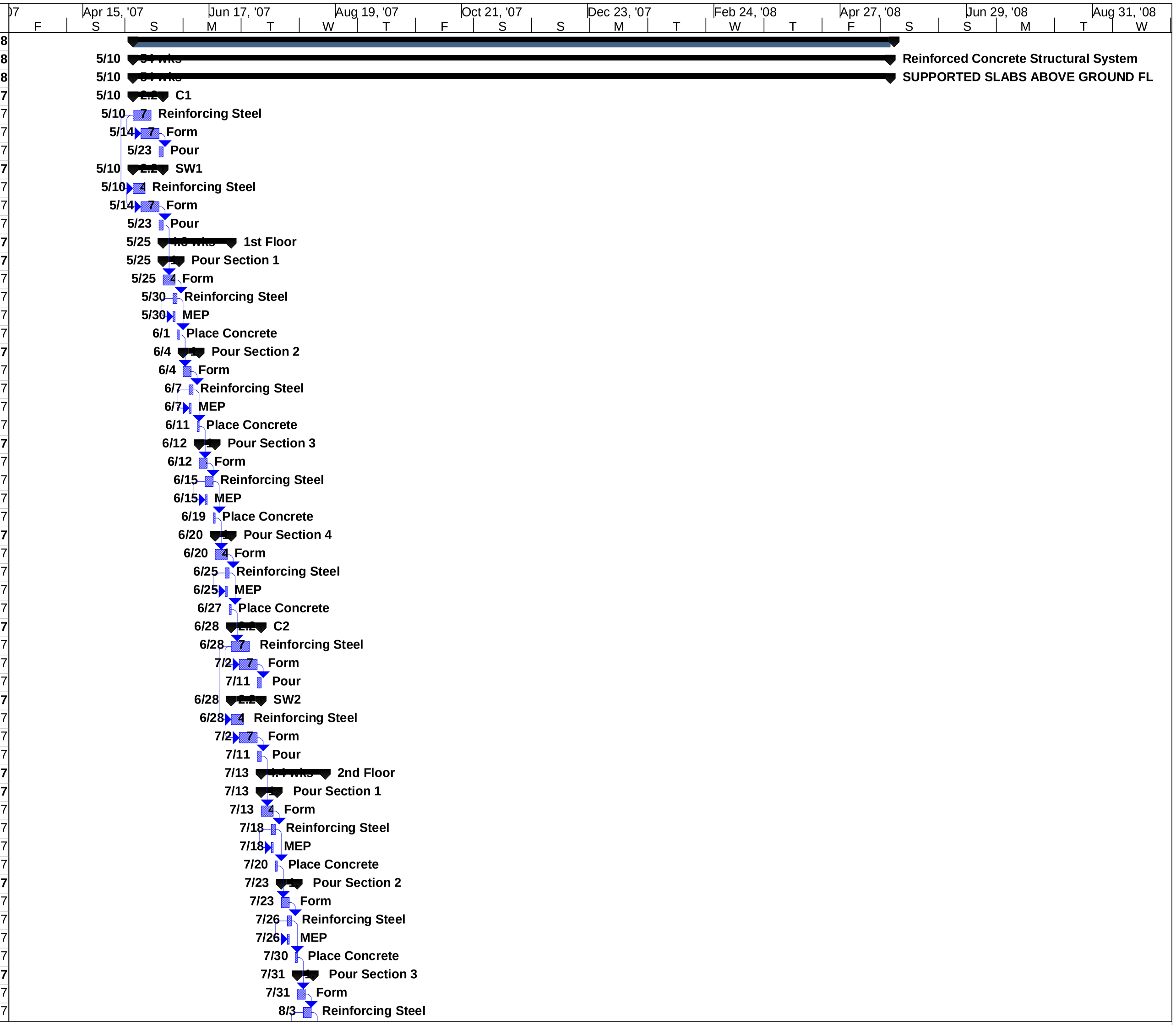
Act ID	Activity Name	Orig Dur	Start	Finish
530	Elev Flr Slab RI - South Half (Ac-Cc) C & D	6	21-Sep-07 A	28-Sep-07 A
525	Elev Flr Slab RI - North Half (Cc-Hc) C & D	4	28-Sep-07 A	03-Oct-07 A
565	Elev Flr Slab Pour - South Half (Ac-Cc) C & D	5	28-Sep-07 A	04-Oct-07 A
545	Elev Flr Slab Pour - North Half (Cc-Hc) C & D	3	04-Oct-07 A	08-Oct-07 A
540	Elevated Floor Slab Rough In - Area G	5	24-Oct-07 A	30-Oct-07 A
590	Elevated Floor Slab Pour - Area G	5	31-Oct-07 A	06-Nov-07 A
600	Elevated Floor Slab Rough In - Area F	3	01-Nov-07 A	05-Nov-07 A
610	Elevated Floor Slab Pour - Area F	3	06-Nov-07 A	08-Nov-07 A
3rd Floor		49	12-Jul-07 A	19-Sep-07 A
3000X	Elevated Floor Slab Rough In - 3rd Floor Area B	3	12-Jul-07 A	16-Jul-07 A
3005X	Elevated Floor Slab Pour - 3rd Floor Area B	2	16-Jul-07 A	18-Jul-07 A
3010X	Elevated Floor Slab Rough In - 3rd Floor Area A	7	09-Aug-07 A	20-Aug-07 A
3025X	Elevated Floor Slab Pour - 3rd Floor Area A	4	20-Aug-07 A	23-Aug-07 A
1056X	Elevated Floor Slab RI - 3rd Floor Snoot	6	31-Aug-07 A	11-Sep-07 A
1058	Elevated Floor Slab Pours - 3rd Floor Snoot	4	14-Sep-07 A	19-Sep-07 A
4th Floor		44	19-Jul-07 A	19-Sep-07 A
4005X	Elevated Floor Slab Rough In - 4th Floor Area B	3	19-Jul-07 A	23-Jul-07 A
4010X	Elevated Floor Slab Pour - 4th Floor Area B	3	20-Jul-07 A	24-Jul-07 A
4020X	Elevated Floor Slab Rough In - 4th Floor Area A	5	20-Aug-07 A	24-Aug-07 A
4030X	Elevated Floor Slab Pour - 4th Floor Area A	5	24-Aug-07 A	30-Aug-07 A
4040X	Elevated Floor Slab RI - 4th Floor Snoot	6	31-Aug-07 A	11-Sep-07 A
4050X	Elevated Floor Slab Pour - 4th Floor Snoot	4	14-Sep-07 A	19-Sep-07 A
5th Floor		42	12-Jul-07 A	10-Sep-07 A
5005X	Elevated Floor Slab Rough In - 5th Floor Area B	6	12-Jul-07 A	20-Jul-07 A
5010X	Elevated Floor Slab Pour - 5th Floor Area B	3	25-Jul-07 A	27-Jul-07 A
5020X	Elev Flr Slab Rough In - 5th Flr Area A & Snoot	5	27-Aug-07 A	31-Aug-07 A
5030X	Elev Flr Slab Pour - 5th Flr Area A & Snoot	5	04-Sep-07 A	10-Sep-07 A
Roof		55	30-Jul-07 A	15-Oct-07 A
6005X	Elevated Roof Slab Rough in - Area B	5	30-Jul-07 A	03-Aug-07 A
6010X	Elevated Roof Slab Pour - Area B	10	06-Aug-07 A	17-Aug-07 A
6015X	Elevated Roof Slab Rough in - Area A & Snoot	4	04-Sep-07 A	07-Sep-07 A
6020X	Elevated Roof Slab Pour - Area A & Snoot	5	07-Sep-07 A	13-Sep-07 A
550	Elevated Roof Slab Rough In - Area D & C 3rd Flr	3	08-Oct-07 A	10-Oct-07 A
575	Elevated Roof Slab Pour - Area D & C - 3rd Flr	3	11-Oct-07 A	15-Oct-07 A
Setting AHUs on A & B Roof		205	03-Sep-07 A	20-Jun-08 A
6040	Area B Concrete Curb	7	03-Sep-07 A	13-Sep-07 A
6140	Center Pipe Racks	1	05-Oct-07 A	05-Oct-07 A
6130	Erect Center Steel	2	08-Oct-07 A	09-Oct-07 A
6050	Finish Area A Concrete Curb	9	10-Oct-07 A	22-Oct-07 A
60A40	Erect Penthouse Steel Less Penthouse Floor Deck	7	10-Oct-07 A	18-Oct-07 A
6120	Install Center Pipe Racks	4	22-Oct-07 A	26-Oct-07 A
59AB	Deliver Penthouse Air Handling Units	1	01-Nov-07 A	01-Nov-07 A
6060	Resinous Waterproofing	9	05-Nov-07 A	16-Nov-07 A
6090	Complete Conduit RI	60	13-Nov-07 A	08-Feb-08 A
6070	Install Penthouse Ductwork	11	28-Nov-07 A	12-Dec-07 A
60A10	Erect AHU Support Steel	13	03-Dec-07 A	19-Dec-07 A
6080	Set Penthouse Pipe Racks	3	07-Dec-07 A	11-Dec-07 A



Act ID	Activity Name	Orig Dur	Start	Finish
6100	Coil Piping	93	13-Dec-07 A	23-Apr-08 A
6110	Complete Conduit RI	11	13-Dec-07 A	07-Jan-08 A
60A50	Finish Penthouse Floor Deck	6	19-Dec-07 A	27-Dec-07 A
60B	Set Area B Penthouse Air Handling Unit	18	24-Dec-07 A	28-Jan-08 A
6025	Elevated Floor Slab Roughin - Mech. Penthouse	21	28-Dec-07 A	28-Jan-08 A
60A	Set Area A Penthouse Air Handling Unit	15	28-Dec-07 A	28-Jan-08 A
6036	AHU A & B Repairs and Testing	62	01-Jan-08 A	27-Mar-08 A
6030	Elevated Floor Slab Pour - Mech. Penthouse	3	29-Jan-08 A	31-Jan-08 A
6055	AHU Framing and Sheathing	45	03-Mar-08 A	02-May-08 A
6035	Penthouse Roof	2	14-Mar-08 A	17-Mar-08 A
6085	Install Steam & Condensate Piping & Misc. Pipe	30	23-Apr-08 A	04-Jun-08 A
6075	Penthouse/AHU Siding	39	28-Apr-08 A	20-Jun-08 A
6065	AHU Roof	4	05-May-08 A	08-May-08 A
6095	Install Louvers at AHUs	10	21-May-08 A	04-Jun-08 A
Exteriors & Roof		198	24-Mar-08 A	02-Jan-09
SE Elevation & Beacon (Patient Tower)		198	24-Mar-08 A	02-Jan-09
SE-19	Install Waterproofing (MB-1), SE Elev	36	24-Mar-08 A	14-May-08 A
SE-39	Install Brick, SE Elev	39	27-Mar-08 A	20-May-08 A
SE-19a	Remove Exterior Scaffold, SE to NE	7	10-May-08 A	20-May-08 A
SE-29	Wash Exterior from Swing Stage, SE Elev	11	14-May-08 A	30-May-08 A
SE-20	Install Punch Windows, SE Elev	34	24-May-08 A	09-Jul-08 A
SE-49	Install louvers, SE Elev	2	09-Jun-08 A	11-Jun-08 A
SE-10	Flashing and Sheet Metal, SE Elev	14	17-Jun-08 A	03-Jul-08 A
SE-12	Caulking, SE Elev	5	09-Jul-08 A	14-Jul-08 A
SE-50	Install SE Ribbon Windows	24	26-Aug-08 A	01-Oct-08 A
SE-22	Punch Out Exterior, SE Elevation	10	18-Dec-08*	02-Jan-09
SW Elevation (Patient Tower)		193	24-Mar-08 A	24-Dec-08
SW-07	Install Brick, SW Elev	50	24-Mar-08 A	03-Jun-08 A
SW-22	Install Waterproofing, SW Elev	6	16-Apr-08 A	23-Apr-08 A
SW-17	Cure Brick, SW Elev	5	03-Jun-08 A	09-Jun-08 A
SW-08	Wash Exterior, SW Elev	16	04-Jun-08 A	24-Jun-08 A
SW-09	Install Punch Windows, SW Elev	19	18-Jun-08 A	11-Jul-08 A
SW-10	Flashing & Sheet Metal, SW Elev	7	26-Jun-08 A	03-Jul-08 A
SW-12	Caulking, SW Elev	10	11-Sep-08 A	23-Sep-08 A
SW-32	Punch Out Exterior, SW Elev	10	11-Dec-08 A	24-Dec-08
NW Elevation (Patient Tower)		168	26-Apr-08 A	24-Dec-08
NW-10	Install Waterproofing (MB-1), NW Elev	43	26-Apr-08 A	26-Jun-08 A
NW-60	Remove Trash Chutes, NW Elev	2	09-May-08 A	10-May-08 A
NW-20	Install Brick, NW Elev	46	13-May-08 A	15-Jul-08 A
2B5.5350	Remove Material Hoist	8	01-Jul-08 A	11-Jul-08 A
2B5.5340	Wash Exterior NW 1st Half	7	22-Jul-08 A	29-Jul-08 A
NW-100	Infill at Material Hoist & Wash Brick	35	24-Jul-08 A	27-Aug-08 A
NW-40	Install Punched Openings, NW Elev	48	29-Jul-08 A	01-Oct-08 A
NW-30	Wash Exterior, NW Elev	11	30-Jul-08 A	11-Aug-08 A
2B5.5360	Complete MB-1 & Bricking at Material Hoist	10	14-Aug-08 A	27-Aug-08 A
NW-50	Install Curtain Wall, NW Elev	65	19-Aug-08 A	13-Nov-08 A
NW-80	Caulking, NW Elev	5	01-Oct-08 A	03-Oct-08 A

ID	Task Name	Duration	Start	Finish
1	**SSM St. Clare Health Center**	**54.4 wks**	**Thu 5/10/07**	**Fri 5/23/08**
2	**Reinforced Concrete Structural System**	**54 wks**	**Thu 5/10/07**	**Wed 5/21/08**
3	**SUPPORTED SLABS ABOVE GROUND FL**	**54 wks**	**Thu 5/10/07**	**Wed 5/21/08**
4	**C1**	**2.2 wks**	**Thu 5/10/07**	**Thu 5/24/07**
5	Reinforcing Steel	7 days	Thu 5/10/07	Fri 5/18/07
6	Form	7 days	Mon 5/14/07	Tue 5/22/07
7	Pour	2 days	Wed 5/23/07	Thu 5/24/07
8	**SW1**	**2.2 wks**	**Thu 5/10/07**	**Thu 5/24/07**
9	Reinforcing Steel	4 days	Thu 5/10/07	Tue 5/15/07
10	Form	7 days	Mon 5/14/07	Tue 5/22/07
11	Pour	2 days	Wed 5/23/07	Thu 5/24/07
12	**1st Floor**	**4.8 wks**	**Fri 5/25/07**	**Wed 6/27/07**
13	**Pour Section 1**	**1.2 wks**	**Fri 5/25/07**	**Fri 6/1/07**
14	Form	4 days	Fri 5/25/07	Wed 5/30/07
15	Reinforcing Steel	2 days	Wed 5/30/07	Thu 5/31/07
16	MEP	1 day	Wed 5/30/07	Wed 5/30/07
17	Place Concrete	1 day	Fri 6/1/07	Fri 6/1/07
18	**Pour Section 2**	**1.2 wks**	**Mon 6/4/07**	**Mon 6/11/07**
19	Form	4 days	Mon 6/4/07	Thu 6/7/07
20	Reinforcing Steel	2 days	Thu 6/7/07	Fri 6/8/07
21	MEP	1 day	Thu 6/7/07	Thu 6/7/07
22	Place Concrete	1 day	Mon 6/11/07	Mon 6/11/07
23	**Pour Section 3**	**1.2 wks**	**Tue 6/12/07**	**Tue 6/19/07**
24	Form	4 days	Tue 6/12/07	Fri 6/15/07
25	Reinforcing Steel	2 days	Fri 6/15/07	Mon 6/18/07
26	MEP	1 day	Fri 6/15/07	Fri 6/15/07
27	Place Concrete	1 day	Tue 6/19/07	Tue 6/19/07
28	**Pour Section 4**	**1.2 wks**	**Wed 6/20/07**	**Wed 6/27/07**
29	Form	4 days	Wed 6/20/07	Mon 6/25/07
30	Reinforcing Steel	2 days	Mon 6/25/07	Tue 6/26/07
31	MEP	1 day	Mon 6/25/07	Mon 6/25/07
32	Place Concrete	1 day	Wed 6/27/07	Wed 6/27/07
33	**C2**	**2.2 wks**	**Thu 6/28/07**	**Thu 7/12/07**
34	Reinforcing Steel	7 days	Thu 6/28/07	Fri 7/6/07
35	Form	7 days	Mon 7/2/07	Tue 7/10/07
36	Pour	2 days	Wed 7/11/07	Thu 7/12/07
37	**SW2**	**2.2 wks**	**Thu 6/28/07**	**Thu 7/12/07**
38	Reinforcing Steel	4 days	Thu 6/28/07	Tue 7/3/07
39	Form	7 days	Mon 7/2/07	Tue 7/10/07
40	Pour	2 days	Wed 7/11/07	Thu 7/12/07
41	**2nd Floor**	**4.4 wks**	**Fri 7/13/07**	**Mon 8/13/07**
42	**Pour Section 1**	**1.2 wks**	**Fri 7/13/07**	**Fri 7/20/07**
43	Form	4 days	Fri 7/13/07	Wed 7/18/07
44	Reinforcing Steel	2 days	Wed 7/18/07	Thu 7/19/07
45	MEP	1 day	Wed 7/18/07	Wed 7/18/07
46	Place Concrete	1 day	Fri 7/20/07	Fri 7/20/07
47	**Pour Section 2**	**1.2 wks**	**Mon 7/23/07**	**Mon 7/30/07**
48	Form	4 days	Mon 7/23/07	Thu 7/26/07
49	Reinforcing Steel	2 days	Thu 7/26/07	Fri 7/27/07
50	MEP	1 day	Thu 7/26/07	Thu 7/26/07
51	Place Concrete	1 day	Mon 7/30/07	Mon 7/30/07
52	**Pour Section 3**	**1.2 wks**	**Tue 7/31/07**	**Tue 8/7/07**
53	Form	4 days	Tue 7/31/07	Fri 8/3/07
54	Reinforcing Steel	2 days	Fri 8/3/07	Mon 8/6/07



Project: SSM St. Clare_TEST.mpp
Date: Mon 4/6/15

Task | Task Progress | Critical Task | Critical Task Progress | Milestone | Summary | Rolled Up Task | Rolled Up Critical Task | Rolled Up Milestone | Rolled Up Progress | Split | External Tasks | Project Summary | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only

ID	Task Name	Duration	Start	Finish
55	MEP	1 day	Fri 8/3/07	Fri 8/3/07
56	Place Concrete	1 day	Tue 8/7/07	Tue 8/7/07
57	**Pour Section 4**	**1 wk**	**Tue 8/7/07**	**Mon 8/13/07**
58	Form	4 days	Wed 8/8/07	Mon 8/13/07
59	Reinforcing Steel	2 days	Tue 8/7/07	Wed 8/8/07
60	MEP	1 day	Tue 8/7/07	Tue 8/7/07
61	Place Concrete	1 day	Thu 8/9/07	Thu 8/9/07
62	**C3**	**2.2 wks**	**Fri 8/10/07**	**Fri 8/24/07**
63	Reinforcing Steel	7 days	Fri 8/10/07	Mon 8/20/07
64	Form	7 days	Tue 8/14/07	Wed 8/22/07
65	Pour	2 days	Thu 8/23/07	Fri 8/24/07
66	**SW3**	**2.2 wks**	**Fri 8/10/07**	**Fri 8/24/07**
67	Reinforcing Steel	4 days	Fri 8/10/07	Wed 8/15/07
68	Form	7 days	Tue 8/14/07	Wed 8/22/07
69	Pour	2 days	Thu 8/23/07	Fri 8/24/07
70	**3rd Floor**	**4.4 wks**	**Mon 8/27/07**	**Tue 9/25/07**
71	**Pour Section 1**	**1.2 wks**	**Mon 8/27/07**	**Mon 9/3/07**
72	Form	4 days	Mon 8/27/07	Thu 8/30/07
73	Reinforcing Steel	2 days	Thu 8/30/07	Fri 8/31/07
74	MEP	1 day	Thu 8/30/07	Thu 8/30/07
75	Place Concrete	1 day	Mon 9/3/07	Mon 9/3/07
76	**Pour Section 2**	**1.2 wks**	**Tue 9/4/07**	**Tue 9/11/07**
77	Form	4 days	Tue 9/4/07	Fri 9/7/07
78	Reinforcing Steel	2 days	Fri 9/7/07	Mon 9/10/07
79	MEP	1 day	Fri 9/7/07	Fri 9/7/07
80	Place Concrete	1 day	Tue 9/11/07	Tue 9/11/07
81	**Pour Section 3**	**1.2 wks**	**Wed 9/12/07**	**Wed 9/19/07**
82	Form	4 days	Wed 9/12/07	Mon 9/17/07
83	Reinforcing Steel	2 days	Mon 9/17/07	Tue 9/18/07
84	MEP	1 day	Mon 9/17/07	Mon 9/17/07
85	Place Concrete	1 day	Wed 9/19/07	Wed 9/19/07
86	**Pour Section 4**	**1 wk**	**Wed 9/19/07**	**Tue 9/25/07**
87	Form	4 days	Thu 9/20/07	Tue 9/25/07
88	Reinforcing Steel	2 days	Wed 9/19/07	Thu 9/20/07
89	MEP	1 day	Wed 9/19/07	Wed 9/19/07
90	Place Concrete	1 day	Fri 9/21/07	Fri 9/21/07
91	**C4**	**2.2 wks**	**Mon 9/24/07**	**Mon 10/8/07**
92	Reinforcing Steel	7 days	Mon 9/24/07	Tue 10/2/07
93	Form	7 days	Wed 9/26/07	Thu 10/4/07
94	Pour	2 days	Fri 10/5/07	Mon 10/8/07
95	**SW4**	**2.2 wks**	**Mon 9/24/07**	**Mon 10/8/07**
96	Reinforcing Steel	4 days	Mon 9/24/07	Thu 9/27/07
97	Form	7 days	Wed 9/26/07	Thu 10/4/07
98	Pour	2 days	Fri 10/5/07	Mon 10/8/07
99	**4th Floor**	**4.4 wks**	**Tue 10/9/07**	**Wed 11/7/07**
100	**Pour Section 1**	**1.2 wks**	**Tue 10/9/07**	**Tue 10/16/07**
101	Form	4 days	Tue 10/9/07	Fri 10/12/07
102	Reinforcing Steel	2 days	Fri 10/12/07	Mon 10/15/07
103	MEP	1 day	Fri 10/12/07	Fri 10/12/07
104	Place Concrete	1 day	Tue 10/16/07	Tue 10/16/07
105	**Pour Section 2**	**1.2 wks**	**Wed 10/17/07**	**Wed 10/24/07**
106	Form	4 days	Wed 10/17/07	Mon 10/22/07
107	Reinforcing Steel	2 days	Mon 10/22/07	Tue 10/23/07
108	MEP	1 day	Mon 10/22/07	Mon 10/22/07

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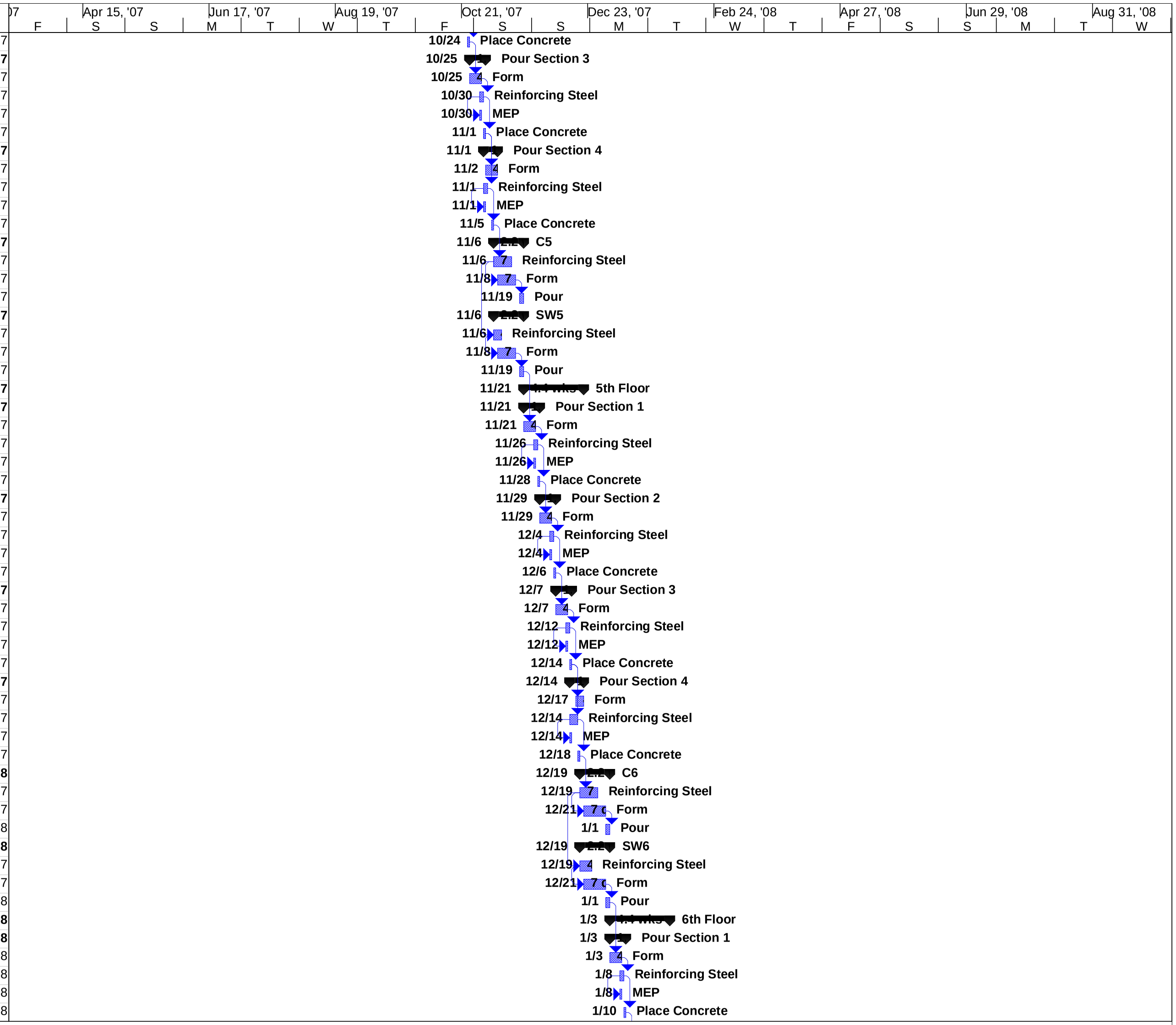
Date: Mon 4/6/15

Task	Summary	Split	Inactive Summary
Task Progress	Rolled Up Task	External Tasks	Manual Task
Critical Task	Rolled Up Critical Task	Project Summary	Duration-only
Critical Task Progress	Rolled Up Milestone	Inactive Task	Manual Summary Rollup
Milestone	Rolled Up Progress	Inactive Milestone	Manual Summary
Start-only	Finish-only		

ID	Task Name	Duration	Start	Finish
109	Place Concrete	1 day	Wed 10/24/07	Wed 10/24/07
110	**Pour Section 3**	**1.2 wks**	**Thu 10/25/07**	**Thu 11/1/07**
111	Form	4 days	Thu 10/25/07	Tue 10/30/07
112	Reinforcing Steel	2 days	Tue 10/30/07	Wed 10/31/07
113	MEP	1 day	Tue 10/30/07	Tue 10/30/07
114	Place Concrete	1 day	Thu 11/1/07	Thu 11/1/07
115	**Pour Section 4**	**1 wk**	**Thu 11/1/07**	**Wed 11/7/07**
116	Form	4 days	Fri 11/2/07	Wed 11/7/07
117	Reinforcing Steel	2 days	Thu 11/1/07	Fri 11/2/07
118	MEP	1 day	Thu 11/1/07	Thu 11/1/07
119	Place Concrete	1 day	Mon 11/5/07	Mon 11/5/07
120	**C5**	**2.2 wks**	**Tue 11/6/07**	**Tue 11/20/07**
121	Reinforcing Steel	7 days	Tue 11/6/07	Wed 11/14/07
122	Form	7 days	Thu 11/8/07	Fri 11/16/07
123	Pour	2 days	Mon 11/19/07	Tue 11/20/07
124	**SW5**	**2.2 wks**	**Tue 11/6/07**	**Tue 11/20/07**
125	Reinforcing Steel	4 days	Tue 11/6/07	Fri 11/9/07
126	Form	7 days	Thu 11/8/07	Fri 11/16/07
127	Pour	2 days	Mon 11/19/07	Tue 11/20/07
128	**5th Floor**	**4.4 wks**	**Wed 11/21/07**	**Thu 12/20/07**
129	**Pour Section 1**	**1.2 wks**	**Wed 11/21/07**	**Wed 11/28/07**
130	Form	4 days	Wed 11/21/07	Mon 11/26/07
131	Reinforcing Steel	2 days	Mon 11/26/07	Tue 11/27/07
132	MEP	1 day	Mon 11/26/07	Mon 11/26/07
133	Place Concrete	1 day	Wed 11/28/07	Wed 11/28/07
134	**Pour Section 2**	**1.2 wks**	**Thu 11/29/07**	**Thu 12/6/07**
135	Form	4 days	Thu 11/29/07	Tue 12/4/07
136	Reinforcing Steel	2 days	Tue 12/4/07	Wed 12/5/07
137	MEP	1 day	Tue 12/4/07	Tue 12/4/07
138	Place Concrete	1 day	Thu 12/6/07	Thu 12/6/07
139	**Pour Section 3**	**1.2 wks**	**Fri 12/7/07**	**Fri 12/14/07**
140	Form	4 days	Fri 12/7/07	Wed 12/12/07
141	Reinforcing Steel	2 days	Wed 12/12/07	Thu 12/13/07
142	MEP	1 day	Wed 12/12/07	Wed 12/12/07
143	Place Concrete	1 day	Fri 12/14/07	Fri 12/14/07
144	**Pour Section 4**	**1 wk**	**Fri 12/14/07**	**Thu 12/20/07**
145	Form	4 days	Mon 12/17/07	Thu 12/20/07
146	Reinforcing Steel	2 days	Fri 12/14/07	Mon 12/17/07
147	MEP	1 day	Fri 12/14/07	Fri 12/14/07
148	Place Concrete	1 day	Tue 12/18/07	Tue 12/18/07
149	**C6**	**2.2 wks**	**Wed 12/19/07**	**Wed 1/2/08**
150	Reinforcing Steel	7 days	Wed 12/19/07	Thu 12/27/07
151	Form	7 days	Fri 12/21/07	Mon 12/31/07
152	Pour	2 days	Tue 1/1/08	Wed 1/2/08
153	**SW6**	**2.2 wks**	**Wed 12/19/07**	**Wed 1/2/08**
154	Reinforcing Steel	4 days	Wed 12/19/07	Mon 12/24/07
155	Form	7 days	Fri 12/21/07	Mon 12/31/07
156	Pour	2 days	Tue 1/1/08	Wed 1/2/08
157	**6th Floor**	**4.4 wks**	**Thu 1/3/08**	**Fri 2/1/08**
158	**Pour Section 1**	**1.2 wks**	**Thu 1/3/08**	**Thu 1/10/08**
159	Form	4 days	Thu 1/3/08	Tue 1/8/08
160	Reinforcing Steel	2 days	Tue 1/8/08	Wed 1/9/08
161	MEP	1 day	Tue 1/8/08	Tue 1/8/08
162	Place Concrete	1 day	Thu 1/10/08	Thu 1/10/08



Project: SSM St. Clare_TEST.mpp
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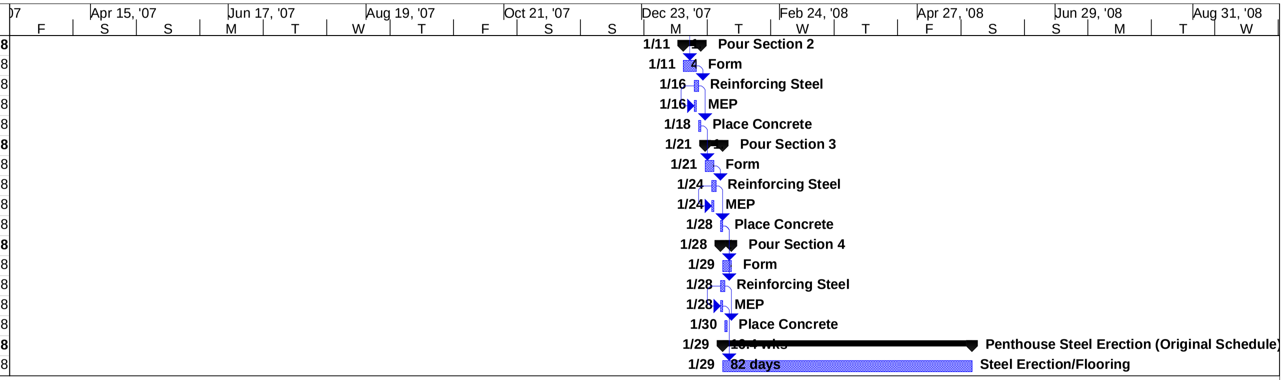
Task		Summary		Split		Inactive Summary		Start-only	
Task Progress		Rolled Up Task		External Tasks		Manual Task		Finish-only	
Critical Task		Rolled Up Critical Task		Project Summary		Duration-only			
Critical Task Progress		Rolled Up Milestone		Inactive Task		Manual Summary Rollup			
Milestone		Rolled Up Progress		Inactive Milestone		Manual Summary			

ID	Task Name	Duration	Start	Finish
163	**Pour Section 2**	**1.2 wks**	**Fri 1/11/08**	**Fri 1/18/08**
164	Form	4 days	Fri 1/11/08	Wed 1/16/08
165	Reinforcing Steel	2 days	Wed 1/16/08	Thu 1/17/08
166	MEP	1 day	Wed 1/16/08	Wed 1/16/08
167	Place Concrete	1 day	Fri 1/18/08	Fri 1/18/08
168	**Pour Section 3**	**1.2 wks**	**Mon 1/21/08**	**Mon 1/28/08**
169	Form	4 days	Mon 1/21/08	Thu 1/24/08
170	Reinforcing Steel	2 days	Thu 1/24/08	Fri 1/25/08
171	MEP	1 day	Thu 1/24/08	Thu 1/24/08
172	Place Concrete	1 day	Mon 1/28/08	Mon 1/28/08
173	**Pour Section 4**	**1 wk**	**Mon 1/28/08**	**Fri 2/1/08**
174	Form	4 days	Tue 1/29/08	Fri 2/1/08
175	Reinforcing Steel	2 days	Mon 1/28/08	Tue 1/29/08
176	MEP	1 day	Mon 1/28/08	Mon 1/28/08
177	Place Concrete	1 day	Wed 1/30/08	Wed 1/30/08
178	**Penthouse Steel Erection (Original Schedule)**	**16.4 wks**	**Tue 1/29/08**	**Wed 5/21/08**
179	Steel Erection/Flooring	82 days	Tue 1/29/08	Wed 5/21/08



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Task		Summary		Split		Inactive Summary		Start-only	
Task Progress		Rolled Up Task		External Tasks		Manual Task		Finish-only	
Critical Task		Rolled Up Critical Task		Project Summary		Duration-only			
Critical Task Progress		Rolled Up Milestone		Inactive Task		Manual Summary Rollup			
Milestone		Rolled Up Progress		Inactive Milestone		Manual Summary			

Appendix C

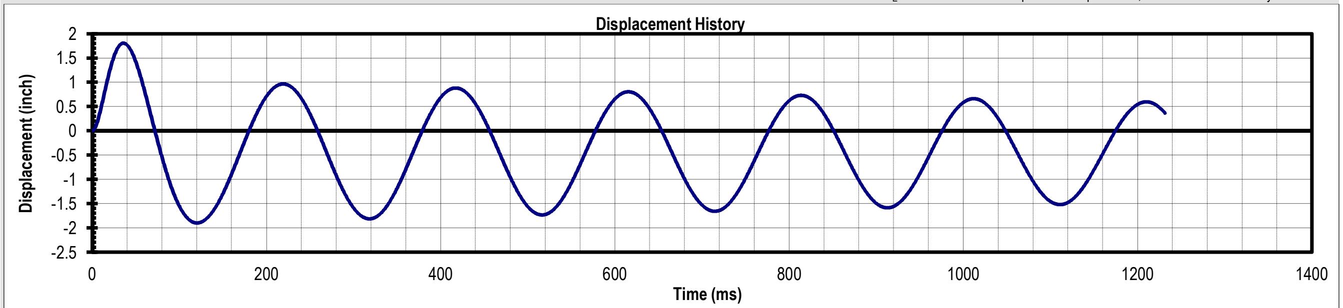
Landscape Architecture Breadth References

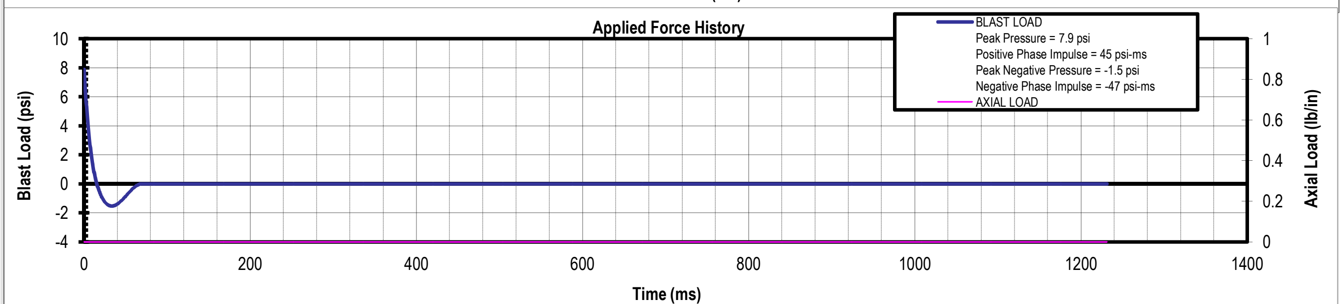
Metal Stud Wall

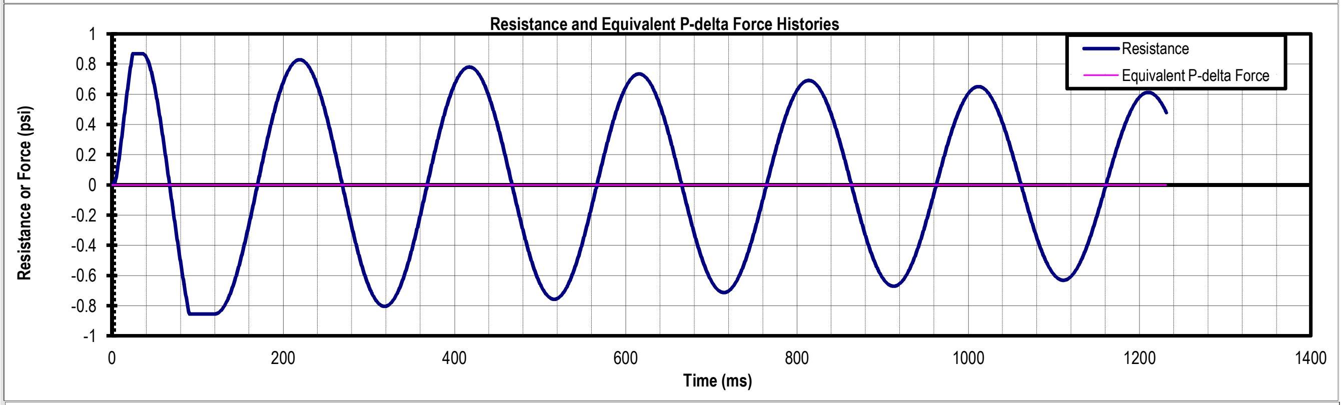
Results Summary					
θ_{max} =	-1.1	deg.			
μ =	1.31				
X_{max} =	1.80	in	at time =	35.70	msec
X_{min} =	-1.90	in	at time =	120.12	msec
R_{max} =	0.87	psi	at time =	24.36	msec
R_{min} =	-0.85	psi	at time =	120.12	msec

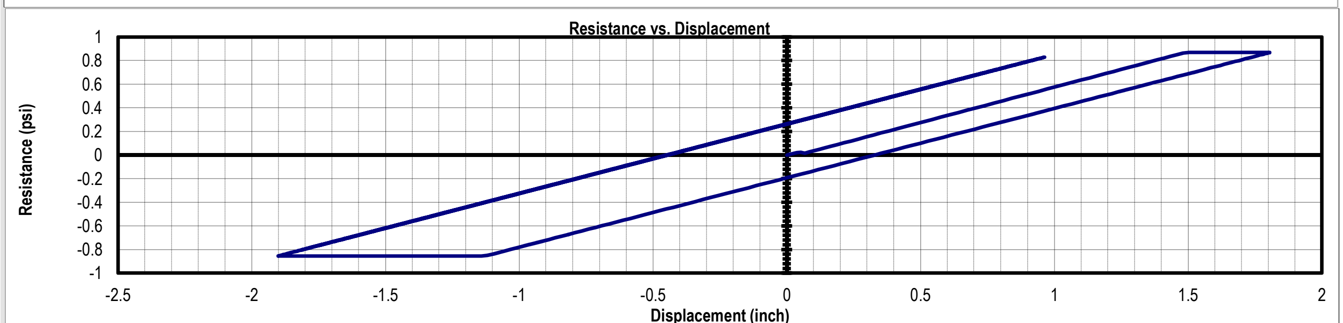
Peak Dynamic Reactions		
$V_{max,Long}$ =	0.87	psi
$V_{max,Short}$ =	0.00	psi
Strain Rate to Yield*		
Strain Rate	0.064	1/ sec

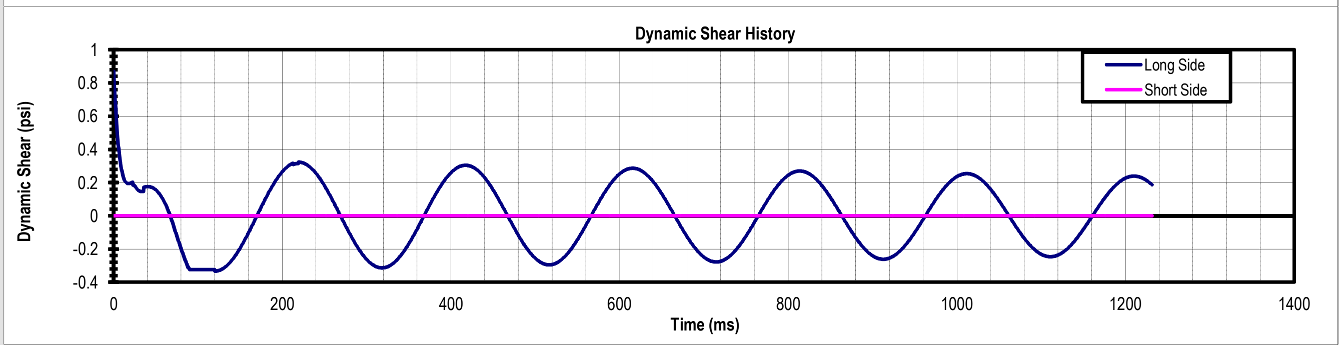
*Yield when deflection=X_E at bottom of SDOF Properties on Input Sheet, or max. deflection if no yield











Curriculum Vitae:

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State College, PA 16801

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North Royalton, OH 44133

OBJECTIVE

Student pursuing an integrated Bachelor's and Master's degree in Architectural Engineering with a focus in structural design and building technologies. Interests include BIM/Lean process and force protection design.

EDUCATION

The Pennsylvania State University — **University Park, PA**

The Schreyer Honors College — *Anticipated May 2015*

College of Engineering

- B.A.E/M.A.E integrated master's program in Architectural Engineering with Structural Option
- Skilled in RAM, RISA, ETABS, SAP2000, and Revit; proficient in Abaqus simulation

Pantheon Institute — **Rome, Italy**

Architectural Engineering Student — *Summer 2013*

- Architectural Studies minor over 8 week program

EXPERIENCE

HGA Architects and Engineers — **Minneapolis, MN**

Structural Department Intern — *May 2014-August 2014*

- Performed steel and concrete design, truss optimizations
- Investigated modeling techniques for semi-rigid diaphragms in RAM SS.
- Created BIM action item database for use firm-wide.

Maclean-Fogg Component Solutions — **Mundelein, IL**

Operational Transformation Intern — *May 2011-August 2011, May 2012-August 2012*

- Traveled to company locations in IL, AR, and MI to advise on Lean management best-practices
- Led implementation teams to standardize processes
- Led teams of temporary workers on facility improvement projects

Maclean-Fogg Component Solutions — **Mundelein, IL**

Engineering Team Intern — *May 2010-August 2010*

PUBLICATIONS AND PRESENTATIONS

Publications

- "Overview of Lamellar Tearing Failures and Representative Case Studies" Failures Wiki (2014)

Presentations

- Collaborative (BIM) Studio Design Presentation (Spring 2014)
- EDSGN 100 Hydrogen City, Section Winners Board Presentation (Fall 2010)

AWARDS

- Melvin H. Peters Endowed Scholarship
- Robert J. McNamara Scholarship
- William and Wyllis Leonhard Scholarship
- Academic Excellence Scholarship

ASSOCIATIONS

- Member of American Institute of Steel Construction (AISC)
- Member of Penn State Structural Engineers Association
- Eagle Scout, Boy Scouts of America

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