THESIS FINAL REPORT

Aubert Ndjolba | Structural Option

PENN COLLEGE OF TECHNOLOGY

Faculty advisor: Dr. Boothby

Date: 04/04/12

DAUPHIN HALL
PENN COLLEGE OF TECHNOLOGY,WILLIAMSPORT, PA

PROJECT OVERVIEW

- Owner: Penn College of Technology
- General Contractor: IMC Construction, Inc
- Architect: Murray Associates Architects, PC
- Civil: Vassallo Engineering & Surveying
- Structural: Whitney, Bailey, Cox & Magnani, LLC
- MEP: Gatter & Diehl, INC
- Total Height: 70'-6"
- Size: 123,676 GSF
- Cost: $ 26,000,000
- Duration: October 2008—August 2010

ARCHITECTURE

- Building façade is composed of 4" split-face blocks.
- The windows are fixed prefinished aluminum units with insulated glass.
- The curtain wall are made of aluminum mullion with 1" insulated tempered safety glass.

STRUCTURAL SYSTEMS

- The foundation is composed of shallow foundations and stone piers (18"-36" dia.)
- The structure is mainly steel framing with moment bracing:
  - Columns: W8 and W10
  - Beams: W14 and W12
- Slab: 4" concrete slab reinforced with 6"x6" - W2.9XW2.9 WWM on 1 1/2 –20 gage composite deck.

MEP SYSTEMS

- Variable Air Volume System (VAV) provides temperature control of multiple comfort zones through the use of a constant volume single-zone HVAC unit.
- Ceiling mounted voltage occupancy sensors with emergency standby generator.
- Uses fluorescent, Metal-halide & LED lights
- Wet pipe sprinkler system.

AUBERT NDJOLBA

ARCHITECTURAL ENGINEERING | STRUCTURAL OPTION

http://www.engr.psu.edu/ae/thesis/portfolios/2011/amn184/index.html

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ACKNOWLEDGEMENT

I would like to thank the following companies and individuals for their expertise and guidance throughout this report:

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Professor Robert Holland

Professor M. Kevin Parfitt

I dedicated this thesis to my friends and family who have supported and encouraged me every step of the way.

EXECUTIVE SUMMARY

Located in Williamsport, Pennsylvania, The Dauphin Hall (DH) is 70 feet high, 210 feet wide and 316 feet long. This 4 story student housing, completed in August, 2010, has a gravity system consisting of lightweight concrete on metal deck, non-loadbearing Concrete Masonry Unit (CMU) walls, and open web bar joists. The lateral resisting system of the DH consists of moment frames in both the East-West and North-South direction.

The overall focus of this report was to investigate the feasibility of utilizing reinforced masonry loadbearing wall structure over the existing steel moment frame design. The secondary focus was to include the effects on the structure caused by the addition of three stories to the existing system. From this report, it was determined that 8” x 4’-0” precast hollow core planks with 2” normal weight concrete topping would be adequate for the floor and roof design. High strength (6000 psi) 8” concrete masonry reinforced at 16” on center vertically would provide sufficient lateral support against the lateral forces experienced by the building. Therefore, no horizontal shear reinforcement is needed.

To compare the effects of these changes on the structure, a cost and schedule analysis for both systems were performed. It was determined that the proposed design cost less than the existing structure when taking into account only four stories of the proposed design. However with the addition of three floors, the total project cost was determined to be $ 3,683,935.36, which is approximately $ 1,133,151.84 additional, compared to the existing system. The estimated project length was calculated to determine which project has a longer time frame since both construction processes involve different tasks. For the existing structure, it was estimated that it would take 377.52 days for the completion of the structural system as compared to 537.88 days for the proposed system when taking into account the additional three floors.

In addition to the construction management breadth, the floor plans of the existing system were altered as part of the architectural breadth. This alteration was necessary to allow a proper redistribution of the loads to the shear walls and to the foundation. Most of the rooms were changed or relocated to promote student collaboration and a better integration of the structural and architectural aspects of the building. It was found that the proposed building provides a total amount of 124 additional student rooms as compared to the existing.

BUILDING INTRODUCTION

In August of 2010, the Pennsylvania College of Technology, located Williamsport, PA, had decided to build a new structure in the 200 block of Rose Street. This new addition, Dauphin Hall, was constructed in the North-East of the campus where most of the dormitories are located. It was a result of the collaboration between Murray Associates Architects, P.C; IMC as the general contractor; Woodburn & Associates, INC as the food service designer; Whitney, Bailey, Cox & Magnani, LLC as the civil engineering firm; and Gatter & Diehl, INC as the MEP firm. Using the design-bid-build project delivery method, this new addition costs approximately $ 26,000,000.

Figure 1: Building bird's view (Courtesy of bing.com)

At approximately 123,676 GSF, this latest addition to the student housing stands at 70 feet tall and provides 268 students with suites and single room configurations. A 40-50 student seating commons enclosed with glass provides a social space for student collaboration. Located within the dormitory are other amenities such as: a 460 seat dining room, two private dining rooms for faculties, a 40 station satellite fitness center, two large leisure rooms, a student grocery store, laundry facilities, student mail boxes, Resident Life Offices, campus police office, and a Hall Coordinator apartment.

Figure 2: South Façade

Figure 3: South Façade

Figure 4: North/East Façade

EXISTING STRUCTURAL OVERVIEW

The structure of the DH is a combination of shallow foundation and stone piers, and composite steel decking with steel framing. The exterior and interior walls are composed primarily of masonry clay brick partitions and non-loadbearing concrete masonry units with a brick veneer façade.

FOUNDATION SYSTEM

According to the geotechnical report provided by CMT Laboratories, Inc, the soil conditions on the site can be described as “filled with brown silty clay, and brown silty sand with gravel”. In addition, it was found that the cohesive alluvial soils beneath the fill materials have low shear strength.

In light of these conditions, the conventional spread/column and continuous footing foundations will not provide adequate bearing capacity to support the building. Deep foundations such as concrete filled tapered piles could support the structure but are not the most economical approach. Therefore, a practical solution is subsurface improvement with the use of shallow foundation. The most technically sound and economically feasible method was to use stone piers typically in the range of 18 inches to 36 inches in diameter depending on their loading and settlement criteria.

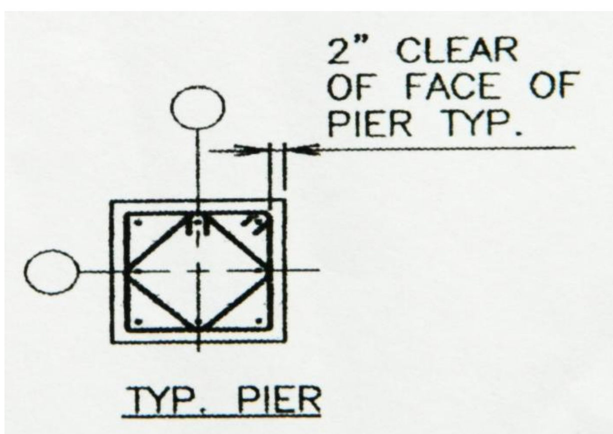


Figure 5: Typical Pier Detail

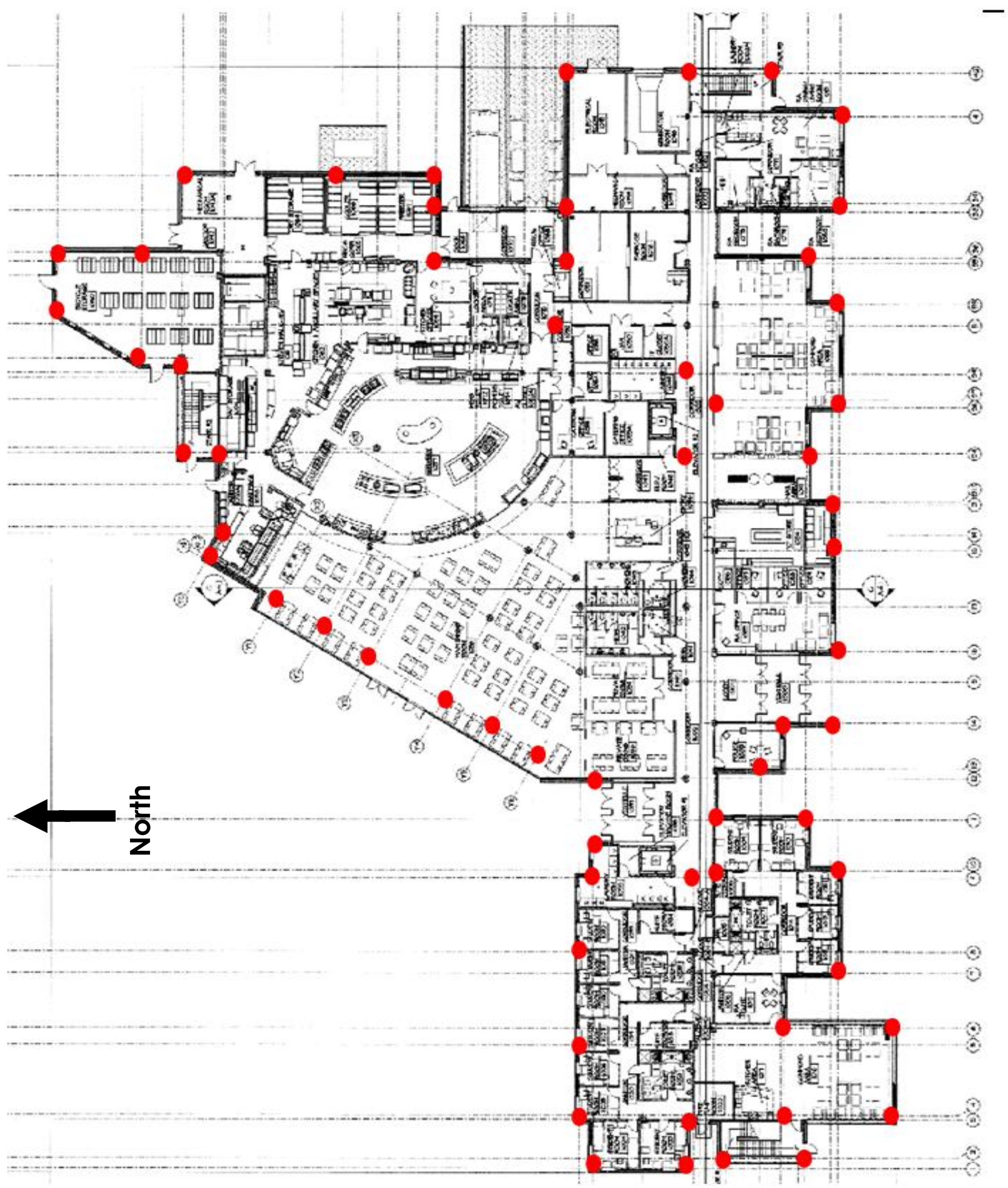


Figure 6: Typical Pier Location in the Building

FLOOR SYSTEM

With a typical span of 25 feet, the floor system of the DH is composed of 4" Light weight concrete slab, reinforced with 6"×6" –W2.9×W2.9 welded wire mesh, on 1 ½" - 20 gage Vulcraft composite deck. Shear studs were not used. The K-series open web bar joists supporting the floor system are spaced equally in column bays with a maximum spacing of 2'-0" O.C in areas of floor framing.

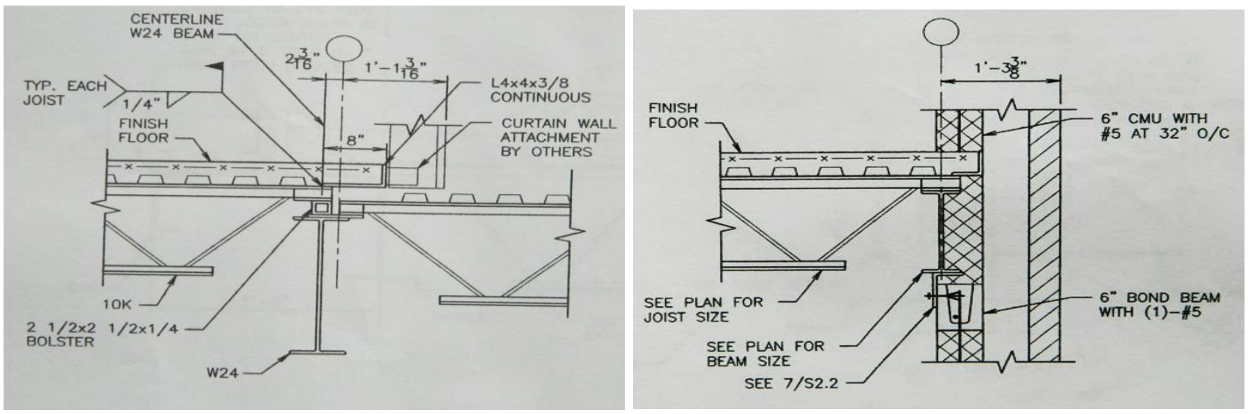


Figure 7: Typical Floor Section Showing Beam and Column interaction

FRAMING SYSTEM

The superstructure of the DH is primarily a combination of K-series joists, W24 girders, steel columns raging in size from W8's to W10's, and light gage metal framing. The K-series open web bar joists are spaced 2'-0" on O.C. The columns are typically on a 25'x30' grid and encased by 5/8" Gypsum board or 6" painted CMU. HSS columns were used in locations near the stairwells. Aside from those used in the lateral system, most of the columns are connected to beams and girders using pinned connections. Interior partitions consist of non-loadbearing clay masonry units.

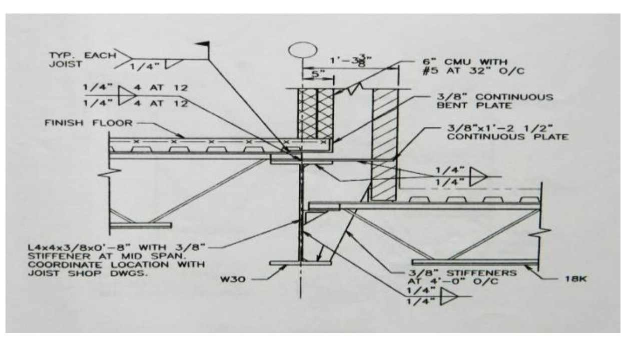


Figure 8: Joists and Beam Interaction

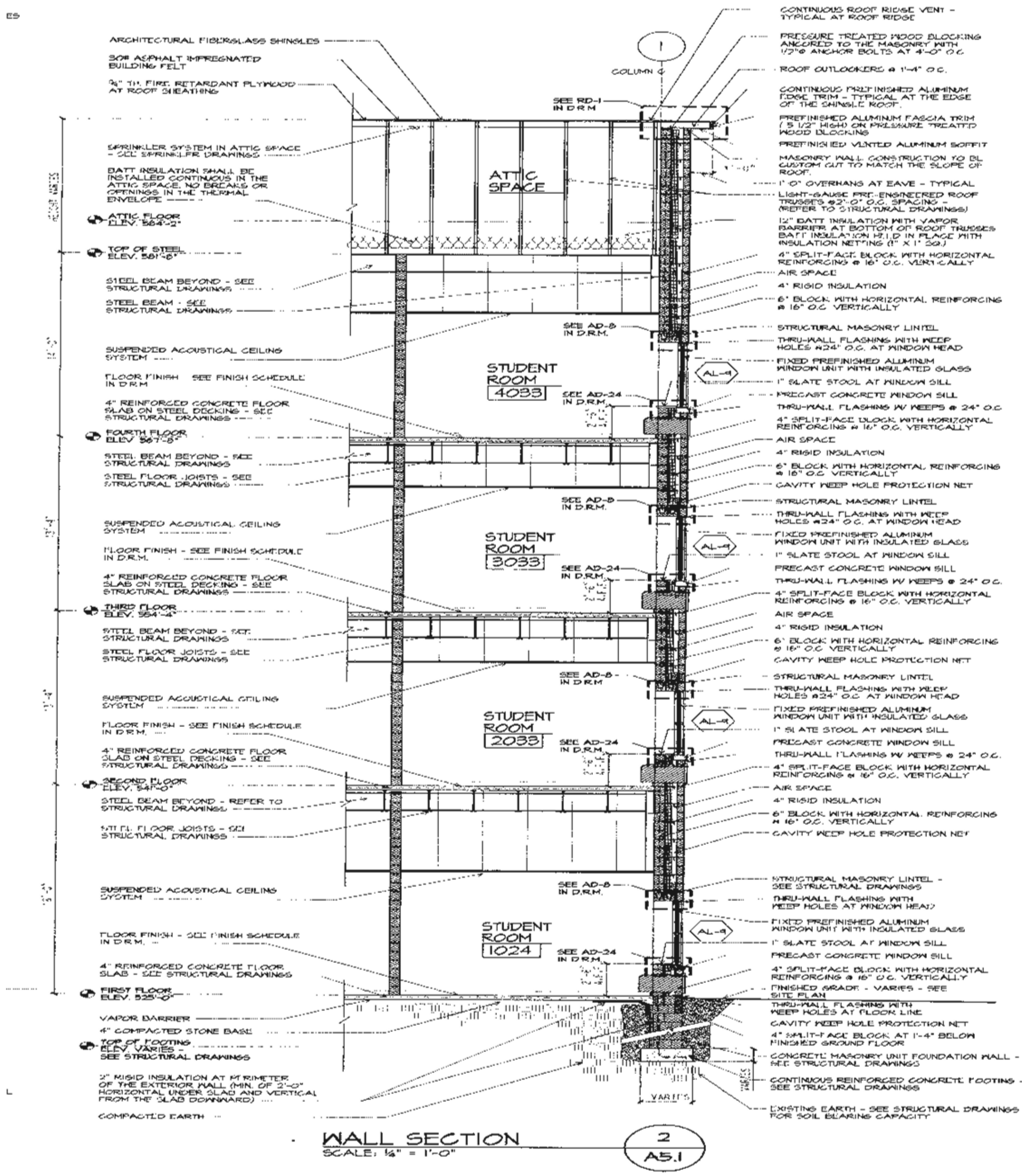
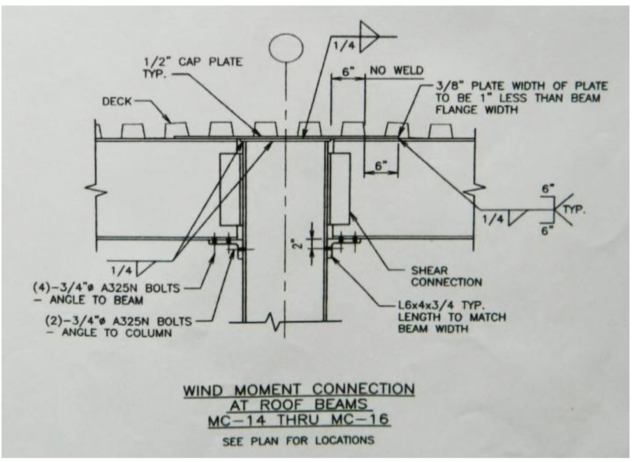


Figure 9: Typical Wall Section

LATERAL SYSTEM

Lateral loads are transmitted through the structure primarily through the use of a series of special moment frames. There are 11 special moment frames running in the North-South, and 11 running in the East-West direction. At the termination of these moment frames, shear connections were added to tie the beam webs to the column flanges.



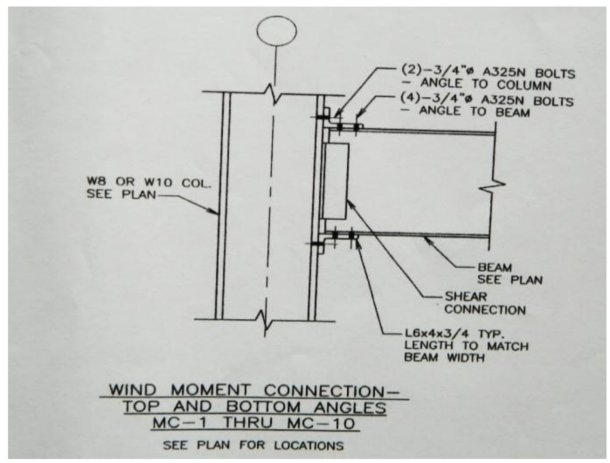


Figure 10: Typical Moment Connections

Figure 11 shows the location of the lateral resisting systems in both transverse and longitudinal direction with the moment connections at the end of each member.

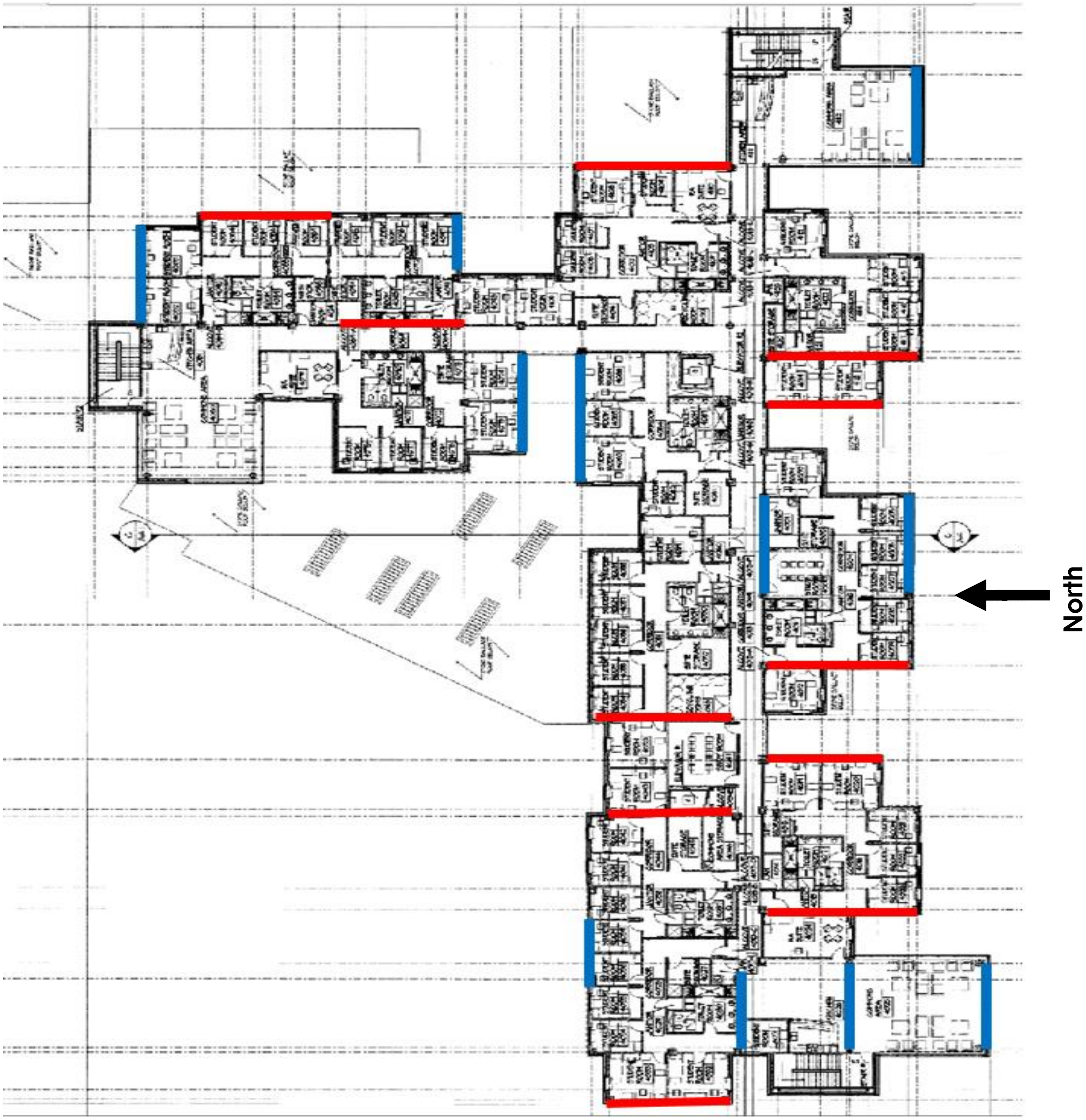


Figure 11: Moment Frames with Moment connections at the Ends of Members.

Longitudinal Moment Resisting System.

Transverse Moment Resisting System.

ROOF SYSTEMS

The roof system is supported in a similar manner to the floors below, with a 1 1/2" – 20 gage type B roof deck (Vulcraft). The roof deck is then supported by K-series open web bar joists spaced at a maximum distance of 4'-0" O.C. between the column bays.

APPLICABLE CODES

ORIGINAL DESIGN CODES USED

All equipment and components of the DH are designed to comply with all applicable latest editions of articles and sections of the following codes in compliances with all Federal, State, County, and Local ordinances and regulations:

- 2006 International Building Code (IBC)
- National Electrical Code (NEC),
- Uniform Plumbing Code (UPC),
- National Sanitation Foundation (NSF)
- Specifications for structural concrete for buildings (ACI 301)
- Building Code Requirements for Reinforced Concrete (ACI 318-08)
- Recommended Practice for Hot Weather Concreting (ACI 305R)
- Recommended Practice for Cold Weather Concreting (ACI 306R)
- Recommended Practice for Concrete Formwork (ACI 347)
- American Society of Civil Engineers (ASCE 7- 10)

DESIGN CODES AND STANDARDS USED IN THE THESIS ANALYSIS

- American Society of Civil Engineers (ASCE)
  - ASCE7-05, Minimum Design Loads for Buildings and Other Structures
- International Building Code, 2009 Edition (IBC)
- American Institute of Steel Construction (AISC)
  - Steel Construction Manual, Fourteenth Edition
- Masonry Standards Joint Committee (MSJC)
  - Building Code Requirements and Specification for Masonry Structures, 2008 Edition

PROPOSAL

PROBLEM STATEMENT

Per previous analysis, it was found that the gravity and lateral resisting system of the DH are adequate in both strength and serviceability. However, the existing lateral system described above is composed of complicated moment connections that are time consuming and labor intensive. An example of this type of connection can be seen in figure 12, where a combination of welds and bolts are being used. This presents an opportunity for an alternative design of the lateral system.

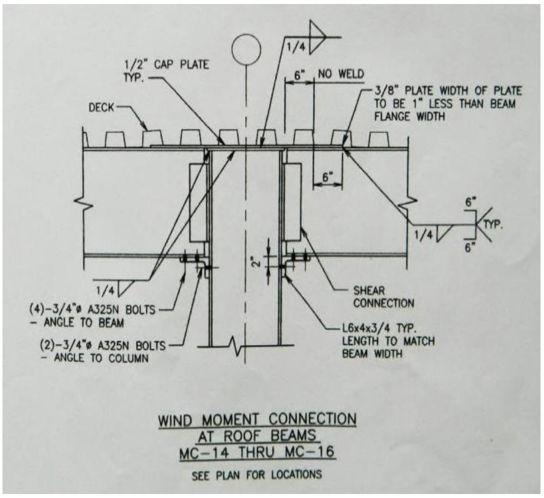


Figure 12: Wind Moment Connection

PROPOSED SOLUTION

The proposed solution will consist primarily of a combination of loadbearing Concrete Masonry Units (CMU) and non-loadbearing walls. All reinforced CMU loadbearing walls will be continuous from the first floor to the roof in both transverse and longitudinal direction. The floor and roof system will be composed of hollow core precast concrete planks which will also be used as part of the lateral resisting system. The figure below shows how the system will be composed.

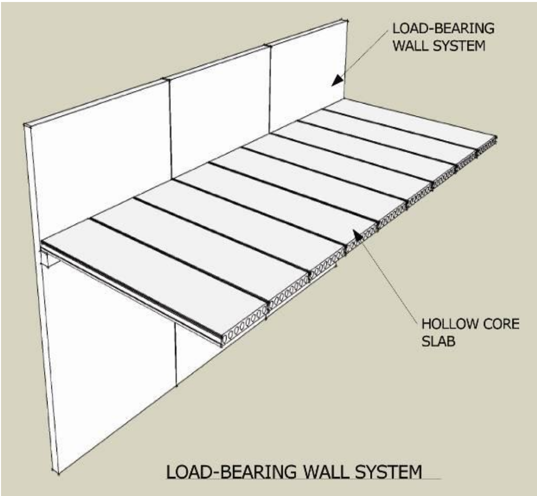


Figure 13: Loadbearing System
http://www.we-inter.com/Conceptual-Design-for-a-Precast-Concrete-Hotel-in-Iraq.aspx

Changing the lateral system from moment frames to reinforced loadbearing CMU's will result in simpler and easier frames to construct. Frame stiffnesses, and lateral movement; and both direct shear and torsional shear will be computed in the lateral system analysis to ensure the safety of the building.

PROPOSED BUILDING OVERVIEW

As mentioned above, the proposed building will consist of masonry loadbearing walls with precast hollow core planks as the floor and roof system. The planks will be topped with a 2” normal weight concrete.

Unlike the existing building, the new structure will stand 7 stories tall with a floor to floor height of 10 feet and will provide 392 students with living spaces contrary to the existing which provides only 268 student rooms. All other amenities will remain the same in the two buildings. Both systems have the same square footage per floor.

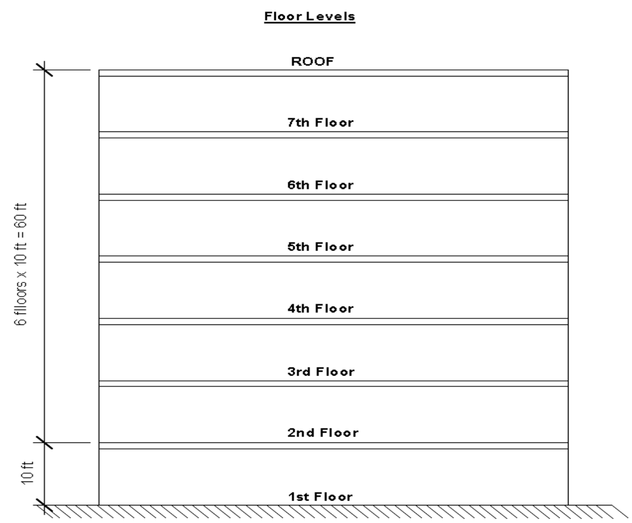


Figure 14: Proposed Building Elevation

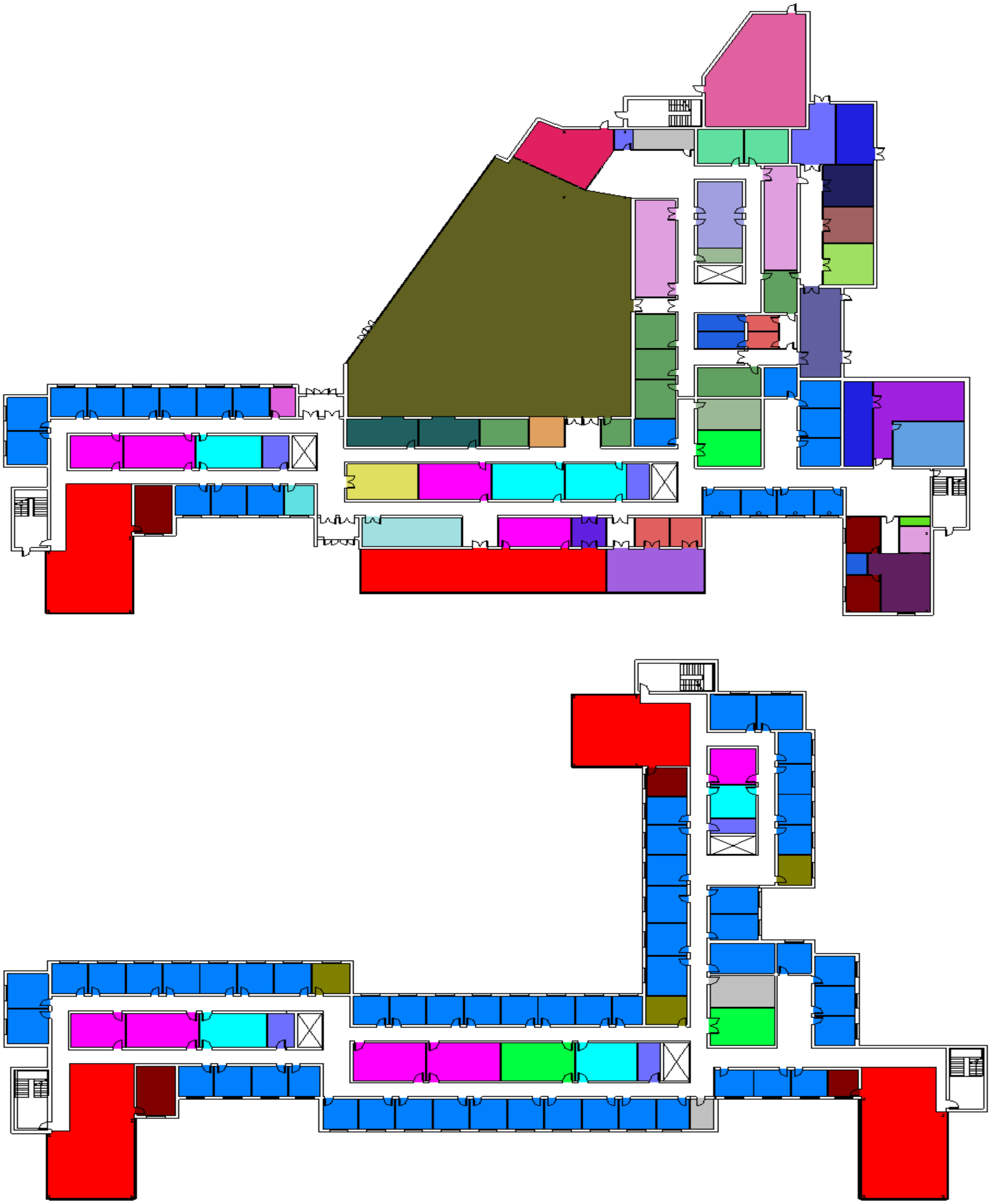


Figure15: Lower (Top Image) and Upper Floors (Bottom Image)

STRUCTURAL DEPTH

BUILDING LOADS SUMMARY

Design loadings for buildings in general, including masonry buildings are prescribed by the legally adopted building code. In most parts of the United States, the legally adopted building code is based on the *International Building Code* (IBC). In the following sections of this report, the 2009 IBC will be used in collaboration with the ASCE 7-05.

Dead loads are due to the weight of the structure itself, plus permanently attached components. Live loads are prescribed by the 2009 IBC. Note that the 2009 IBC loads are identical to those prescribed by the ASCE 7-05. In this report the gravity loads are not similar to the existing structure. In addition, the seismic design loads changed due to the overall weight of the building. All of the changes are summarized in the table below.

Existing System Loads	
Dead Loads	
Roof	
Roofing	3 psf
Framing	5 psf
Insulation	3 psf
Ceiling	2 psf
Elec./Lights	3 psf
Mechanical	5 psf
Sprinklers	3 psf
Miscellaneous	1 psf
Floors	
4" Slab and deck (LWC)	44 psf
Framing	5 psf
Mechanical	5 psf
Elec./Lights	3 psf
Ceiling	2 psf
Sprinklers	3 psf
Miscellaneous	3 psf
Superimposed DL	**30 psf**
Snow	**35 psf**
Live Loads	
Roof	30 psf
First floor	100 psf
Stairs	100 psf
Dorm rooms	40 psf
Corridors	100 psf
Storage	125 psf
Mechanical room	125 psf
Common Areas	100 psf

Thesis Gravity Loads		
Dead Loads		
Reinforced Concrete		150 pcf
Steel		490 pcf
Precast Concrete Plank		
	Plank	61 psf
	2" Toping	25 psf
Superimposed Dead Load		30 psf
MEP		10 psf
Partitions		15 psf
Miscelaneous		5 psf
Snow		30 psf
8" Light Weight CMU		51 psf
Live Loads		
Roof		30 psf
First floor		100 psf
Stairs		100 psf
Dorm rooms		40 psf
Corridors		100 psf
Storage		125 psf
Mechanical room		125 psf
Common Areas		100 psf

Table1: Dead and Live Loads Summary

LATERAL FORCE DESIGN

WIND

Wind loads were calculated using the provisions of ASCE 7-05. The basic wind speed for Williamsport, PA is 90 mph. Other factor such as topography and the effect of the height of the building are taken into consideration as prescribed by ASCE 7-05. Three procedures are given by ASCE 7-05: the simplified procedure, an analytical procedure, and a wind tunnel procedure. Since the Dauphin Hall is 70 ft tall, the analytical procedure will be discussed. The values in the following tables are all the variables used to determine the wind pressure on the building. Microsoft Excel was used extensively in determining the net wind pressures, story forces, and overturning moments. The net wind loads were found after the net wind pressures were determined. Wind loads were the largest in the North/South direction resulting in a base shear of 273.6 kips and an overturning moment of 11,285 ft-kips.

Velocity Pressures Coeff. And Velocity Pressure			
Level	Elevation	Kz	$q_z = q_h$
1	0	0.85	17.6
2	10	0.85	17.6
3	20	0.9	18.7
4	30	0.98	20.3
5	40	1.04	21.6
6	50	1.09	22.6
7	60	1.13	23.4
Top	70	1.17	24.3

Table 2: Effects of height on building

Wind Design Variables			
			ASCE Reference
Basic Wind Speed	V	90 mph	Fig. 6-1
Wind Importance Factor	I	1.15	Table 6-1
Exposure Category		C	Sec 6.5.6.3
Directionality Factor	Kd	1	Table 6-4
Topografic Factor	Kzt	1	Sec 6.5.7.1
Velocity Pressure Exposure Coefficient evaluated at Height Z	Kz	Varies	Table 6-3
Velocity Pressure at Mean Roof Height	qz	70 ft	Eq. 6-15
Internal Pressure Coefficient	G_{Cpi}	0.18	Fig. 6-5
Occupancy category		III	Table 1-1
Guest Effect Factor	G	0.85	Eq. 6-4
Enclosure classification		Enclosed	

Table 3: Design variables

Design Wind pressures for MWFRS

Design wind pressures are determined using the equation:

$$P = qGCp - qi(GCpi) \qquad \text{(Equation 6-17)}$$

Figure X show how the geometry of the building and how it is affected by the pressures.

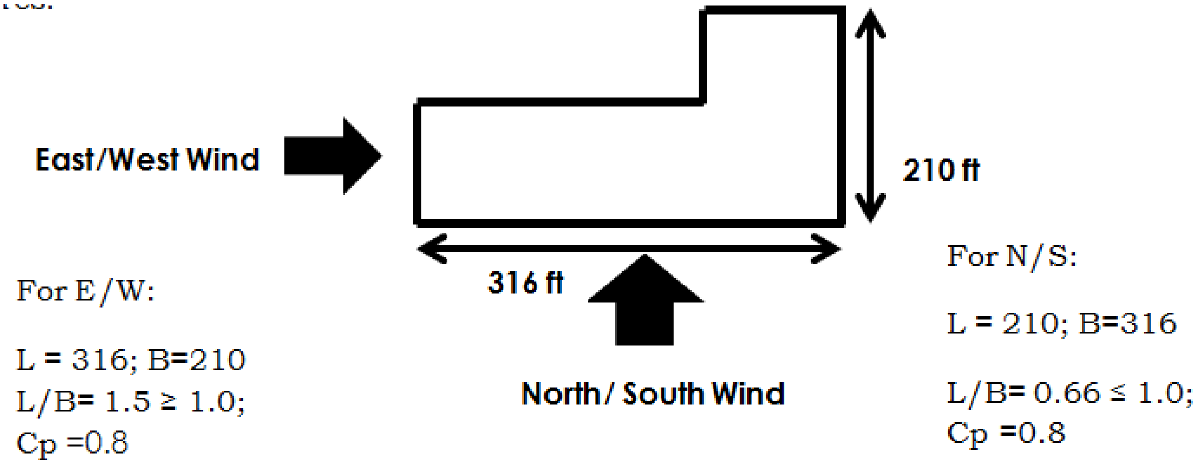


Figure 16: Wind Diagram

WIND PRESSURE (psf) North/South			
Level	Height (ft)	Windward	Leeward
Roof	70	16.5	-10.3
7	60	15.9	-10.3
6	50	15.4	-10.3
5	40	14.7	-10.3
4	30	13.8	-10.3
3	20	12.7	-10.3
2	10	12.0	-10.3
1	0	12.0	-10.3

WIND FORCE North/South			
Level	Height (ft)	Force (kips)	Overturning Moment (ft-k)
Roof	70	42.4	2968.0
7	60	41.4	2484.0
6	50	40.6	2030.0
5	40	39.5	1580.0
4	30	38.1	1143.0
3	20	36.4	728.0
2	10	35.2	352.0
1	0	0.0	0.0
	Base Shear =	273.6	11285.0

Table 4: Wind pressure and Forces in North/South direction

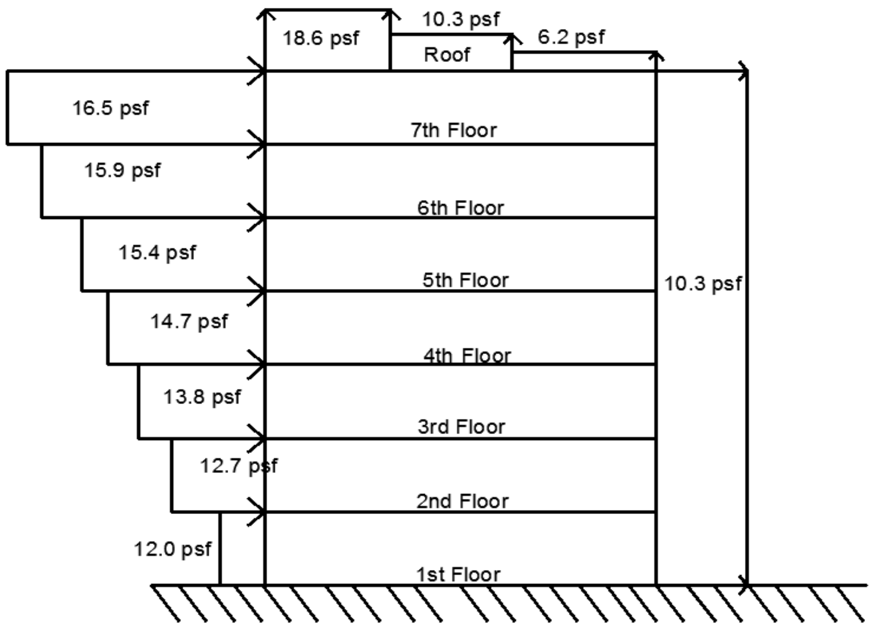
WIND PRESSURE (psf) EAST/WEST			
Level	Height (ft)	Windward	Leeward
Roof	70	16.5	-8.3
7	60	15.9	-8.3
6	50	15.4	-8.3
5	40	14.7	-8.3
4	30	13.8	-8.3
3	20	12.7	-8.3
2	10	12.0	-8.3
1	0	12.0	-8.3

WIND FORCE East/West			
Level	Height (ft)	Force (kips)	Overturning Moment (ft-k)
Roof	70	26.0	1820.0
7	60	25.4	1524.0
6	50	24.9	1245.0
5	40	24.1	964.0
4	30	23.2	696.0
3	20	22.1	442.0
2	10	21.3	213.0
1	0	0.0	0.0
	Base Shear =	167.0	6904.0

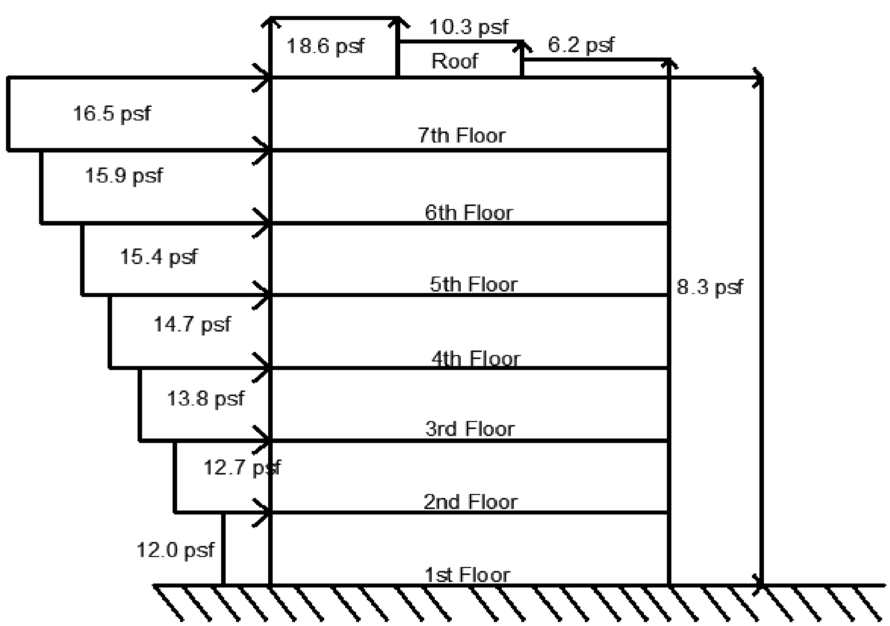
Table 5: Wind Forces in East/West direction

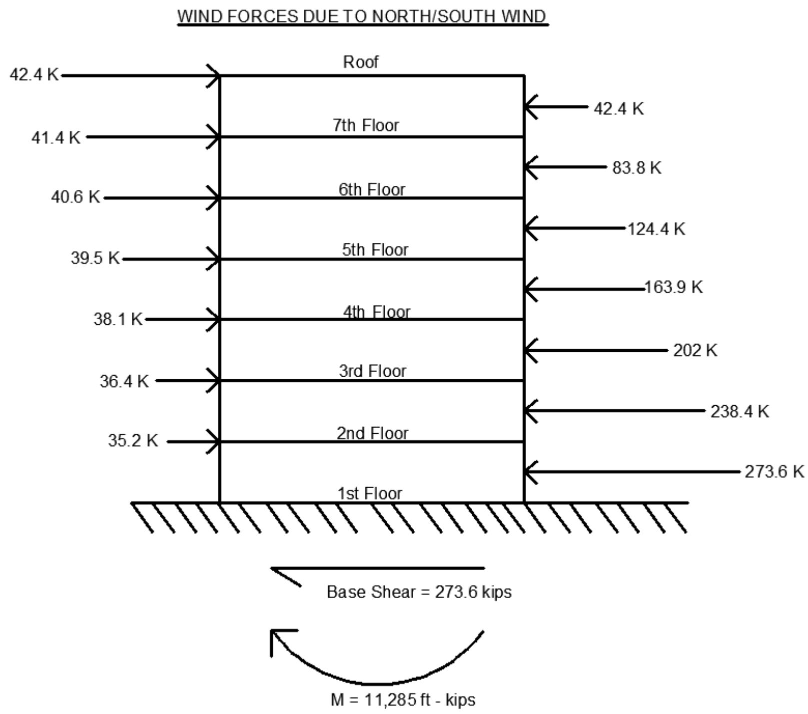
Please refer to Appendix A for a complete wind force design calculations. The wind controls in the direction with the larger surface area to catch the forces. The following figures show graphic representations of the wind pressures on the building surface.

WIND PRESSURES DUE TO NORTH/SOUTH WIND

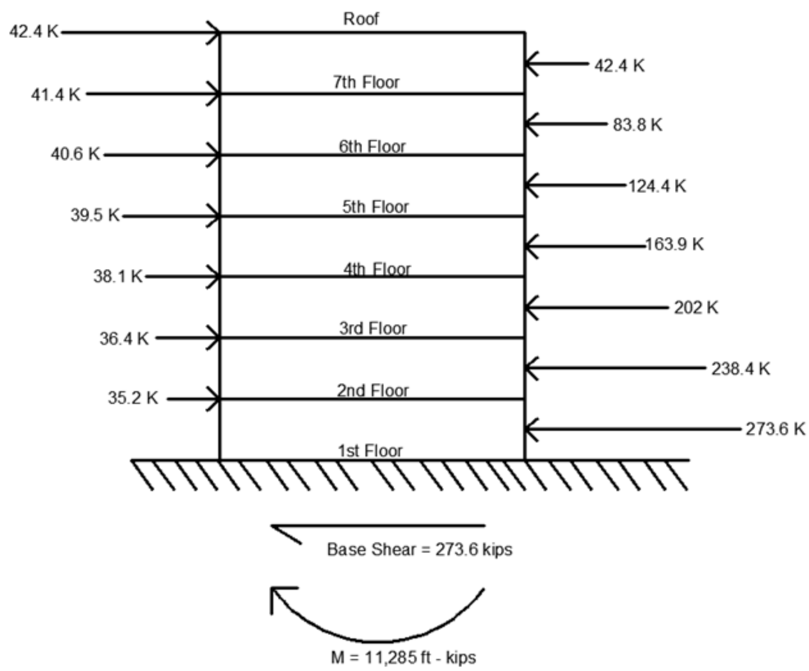


WIND PRESSURES DUE TO EAST/WEST WIND

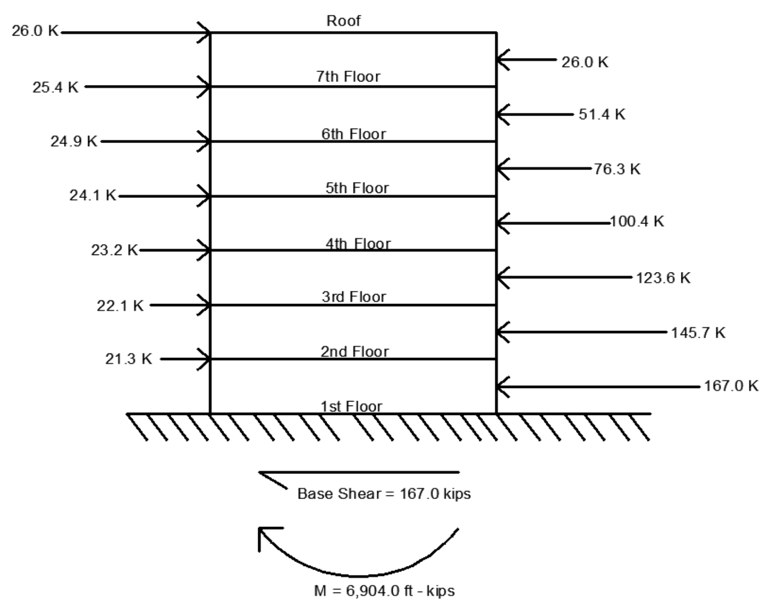



WIND FORCES DUE TO NORTH/SOUTH WIND
42.4 K
41.4 K
40.6 K
39.5 K
38.1 K
36.4 K
35.2 K
Roof
7th Floor
6th Floor
5th Floor
4th Floor
3rd Floor
2nd Floor
1st Floor
42.4 K
83.8 K
124.4 K
163.9 K
202 K
238.4 K
273.6 K
Base Shear = 273.6 kips
M = 11,285 ft - kips

WIND FORCES DUE TO NORTH/SOUTH WIND



WIND FORCES DUE TO EAST/WEST WIND



SEISMIC

The design earthquake loads are calculated according to sec.1613 of the 2009 IBC, which essentially references ASCE 7-05. Different buildings react differently under seismic loads based on their period and their ductility. In ASCE 7-05, the seismic design criteria are given in chapter 12, which prescribes basic requirements; selection of structural systems; diaphragm characteristics and other possible irregularities; seismic design loads effects and combinations; direction of loading; analysis procedures; etc… Four procedures are prescribed. This report only focuses on the equivalent lateral force procedure. The following table provides a summary of the seismic forces distribution on the building including the base shear and the overturning moment.

Table 2: SHEAR DISTRIBUTION AT EACH FLOOR LEVEL

Level	Wx (kips)	hx (ft)	Wx*hx^k (k-ft)	(wxhi)/∑(wihi)^k	Fx (kips)	Vx (kips)	Moment (ft-kips)
Roof	2801	70	196070	0.21	357	-	24965
7	3420	60	205200	0.22	373	357	22395
6	3420	50	171000	0.19	311	730	15552
5	3420	40	136800	0.15	249	1041	9953
4	3420	30	102600	0.11	187	1290	5599
3	3420	20	68400	0.07	124	1476	2488
2	3420	10	34200	0.04	62	1601	622
1	3420	0	0	0.00	0	1663	0
	23321		**914270**	**1.00**	**1663**		**81574**

Total Overturning moment = 81,574 ft-kips
Base Shear = 1663 kips

Table 6: Shear Distribution and overturning moment

Since the building uses both reinforced masonry in both directions, the code specified period, T_a is independent of the direction for this structure. Therefore, a single analysis holds for both directions. A detailed set of calculation procedures are located in Appendix B.

The analysis resulted in a base shear of 1663 kips and an overturning moment of 81,574 ft-kips.

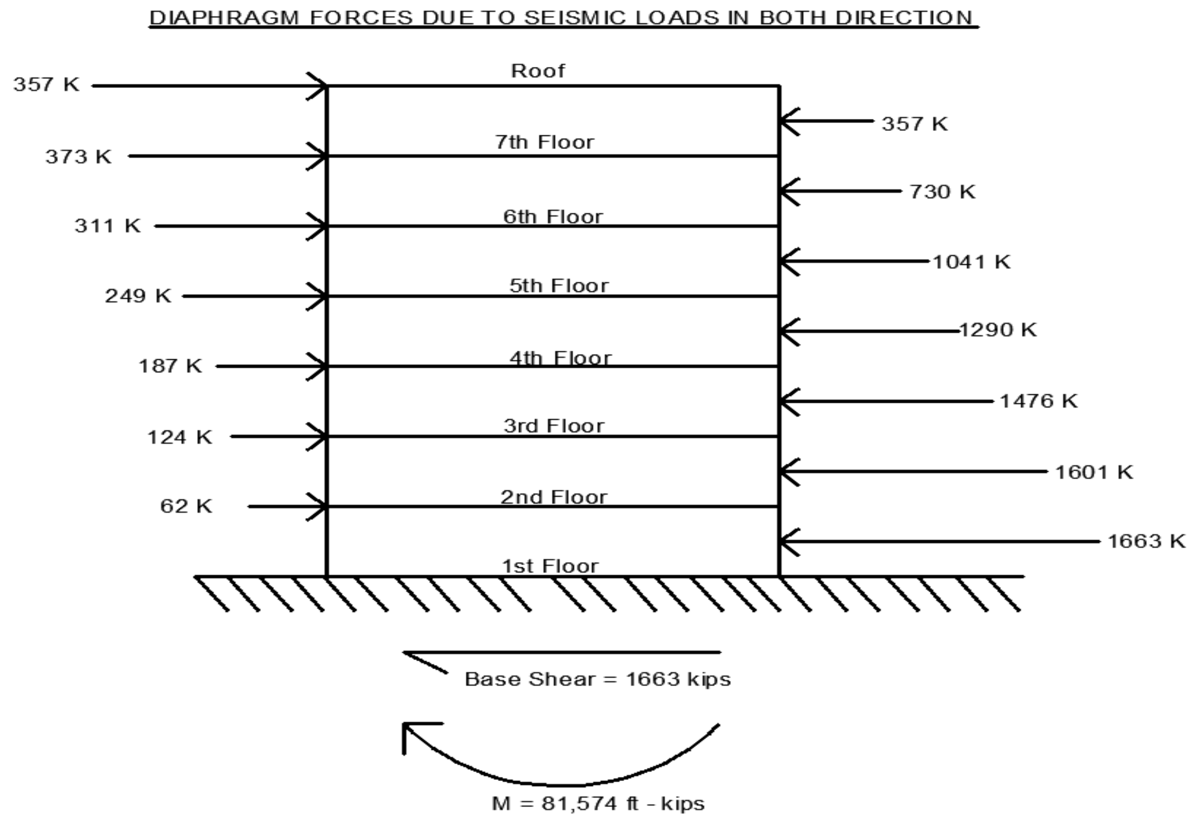


Figure 17: Seismic Forces Distribution on Building

A system comparison of the two lateral forces shows that seismic forces govern over wind forces as expected for masonry structures under these circumstances.

	Base Shear (kips)	Overturning Moment (ft-K)
Wind	273.6	11285
Seimic	1663	81574

Table 7: Base Shear and Overturning Moment Summary

REINFORCED MASONRY WALL DESIGN BASED ON GRAVITY LOADS (ASD)

In calculating the seismic loads above, the loadbearing walls were assume to be 8" lightweight concrete masonry walls at 16" O.C. However, this assertion needs to be verified. Therefore, the walls need to be checked at the bottom floor under gravity loads to ensure the adequacy of the structure before the continuation of the design.

Using the basic load combinations below from the IBC 2009, we determined the maximum axial load and moment capacity of the masonry walls at all levels. Partition loads were included because it was greater than 10 psf; however, snow loads were not included because it was equal to 30 psf and no storage live loads were added.

Given Factors:

f'm = 6000 psi (Assume 8" hollow core @ 16" o.c. Weight wall = 51 psf)

Partitions = 15 psf

Floor DL = 61.25 psf (planks) + 25 psf (2" Concrete topping) = 86 psf

Allowance = 10 psf; Snow Load = 30 psf

Maximum span = 19 ft Note: Intermediate reinforced masonry

Load Combinations:

1. $D + F$
2. $D + H + F + L + T$
3. $D + H + F + (L_r \text{ or } S \text{ or } R)$
4. $D + H + F + 0.75(L + T) + 0.75(L_r \text{ or } S \text{ or } R)$
5. $D + H + F + (W \text{ or } 0.7E)$
6. $D + H + F + 0.75(W \text{ or } 0.7E) + 0.75L + 0.75(L_r \text{ or } S \text{ or } R)$
7. $0.6D + W + H$
8. $0.6D + 0.7E + H$

Floor	DL (kips)	LL (Kips)
7	1.9	2
6	3.8	4
5	5.7	6
4	7.6	8
3	9.5	10
2	11.4	12
1	13.3	14

Table 8: Dead and Live

PD = [(19) (86)] + [(51) (5)] = 1889 lbs ≈ 1900 lbs

PLL = [(100 + 10) (19)] = 2090 lbs

Pmax @ level 1= PD + PL = 13.3 + 14 = 27.3 kips

Eccentricity (e) = (t/2) – (plate/3) = (8/2)-(4/3) = 2.67”

Mlive @ level 1 = (14) (2.67/2) = 18.69 Kips-in

MDead @ level 1 = (13.3) (2.67/2) = 17.8 Kips-in

Mmax @ level 1 = 18.69 + 17.8 = 36.49 Kips-in

Assume: fs = 24,000 psi; j = 7d/8 = 0.9; d = 3.8”

Section properties of 8” hollow core CMU are: A = 62 in^2; I = 378.6 in^3; S = 99.3 in^4

$$As = \frac{\text{M}}{fs.j.d} = \frac{36490}{(24000)(0.9)(3.8)} = 0.44\ in$$

Fb = (1/3) f’m = (1/3) (6000) = 2000 psi

fa = P/A = (27300)/(62) = 440 psi

$$r = \sqrt{\frac{I}{A}} = \sqrt{\frac{378.6}{62}} = 2.47$$

kh/r = (10)(12)/(2.47) = 48.6 ≤ 99, therefore

$$Fa = 0.25\ f'm\left[1-\left(\frac{\frac{h}{r}}{140}\right)^2\right] = 0.25(6000)\left[1-\left(\frac{48.6}{140}\right)^2\right] = 1319\ psi$$

Em = 900f’m = 900(6000) = 5400 ksi

n = Es/Em = 29000/5400 = 5.37

$$fb = \left(1-\left(\frac{fa}{Fa}\right)\right)(Fb) = \left(1-\left(\frac{440}{1319}\right)\right)(2000) = 1334\ psi$$

$$k = \frac{n}{\left(\frac{Fs}{Fb}\right)+n} = \frac{5.37}{\left(\frac{24000}{2000}\right)+5.37} = 0.309$$

J = 1-(k/3) = 1-(0.31/3) = 0.9; 2/jk = 2/ (0.9*0.31) = 7.2

$$fm = \left(\frac{M}{bd^2}\right)\left(\frac{2}{jk}\right) = \frac{36490}{\left((12)(3.8^2)\right)}(7.2) = 1516\ psi\ \geq 1334\ psi; Fb\ governs$$

$$jk = \frac{2M}{f_b b d^2} = \frac{(2)(36490)}{1334 * 12 * 3.8^2} = 0.316$$

$$k^2 - 3k + 3jk = 0 \rightarrow k = 2.64\ and\ 0.36\ (governs)$$

$$jk = 0.316 \rightarrow j = \left(\frac{0.316}{0.36}\right) = 0.88$$

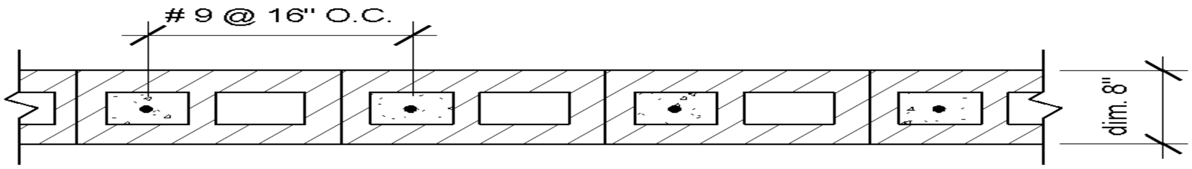
$$(fs)_{rev} = (nf_b)\left(\frac{1-k}{k}\right) = (5.37 * 1334)\left[\frac{1-0.36}{0.36}\right] = 12735\ psi \leq f_s = 24000\ psi; OK$$

$$A_s = \frac{M}{f_{s,rev}\ jd} = \frac{36490}{12735 * 0.88 * 3.8} = 0.85\ in^2$$

Therefore, use (1) # 9's @ 16" o.c. (As = 1.0 in^2) or (2)#6's @16" O.C. (As =0.88in^2)

Under Earthquake (Level 1): Plot Point (P,M) = (13,300 lbs; 41,000 lbs-in) → OK

Sketch of (1) # 9's @ 16" o.c.



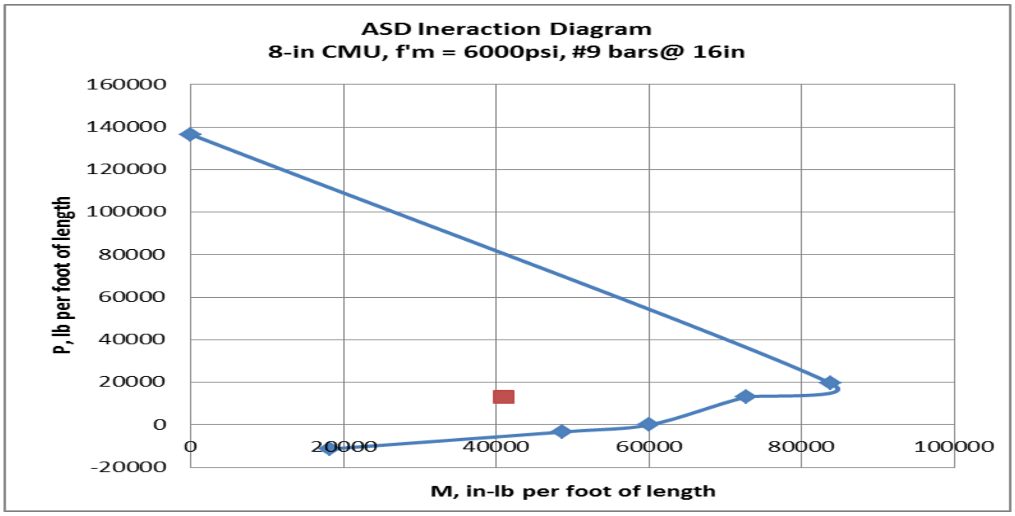


Figure 18: Interraction Diagram (See Appendix D & E)

FLOOR/ROOF SYSTEM

Bearing walls that resist out-of-plane loads, and shear walls, must be designed to transfer lateral loads to the floors above and below. The proposed floor and roof system would be composed entirely of 8" x 4' concrete hollow core planks with 2" normal weight concrete topping. An example of such connection is shown in Figure 19. This type of connection would have to be strengthened for regions subjected to strong earthquakes or strong winds; however, it is not necessary due to the location of the Dauphin Hall. Section 1604.8.2 of the 2009 IBC has additional requirements for anchorage of diaphragms for masonry walls.

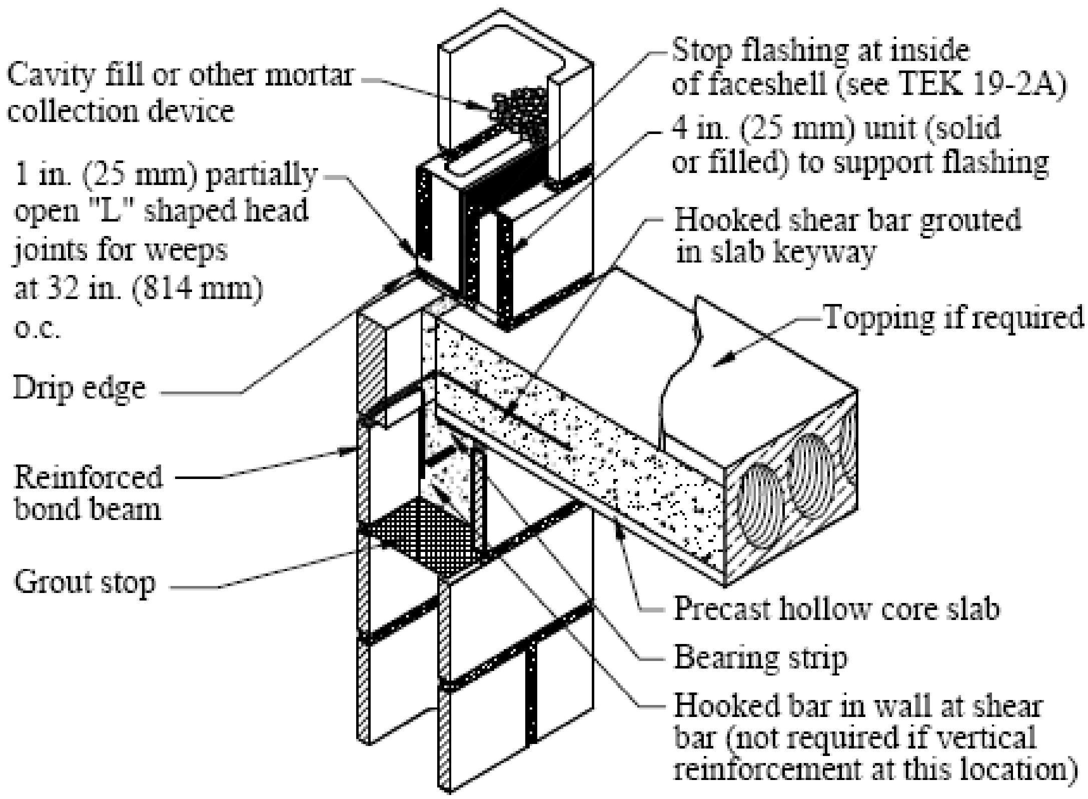


Figure 19: Bearing Wall floor/roof system. Courtesy of NCMA TEK 5-7A

This configuration will have enough strength to act as a rigid diaphragm to transfer the loads to the shear walls. Due to the time constraint, the reinforced bond beams were not designed in this report.

LOAD PATH

Design for lateral loads in multistory buildings involves the use of rigid floor and roof diaphragms to transfer the loads to the shear walls, which, in turn, carry these forces to the foundation. Therefore, it is essential to provide shear walls in the two orthogonal directions of the building to resist lateral loads from any direction. The transfer of the shear forces to the walls requires continuity of the diaphragm, which, is provided by proper connection details between the floor and the walls.

Gravity loads provide lateral stability against overturning to prevent flexural cracking in the case of unreinforced walls or by the use of reinforcing steel to create a tension force where cracking occurs in reinforced walls. At the base of the shear walls, foundations must be designed to develop the required moment resistance.

The diagram below illustrates the lateral load transfer in multistory loadbearing masonry buildings.

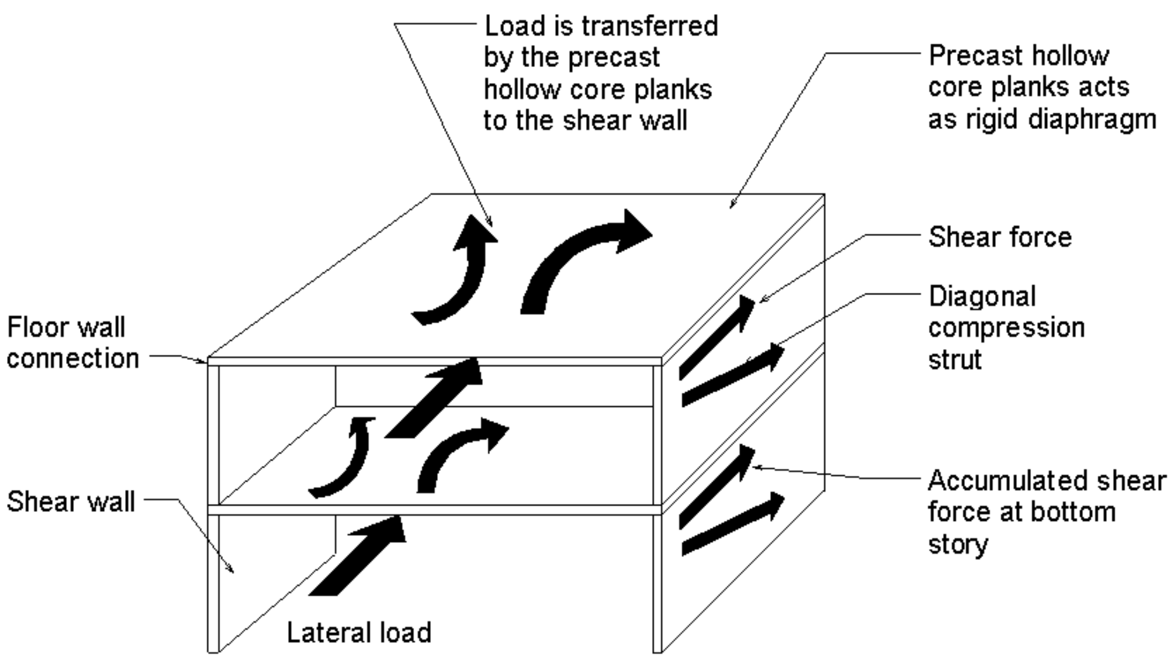


Figure 20: Load Transfer Diagram

PRECAST HOLLOW CORE SLAB DESIGN

Live Load = 100 psf

Partitions = 15psf

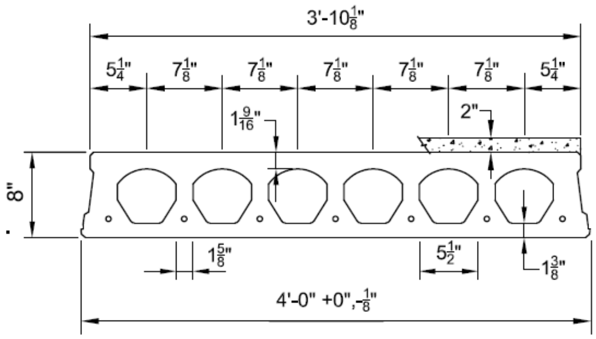
Allowance = 10 psf

Maximum span = 19 ft Ec = 57000√f'c = 57000(77.46) = 4415201 psi

Controlling Load Combination: 1.2D +1.6L

Pmax = 1.2 (25psf) + 1.6 (100 psf) = 190 psf ≤ 214 psf

Therefore, use 4-1/2" Φ strand 8"x4-0" hollow core planks



PHYSICAL PROPERTIES
Composite Section

A_c = 301 in.^{2}	Precast b_w = 13.13 in.
I_c = 3134 in.^{4}	Precast S_{bcp} = 616 in.^{3}
Y_{bcp} = 5.09 in.	Topping S_{tct} = 902 in.^{3}
Y_{tcp} = 2.91 in.	Precast S_{tcp} = 1076 in.^{3}
Y_{tct} = 4.91 in.	Precast Wt. = 245 PLF
	Precast Wt. = 61.25 PSF

SAFE SUPERIMPOSED SERVICE LOADS		IBC 2006 & ACI 318-05 (1.2 D + 1.6 L)																		
Strand Pattern		SPAN (FEET)																		
		17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
4 - 1/2"ø	LOAD (PSF)	280	24[illegible]	214	185	159	138	118	102	87	74	62	52	42						
6 - 1/2"ø	LOAD (PSF)	366	341	318	299	271	239	211	187	165	146	129	114	101	88	77	67	58	50	42
7 - 1/2"ø	LOAD (PSF)	367	342	320	300	282	265	243	221	202	181	161	144	128	114	101	90	79	70	61

Table 9: Courtesy of Nitterhouse Concrete Products

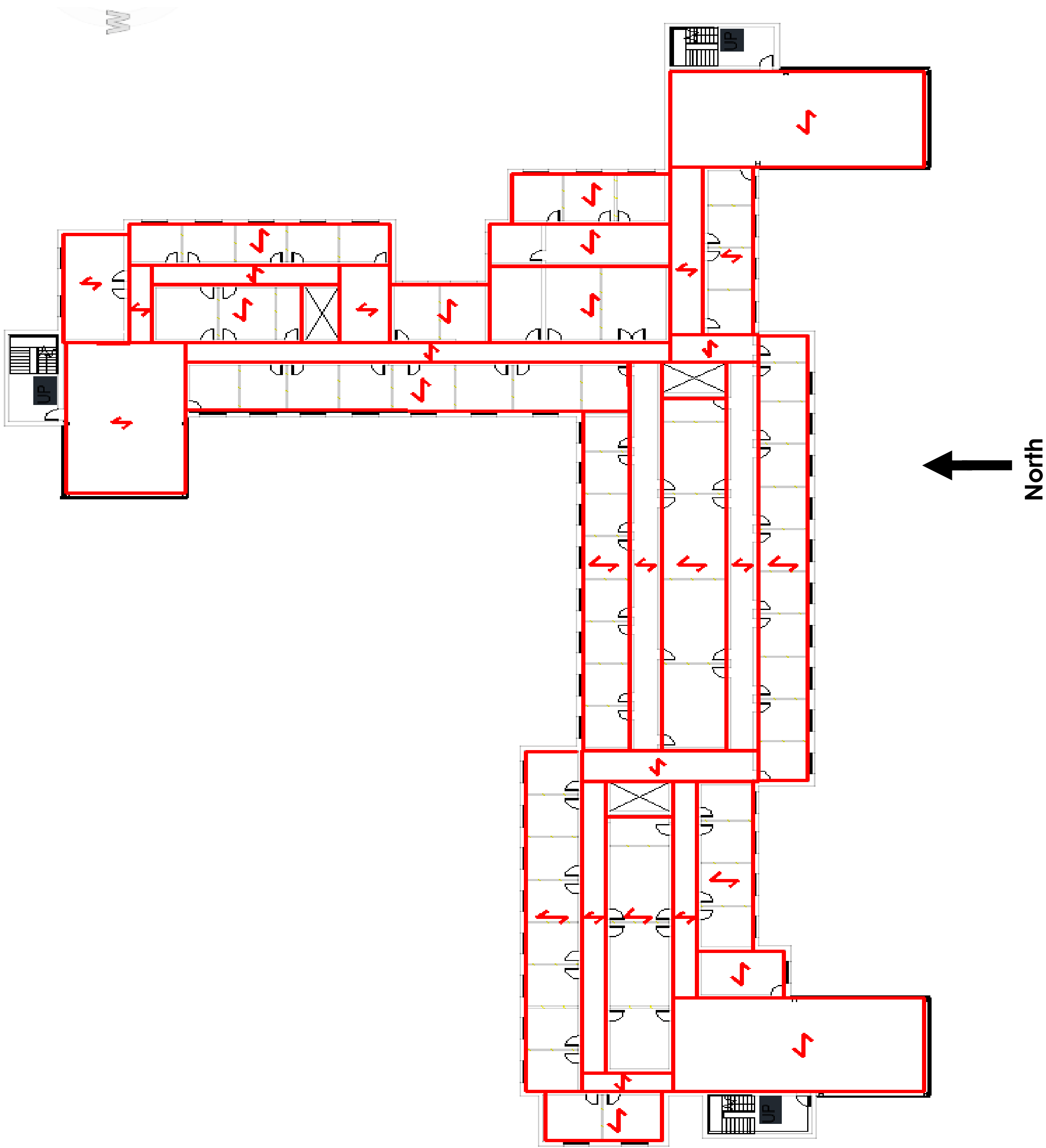
Similarly to the reinforced concrete masonry walls, the precast hollow core planks needs to be checked for flexure and deflection. It was found that both flexure and serviceability issues are met.

Δ_{actual} = 5(190*4)(19^4)(1728)/(384*4415201*3134) = 0.16 in

Δ_{limit} = L/360 = (19*12)/360 = 0.63 in ≥ 0.16 in → OK

The figure below shows the layout of the precast concrete planks on the building floor.

Precast Concrete planks layout



LATERAL SYSTEM REDESIGN

With the design of the gravity system completed, it is time to move on to design members to transfer loads to the foundation. For most masonry building not located in high wind or seismic regions, shear reinforcement is not required. However, the system needs to be checked to insure its adequacy.

Lateral element location

The Figure below shows the locations of all the reinforced concrete masonry walls that will interact as shear walls. Once the location, length, and height of the walls are determined, we can proceed to determine the rigidity of each wall respectively. A summary of the rigidities is provided in the following tables.

The wall system was evaluated as a cantilever wall. Under this assumption, the rigidity was calculated as following:

$$R = \frac{Et}{\left[4\left(\frac{h}{L}\right)^3 + 3\left(\frac{h}{L}\right)\right]} \quad ; \qquad where\ E_m = 900f'm$$

The center of rigidity (CR) was determined as following:

$$\text{CRx} = \frac{\sum \text{Rx}*\text{Xi}}{\sum \text{Rx}};\ \text{CRy} = \frac{\sum \text{Ry}*\text{Yi}}{\sum \text{Ry}}$$

Relative stiffness: $R = \frac{R}{\sum R}$;

Similarly, the center of mass (CM) was determined by the following formula:

$$\text{CMx} = \frac{\sum \text{L}*\text{X}}{\sum \text{L}} = \ ; \text{CMy} = \frac{\sum \text{L}*\text{Y}}{\sum \text{L}}$$

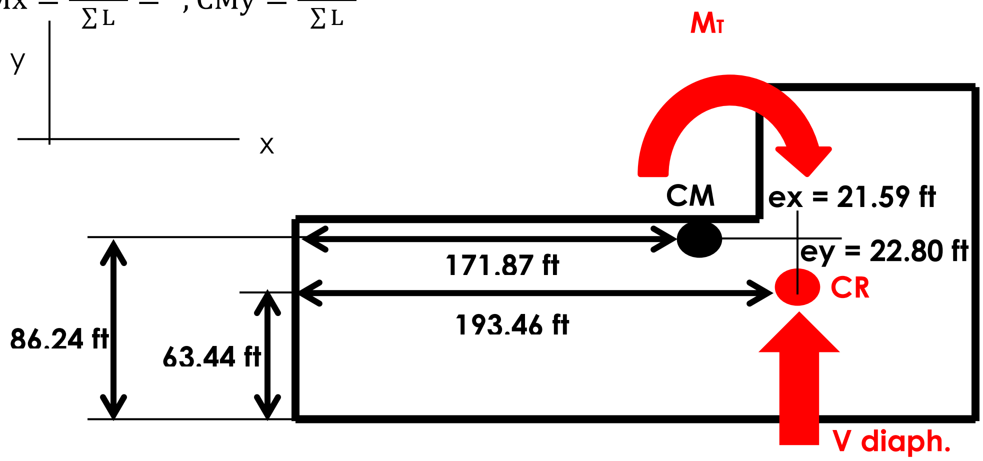
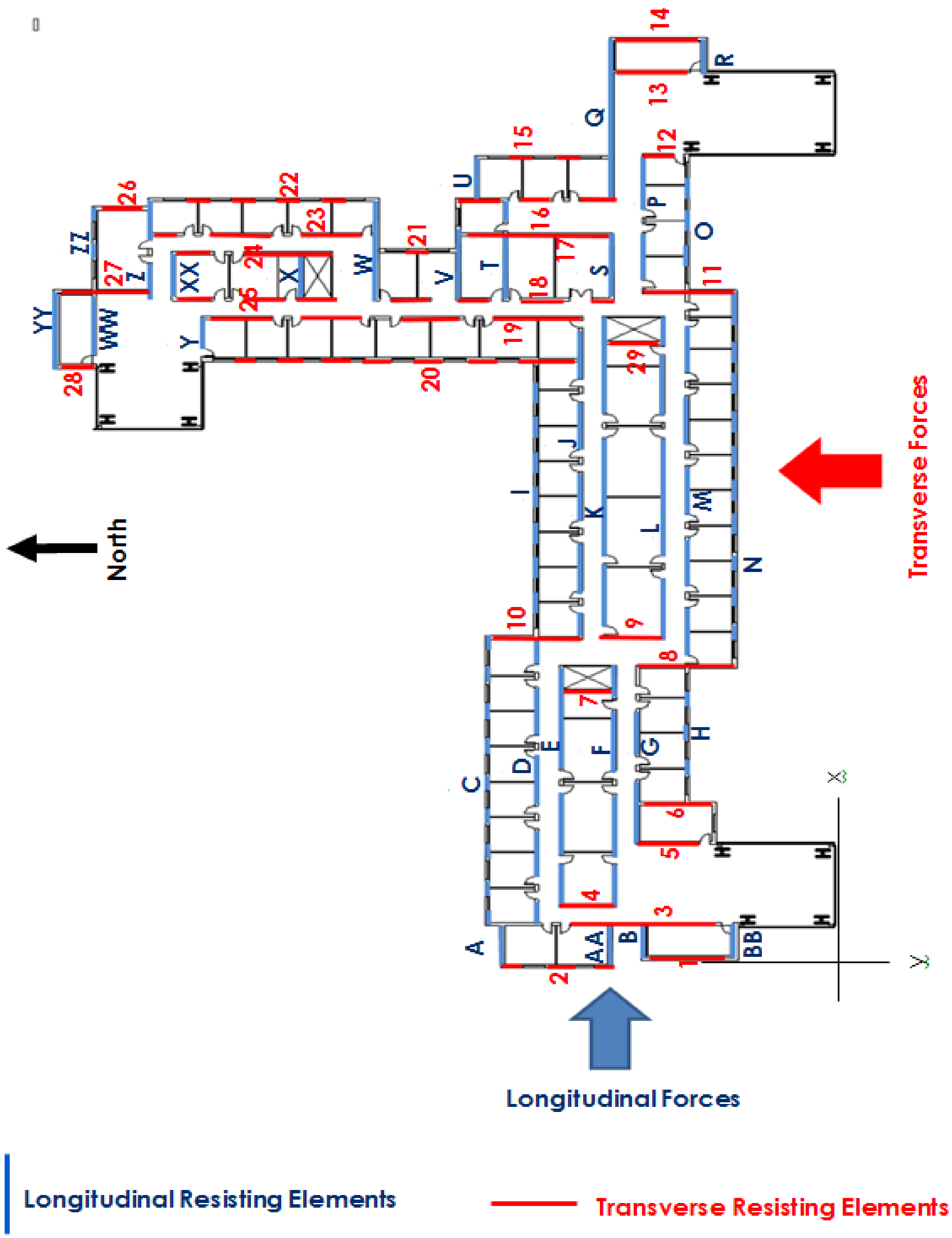


Figure 20: Center of Mass and Rigidity

Lateral Resisting Elements



Wall Rigidity in N/S Direction									
Wall Name	Height (in)	Length (in)	Thickness (in)	f'c (psi)	E (Ksi)	H/L	(H/L)^3	Rigidity (kip/in)	Relative Stiffness
1	120	300	8	6000	4415201	0.400	0.064	24259346.23	0.033
2	120	168	8	6000	4415201	0.714	0.364	9809968.894	0.013
3	120	480	8	6000	4415201	0.250	0.016	43472748.45	0.058
4	120	156	8	6000	4415201	0.769	0.455	8555851.492	0.011
5	120	204	8	6000	4415201	0.588	0.204	13696532.02	0.018
6	120	228	8	6000	4415201	0.526	0.146	16336541.48	0.022
7	120	156	8	6000	4415201	0.769	0.455	8555851.492	0.011
8	120	300	8	6000	4415201	0.400	0.064	24259346.23	0.033
9	120	192	8	6000	4415201	0.625	0.244	12386755.72	0.017
10	120	300	8	6000	4415201	0.400	0.064	24259346.23	0.033
11	120	288	8	6000	4415201	0.417	0.072	22945766.48	0.031
12	120	120	8	6000	4415201	1.000	1.000	5045944.017	0.007
13	120	240	8	6000	4415201	0.500	0.125	17660804.06	0.024
14	120	312	8	6000	4415201	0.385	0.057	25568887.33	0.034
15	120	240	8	6000	4415201	0.500	0.125	17660804.06	0.024
16	120	300	8	6000	4415201	0.400	0.064	24259346.23	0.033
17	120	492	8	6000	4415201	0.244	0.015	44725345.45	0.060
18	120	492	8	6000	4415201	0.244	0.015	44725345.45	0.060
19	120	972	8	6000	4415201	0.123	0.002	93468857.94	0.126
20	120	720	8	6000	4415201	0.167	0.005	68120244.23	0.091
21	120	144	8	6000	4415201	0.833	0.579	7336026.301	0.010
22	120	336	8	6000	4415201	0.357	0.046	28175143.22	0.038
23	120	480	8	6000	4415201	0.250	0.016	43472748.45	0.058
24	120	408	8	6000	4415201	0.294	0.025	35891429.3	0.048
25	120	360	8	6000	4415201	0.333	0.037	30763981.26	0.041
26	120	156	8	6000	4415201	0.769	0.455	8555851.492	0.011
27	120	300	8	6000	4415201	0.400	0.064	24259346.23	0.033
28	120	108	8	6000	4415201	1.111	1.372	4004580.454	0.005
29	120	192	8	6000	4415201	0.625	0.244	12386755.72	0.017
								744619495.9	

Wall Rigidity In E/W Direction									
Wall Name	Height (in)	Length (in)	Thickness (in)	f'c (psi)	E (Ksi)	H/L	(H/L)^3	Rigidity (kip/in)	Relative Stiffness
A	120	168	8	6000	4415201.015	0.714	0.364	9809968.894	0.008
AA	120	168	8	6000	4415201.015	0.714	0.364	9809968.894	0.008
B	120	132	8	6000	4415201.015	0.909	0.751	6161606.868	0.005
BB	120	132	8	6000	4415201.015	0.909	0.751	6161606.868	0.005
C	120	576	8	6000	4415201.015	0.208	0.009	53422966.15	0.042
D	120	768	8	6000	4415201.015	0.156	0.004	72977203.96	0.058
E	120	840	8	6000	4415201.015	0.143	0.003	80233851.55	0.064
F	120	768	8	6000	4415201.015	0.156	0.004	72977203.96	0.058
G	120	540	8	6000	4415201.015	0.222	0.011	49709367.41	0.039
H	120	264	8	6000	4415201.015	0.455	0.094	20308017.45	0.016
I	120	552	8	6000	4415201.015	0.217	0.010	50949378.3	0.040
J	120	864	8	6000	4415201.015	0.139	0.003	82646185.97	0.065
K	120	1128	8	6000	4415201.015	0.106	0.001	109029145.8	0.086
L	120	1056	8	6000	4415201.015	0.114	0.001	101856325.9	0.081
M	120	984	8	6000	4415201.015	0.122	0.002	94668502.94	0.075
N	120	768	8	6000	4415201.015	0.156	0.004	72977203.96	0.058
O	120	240	8	6000	4415201.015	0.500	0.125	17660804.06	0.014
P	120	408	8	6000	4415201.015	0.294	0.025	35891429.3	0.028
Q	120	648	8	6000	4415201.015	0.185	0.006	60798881.73	0.048
R	120	144	8	6000	4415201.015	0.833	0.579	7336026.301	0.006
S	120	264	8	6000	4415201.015	0.455	0.094	20308017.45	0.016
T	120	348	8	6000	4415201.015	0.345	0.041	29471731.11	0.023
U	120	168	8	6000	4415201.015	0.714	0.364	9809968.894	0.008
V	120	288	8	6000	4415201.015	0.417	0.072	22945766.48	0.018
W	120	396	8	6000	4415201.015	0.303	0.028	34615561.25	0.027
X	120	168	8	6000	4415201.015	0.714	0.364	9809968.894	0.008
Y	120	120	8	6000	4415201.015	1.000	1.000	5045944.017	0.004
Z	120	276	8	6000	4415201.015	0.435	0.082	21628485.45	0.017
XX	120	168	8	6000	4415201.015	0.714	0.364	9809968.894	0.008
ZZ	120	420	8	6000	4415201.015	0.286	0.023	37163532.47	0.029
YY	120	288	8	6000	4415201.015	0.417	0.072	22945766.48	0.018
WW	120	288	8	6000	4415201.015	0.417	0.072	22945766.48	0.018
								1261886124	

Table 10: Wall Rigidity in Transverse and Longitudinal Direction

Center of Rigidity, CRx at Level 1-Roof			
Wall Name	Rx	Yi	Rx*Yi
A	9809968.894	1068	10477046779
AA	9809968.894	720	7063177604
B	6161606.868	612	3770903403
BB	6161606.868	312	1922421343
C	53422966.15	1104	58978954630
D	72977203.96	960	70058115801
E	80233851.55	876	70284853959
F	72977203.96	876	63928030668
G	49709367.41	636	31615157672
H	20308017.45	468	9504152168
I	50949378.3	948	48300010629
J	82646185.97	804	66447533523
K	109029145.8	744	81117684488
L	101856325.9	540	55002415964
M	94668502.94	470.4	44532063782
N	72977203.96	470.4	34328476742
O	17660804.06	459.6	8116905545
P	35891429.3	459.6	16495700908
Q	60798881.73	721.2	43848153503
R	7336026.301	432	3169163362
S	20308017.45	705.6	14329337115
T	29471731.11	1063.2	31334344517
U	9809968.894	1153.2	11312856129
V	22945766.48	1206	27672594370
W	34615561.25	1470	50884875033
X	9809968.894	1728	16951626249
Y	5045944.017	2043.6	10311891193
Z	21628485.45	2212.8	47859512612
XX	9809968.894	2143.2	21024725334
ZZ	37163532.47	2401.2	89237074160
YY	22945766.48	2528.4	58016075959
WW	22945766.48	2401.2	55097374463
	1261886124		**9.60643E+11**

Center of Rigidity, CRy at Level 1-Roof			
Wall Name	Rigidity (kip/in)	Xi	Ry*Xi
1	24259346.23	28.8	698669171.6
2	9809968.894	12	117719626.7
3	43472748.45	180	7825094721
4	8555851.492	252	2156074576
5	13696532.02	511.2	7001667168
6	16336541.48	663.6	10840928923
7	8555851.492	1124.4	9620199418
8	24259346.23	1230	29838995868
9	12386755.72	1346.4	16677527906
10	24259346.23	1354.8	32866562278
11	22945766.48	2748	63054966277
12	5045944.017	3301.2	16657670388
13	17660804.06	3649.2	64447806171
14	25568887.33	3780	96650394092
15	17660804.06	3301.2	58301846359
16	24259346.23	3128.4	75892938760
17	44725345.45	2997.6	1.34069E+11
18	44725345.45	2721.6	1.21725E+11
19	93468857.94	2654.4	2.48104E+11
20	68120244.23	2484	1.69211E+11
21	7336026.301	2934	21523901168
22	28175143.22	3139.2	88447409594
23	43472748.45	2985.6	1.29792E+11
24	35891429.3	2919.6	1.04789E+11
25	30763981.26	2733.6	84096419182
26	8555851.492	3139.2	26858529004
27	24259346.23	2721.6	66024236712
28	4004580.454	2450.4	9812823944
29	12386755.72	2545.2	31526770667
	744619495.9		**1.72863E+12**

Table 11: Values Used to Calculate the Center of Rigidity

CRx (ft) =	**193.46**
CRy (ft) =	**63.44**

CENTER OF MASS IN X-DIRECTION					
Wall Name	Length (ft)	Xi	Yi	L*X	L*Y
A	14	7	89	98	1246
AA	14	7	60	98	840
B	11	9	51	99	561
BB	11	9	26	99	286
C	48	63	92	3024	4416
D	64	63	80	4032	5120
E	70	62	73	4340	5110
F	64	62	73	3968	4672
G	45	75	53	3375	2385
H	22	79	39	1738	858
I	46	160	79	7360	3634
J	72	166	67	11952	4824
K	94	166.5	62	15651	5828
L	88	166.5	45	14652	3960
M	82	166.5	39.2	13653	3214.4
N	64	166.5	39.2	10656	2508.8
O	20	254	38.3	5080	766
P	34	254	38.3	8636	1302.2
Q	54	290.3	60.1	15676.2	3245.4
R	12	307.5	36	3690	432
S	22	238.5	58.8	5247	1293.6
T	29	243.9	88.6	7073.1	2569.4
U	14	269.9	96.1	3778.6	1345.4
V	24	243.9	100.5	5853.6	2412
W	33	243.9	122.5	8048.7	4042.5
X	14	235.2	144	3292.8	2016
Y	10	224.4	170.3	2244	1703
Z	23	241.7	184.4	5559.1	4241.2
XX	14	235.2	178.6	3292.8	2500.4
ZZ	35	244.3	200.1	8550.5	7003.5
YY	24	216.1	210.7	5186.4	5056.8
WW	24	216.1	200.1	5186.4	4802.4
	1195			191190.2	94195

CENTER OF MASS IN Y-DIRECTION					
Wall Name	Length (FT)	Xi	Yi	L*X	L*Y
1	25	2.4	39	60	975
2	14	1	74.1	14	1037.4
3	40	15	57.5	600	2300
4	13	21	66.8	273	868.4
5	17	42.6	42.8	724.2	727.6
6	19	55.3	42.8	1050.7	813.2
7	13	93.7	66.5	1218.1	864.5
8	25	102.5	39.9	2562.5	997.5
9	16	112.2	54	1795.2	864
10	25	112.9	80.1	2822.5	2002.5
11	24	229	38.7	5496	928.8
12	10	275.1	45.7	2751	457
13	20	304.1	47.5	6082	950
14	26	315	57.5	8190	1495
15	20	275.1	78	5502	1560
16	25	260.7	80.1	6517.5	2002.5
17	41	249.8	80.1	10241.8	3284.1
18	41	226.8	91	9298.8	3731
19	81	221.2	118.3	17917.2	9582.3
20	60	207	118.3	12420	7098
21	12	244.5	112.4	2934	1348.8
22	28	261.6	153.7	7324.8	4303.6
23	40	248.8	153.7	9952	6148
24	34	243.3	156.8	8272.2	5331.2
25	30	227.8	156.8	6834	4704
26	13	261.6	192	3400.8	2496
27	25	226.8	200.2	5670	5005
28	9	204.2	204.9	1837.8	1844.1
29	16	212.1	54	3393.6	864
	762			145155.7	74583.5

Table 12: Center of Mass

ΣL*X	=	336345.9	CMx (ft)	=	171.87
ΣL*Y	=	168778.5	CMy (ft)	=	86.24
ΣL	=	1957			

Where e = CR-CM

ex	(ft)	=	21.59
ey	(ft)	=	22.80

DISTRIBUTION OF LATERAL SHEAR FORCES

<u>DIRECT SHEAR</u>

With the assumption that precast concrete hollow core planks with 2" topping will constitute a diaphragm that is infinitely stiff, shear forces will be distributed in direct proportion to wall stiffness. Thus, direct shear in each wall is calculated using the following formula:

$V_{di} = \left(\frac{R_i}{\sum Ri}\right) V;$ where V is the diaphragm force and $\left(\frac{R_i}{\sum Ri}\right)$ the relative rigidity

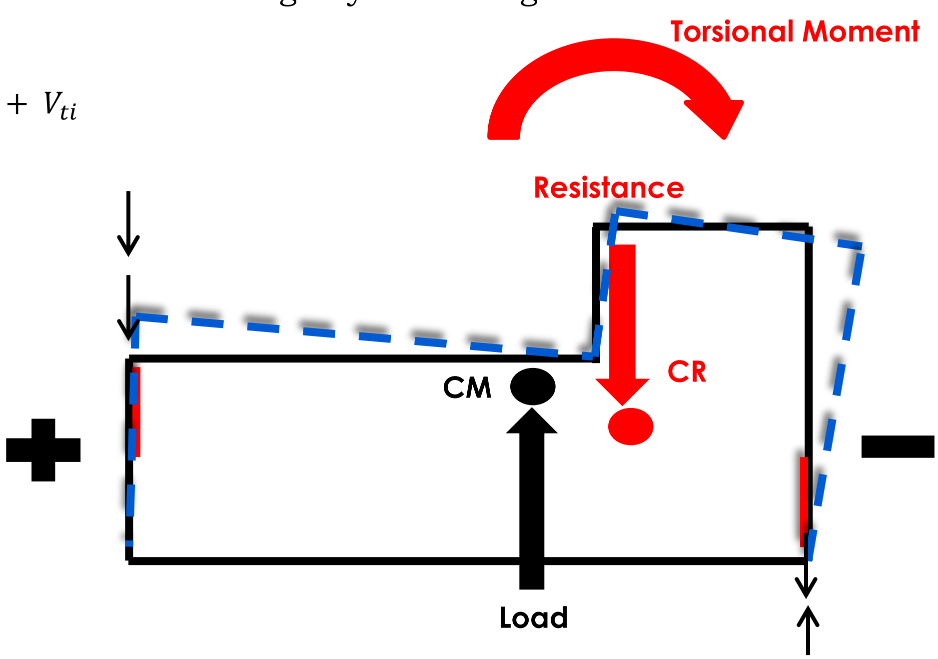
<u>TORSIONAL SHEAR</u>

Next, the torsional force is distributed to individual walls based on their rigidity and location relative to the center of rigidity; this value is known as d_i.

$$J = \sum (d_i R_i^2) \ ; \qquad d_i = d - CR \quad \text{and} \quad V_{ti} = T * \left(\frac{d_i R_i}{J}\right)$$

Depending on the location of the shear walls, sometimes the torsional shear, V_{ti}, acts in the same direction as the direct shear, V_{di}, in which case the forces are additive, while sometimes, the forces act in opposite directions, in which case the forces are subtractive. Torsional forces are a lot stronger as you move far away from the center of rigidity, while direct forces are larger than torsional forces. This explains the reason which most controlling forces are located far away from the center of rigidity. The diagram below shows how the forces interact.

$V_{Total} = V_{di} + V_{ti}$



The table below shows the summary of the resultant direct and torsional shear forces in each wall on the first floor, base level.

Direct Shear in North/South Direction At Level 2				
Wall Name	Rx	Vi (Kips)	Ri/ΣRi	V_{di}
A	9809968.9	62	0.008	0.482
AA	9809968.9	62	0.008	0.482
B	6161606.9	62	0.005	0.303
BB	6161606.9	62	0.005	0.303
C	53422966	62	0.042	2.625
D	72977204	62	0.058	3.586
E	80233852	62	0.064	3.942
F	72977204	62	0.058	3.586
G	49709367	62	0.039	2.442
H	20308017	62	0.016	0.998
I	50949378	62	0.040	2.503
J	82646186	62	0.065	4.061
K	109029146	62	0.086	5.357
L	101856326	62	0.081	5.004
M	94668503	62	0.075	4.651
N	72977204	62	0.058	3.586
O	17660804	62	0.014	0.868
P	35891429	62	0.028	1.763
Q	60798882	62	0.048	2.987
R	7336026.3	62	0.006	0.360
S	20308017	62	0.016	0.998
T	29471731	62	0.023	1.448
U	9809968.9	62	0.008	0.482
V	22945766	62	0.018	1.127
W	34615561	62	0.027	1.701
X	9809968.9	62	0.008	0.482
Y	5045944	62	0.004	0.248
Z	21628485	62	0.017	1.063
XX	9809968.9	62	0.008	0.482
ZZ	37163532	62	0.029	1.826
YY	22945766	62	0.018	1.127
WW	22945766	62	0.018	1.127
	1.262E+09			

Direct Shear in East/West Direction At Level 2				
Wall Name	Rx	Vi (Kips)	Ri/ΣRi	V_{di}
1	24259346.23	62	0.033	2.020
2	9809968.894	62	0.013	0.817
3	43472748.45	62	0.058	3.620
4	8555851.492	62	0.011	0.712
5	13696532.02	62	0.018	1.140
6	16336541.48	62	0.022	1.360
7	8555851.492	62	0.011	0.712
8	24259346.23	62	0.033	2.020
9	12386755.72	62	0.017	1.031
10	24259346.23	62	0.033	2.020
11	22945766.48	62	0.031	1.911
12	5045944.017	62	0.007	0.420
13	17660804.06	62	0.024	1.471
14	25568887.33	62	0.034	2.129
15	17660804.06	62	0.024	1.471
16	24259346.23	62	0.033	2.020
17	44725345.45	62	0.060	3.724
18	44725345.45	62	0.060	3.724
19	93468857.94	62	0.126	7.783
20	68120244.23	62	0.091	5.672
21	7336026.301	62	0.010	0.611
22	28175143.22	62	0.038	2.346
23	43472748.45	62	0.058	3.620
24	35891429.3	62	0.048	2.988
25	30763981.26	62	0.041	2.562
26	8555851.492	62	0.011	0.712
27	24259346.23	62	0.033	2.020
28	4004580.454	62	0.005	0.333
29	12386755.72	62	0.017	1.031
	744619495.9			

Table 13: Direct Shear Forces in Longitudinal and Transverse Direction

Because of the uncertainty in the determinations of the center of mass and the center of rigidity, accidental eccentricity was added to the calculated eccentricity used to determine the torsional moment. The ASCE requires a minimum eccentricity of ± 5% of the building dimension. Therefore, the maximum eccentricities in the two directions are:

$$e_{xmax} = e_x \pm 0.05D_x = 21.59 \pm 0.05(316) = 37.39\ ft$$

$$e_{ymax} = e_y \pm 0.05D_y = 22.91 + 0.05(210) = 33.41\ ft$$

Torsional Shear in North/South At Level 2										
Wall Name	Rx (k/in)	dx (in)	Yi (in)	(Xi)^2	(Yi)^2	Ri*(Yi)^2	Ri*(Xi)^2	J	M_T	V_{ti}
A	9809968.9	-2237	302	5004169	91204	8.95E+11	4.9E+13	1.60E+15	27910.8	-0.38
AA	9809968.9	-2237	-46	5004169	2116	2.08E+10	4.9E+13	1.60E+15	27910.8	-0.38
B	6161606.9	-2213	-154	4897369	23716	1.46E+11	3.0E+13	1.60E+15	27910.8	-0.24
BB	6161606.9	-2213	-454	4897369	206116	1.27E+12	3.0E+13	1.60E+15	27910.8	-0.24
C	53422966	-1565	338	2449225	114244	6.10E+12	1.3E+14	1.60E+15	27910.8	-1.46
D	72977204	-1565	194	2449225	37636	2.75E+12	1.8E+14	1.60E+15	27910.8	-1.99
E	80233852	-1577	110	2486929	12100	9.71E+11	2.0E+14	1.60E+15	27910.8	-2.21
F	72977204	-1577	110	2486929	12100	8.83E+11	1.8E+14	1.60E+15	27910.8	-2.01
G	49709367	-1421	-130	2019241	16900	8.40E+11	1.0E+14	1.60E+15	27910.8	-1.23
H	20308017	-1373	-298	1885129	88804	1.80E+12	3.8E+13	1.60E+15	27910.8	-0.49
I	50949378	-401	182	160801	33124	1.69E+12	8.2E+12	1.60E+15	27910.8	-0.36
J	82646186	-329	38	108241	1444	1.19E+11	8.9E+12	1.60E+15	27910.8	-0.47
K	109029146	-323	-22	104329	484	5.28E+10	1.1E+13	1.60E+15	27910.8	-0.62
L	101856326	-323	-226	104329	51076	5.20E+12	1.1E+13	1.60E+15	27910.8	-0.57
M	94668503	-323	-295.6	104329	87379.36	8.27E+12	9.9E+12	1.60E+15	27910.8	-0.53
N	72977204	-323	-295.6	104329	87379.36	6.38E+12	7.6E+12	1.60E+15	27910.8	-0.41
O	17660804	727	-306.4	528529	93880.96	1.66E+12	9.3E+12	1.60E+15	27910.8	0.22
P	35891429	727	-306.4	528529	93880.96	3.37E+12	1.9E+13	1.60E+15	27910.8	0.46
Q	60798882	1162.6	-44.8	1351639	2007.04	1.22E+11	8.2E+13	1.60E+15	27910.8	1.23
R	7336026.3	1369	-334	1874161	111556	8.18E+11	1.4E+13	1.60E+15	27910.8	0.18
S	20308017	541	-60.4	292681	3648.16	7.41E+10	5.9E+12	1.60E+15	27910.8	0.19
T	29471731	605.8	297.2	366993.6	88327.84	2.60E+12	1.1E+13	1.60E+15	27910.8	0.31
U	9809968.9	917.8	387.2	842356.8	149923.8	1.47E+12	8.3E+12	1.60E+15	27910.8	0.16
V	22945766	605.8	440	366993.6	193600	4.44E+12	8.4E+12	1.60E+15	27910.8	0.24
W	34615561	605.8	704	366993.6	495616	1.72E+13	1.3E+13	1.60E+15	27910.8	0.37
X	9809968.9	501.4	962	251402	925444	9.08E+12	2.5E+12	1.60E+15	27910.8	0.09
Y	5045944	371.8	2477.6	138235.2	6138502	3.10E+13	7.0E+11	1.60E+15	27910.8	0.03
Z	21628485	579.4	1446.8	335704.4	2093230	4.53E+13	7.3E+12	1.60E+15	27910.8	0.22
XX	9809968.9	501.4	1377.2	251402	1896680	1.86E+13	2.5E+12	1.60E+15	27910.8	0.09
ZZ	37163532	610.6	1635.2	372832.4	2673879	9.94E+13	1.4E+13	1.60E+15	27910.8	0.40
YY	22945766	272.2	1762.4	74092.84	3106054	7.13E+13	1.7E+12	1.60E+15	27910.8	0.11
WW	22945766	272.2	1635.2	74092.84	2673879	6.14E+13	1.7E+12	1.60E+15	27910.8	0.11
	1.262E+09					**4.05E+14**	**1.2E+15**			**-9.21**

Torsional Shear in East/West At Level 2										
Wall Name	Rx (k/in)	Xi (in)	Yi (in)	(Xi)^2	(Yi)^2	Ri*(Yi)^2	Ri*(Xi)^2	J	V_{ey}	V_{ti}
1	24259346	-2292.2	-298	5254181	88804	2.15E+12	1.27E+14	1.17E+15	24940.8	-0.154
2	9809968.9	-2309	123.2	5331481	15178.24	1.49E+11	5.23E+13	1.17E+15	24940.8	0.026
3	43472748	-2141	-76	4583881	5776	2.51E+11	1.99E+14	1.17E+15	24940.8	-0.070
4	8555851.5	-2069	35.6	4280761	1267.36	1.08E+10	3.66E+13	1.17E+15	24940.8	0.006
5	13696532	-1809.8	-252.4	3275376	63705.76	8.73E+11	4.49E+13	1.17E+15	24940.8	-0.074
6	16336541	-1657.4	-252.4	2746975	63705.76	1.04E+12	4.49E+13	1.17E+15	24940.8	-0.088
7	8555851.5	-1196.6	32	1431852	1024	8.76E+09	1.23E+13	1.17E+15	24940.8	0.006
8	24259346	-1091	-287.2	1190281	82483.84	2.00E+12	2.89E+13	1.17E+15	24940.8	-0.148
9	12386756	-974.6	-118	949845.2	13924	1.72E+11	1.18E+13	1.17E+15	24940.8	-0.031
10	24259346	-966.2	195.2	933542.4	38103.04	9.24E+11	2.26E+13	1.17E+15	24940.8	0.101
11	22945766	427	-301.6	182329	90962.56	2.09E+12	4.18E+12	1.17E+15	24940.8	-0.147
12	5045944	980.2	-217.6	960792	47349.76	2.39E+11	4.85E+12	1.17E+15	24940.8	-0.023
13	17660804	1328.2	-196	1764115	38416	6.78E+11	3.12E+13	1.17E+15	24940.8	-0.074
14	25568887	1459	-76	2128681	5776	1.48E+11	5.44E+13	1.17E+15	24940.8	-0.041
15	17660804	980.2	170	960792	28900	5.10E+11	1.70E+13	1.17E+15	24940.8	0.064
16	24259346	807.4	195.2	651894.8	38103.04	9.24E+11	1.58E+13	1.17E+15	24940.8	0.101
17	44725345	676.6	195.2	457787.6	38103.04	1.70E+12	2.05E+13	1.17E+15	24940.8	0.186
18	44725345	400.6	326	160480.4	106276	4.75E+12	7.18E+12	1.17E+15	24940.8	0.311
19	93468858	333.4	653.6	111155.6	427193	3.99E+13	1.04E+13	1.17E+15	24940.8	1.302
20	68120244	163	653.6	26569	427193	2.91E+13	1.81E+12	1.17E+15	24940.8	0.949
21	7336026.3	613	582.8	375769	339655.8	2.49E+12	2.76E+12	1.17E+15	24940.8	0.091
22	28175143	818.2	1078.4	669451.2	1162947	3.28E+13	1.89E+13	1.17E+15	24940.8	0.647
23	43472748	664.6	1078.4	441693.2	1162947	5.06E+13	1.92E+13	1.17E+15	24940.8	0.999
24	35891429	598.6	1115.6	358322	1244563	4.47E+13	1.29E+13	1.17E+15	24940.8	0.853
25	30763981	412.6	1115.6	170238.8	1244563	3.83E+13	5.24E+12	1.17E+15	24940.8	0.731
26	8555851.5	818.2	1538	669451.2	2365444	2.02E+13	5.73E+12	1.17E+15	24940.8	0.280
27	24259346	400.6	1636.4	160480.4	2677805	6.50E+13	3.89E+12	1.17E+15	24940.8	0.846
28	4004580.5	129.4	1692.8	16744.36	2865572	1.15E+13	6.71E+10	1.17E+15	24940.8	0.144
29	12386756	224.2	-118	50265.64	13924	1.72E+11	6.23E+11	1.17E+15	24940.8	-0.031
	744619496					**3.53E+14**	**8.17E+14**			**6.760**

Table 14: Torsional Force in Each Wall in Both Directions on the First Floor

Shear in Each Wall at All Levels in Longitudinal Direction (Kips)								
Wall No.	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Level 5**	**Level 6**	**Level 7**	**Roof**
A	-	0.48	0.96	1.45	1.94	2.42	2.90	2.78
AA	-	0.48	0.96	1.45	1.94	2.42	2.90	2.78
B	-	0.30	0.61	0.91	1.22	1.52	1.82	1.74
BB	-	0.30	0.61	0.91	1.22	1.52	1.82	1.74
C	-	2.62	5.25	7.92	10.54	13.17	15.79	15.11
D	-	3.59	7.17	10.81	14.40	17.99	21.57	20.65
E	-	3.94	7.88	11.89	15.83	19.77	23.72	22.70
F	-	3.59	7.17	10.81	14.40	17.99	21.57	20.65
G	-	2.44	4.88	7.37	9.81	12.25	14.69	14.06
H	-	1.00	2.00	3.01	4.01	5.01	6.00	5.75
I	-	2.50	5.01	7.55	10.05	12.56	15.06	14.41
J	-	4.06	8.12	12.25	16.31	20.37	24.43	23.38
K	-	5.36	10.71	16.16	21.51	26.87	32.23	30.85
L	-	5.00	10.01	15.09	20.10	25.10	30.11	28.82
M	-	4.65	9.30	14.03	18.68	23.33	27.98	26.78
N	-	3.59	7.17	10.81	14.40	17.99	21.57	20.65
O	-	1.09	2.18	3.29	4.38	5.47	6.57	6.28
P	-	2.22	4.44	6.69	8.90	11.12	13.34	12.77
Q	-	4.22	8.44	12.71	16.93	21.16	25.38	24.28
R	-	0.54	1.07	1.61	2.15	2.68	3.22	3.08
S	-	1.19	2.38	3.59	4.77	5.96	7.15	6.85
T	-	1.76	3.52	5.30	7.06	8.82	10.58	10.13
U	-	0.64	1.28	1.93	2.56	3.20	3.84	3.68
V	-	1.37	2.74	4.13	5.50	6.87	8.24	7.88
W	-	2.07	4.13	6.23	8.30	10.36	12.43	11.89
X	-	0.57	1.14	1.71	2.28	2.85	3.42	3.27
Y	-	0.28	0.56	0.85	1.13	1.41	1.69	1.62
Z	-	1.28	2.56	3.86	5.14	6.42	7.71	7.37
XX	-	0.57	1.14	1.71	2.28	2.85	3.42	3.27
ZZ	-	2.22	4.44	6.70	8.92	11.14	13.36	12.79
YY	-	1.24	2.47	3.73	4.96	6.20	7.44	7.12
WW	-	1.24	2.47	3.73	4.96	6.20	7.44	7.12

Table 15: Total Shear in all Walls at all the Level

Building Torsion in North/South Direction					
Level	**Fx (kips)**	**L**	e_{acc}	e_i	M_T **(k-ft)**
Roof	357	316	15.8	21.59	13334.7
7	373	316	15.8	21.59	13955.7
6	311	316	15.8	21.59	11629.7
5	249	316	15.8	21.59	9303.8
4	187	316	15.8	21.59	6977.8
3	124	316	15.8	21.59	4651.9
2	62	316	15.8	21.59	2325.9
1	-	-	-	-	-
				TOTAL: (ft-kips) =	**62179.6**

Table 16: Building Torsion in North/South Direction

Shear in Each Wall at All Levels in Transverse Direction (Kips)								
Wall No.	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Level 5**	**Level 6**	**Level 7**	**Roof**
1	-	2.02	4.04	6.09	8.11	10.13	12.15	11.63
2	-	0.82	1.63	2.46	3.28	4.10	4.91	4.70
3	-	3.62	7.24	10.92	14.54	18.16	21.78	20.84
4	-	0.71	1.42	2.15	2.86	3.57	4.29	4.10
5	-	1.14	2.28	3.44	4.58	5.72	6.86	6.57
6	-	1.36	2.72	4.10	5.46	6.82	8.18	7.83
7	-	0.71	1.42	2.15	2.86	3.57	4.29	4.10
8	-	2.02	4.04	6.09	8.11	10.13	12.15	11.63
9	-	1.03	2.06	3.11	4.14	5.17	6.20	5.94
10	-	2.12	4.19	6.31	8.41	10.50	12.60	12.05
11	-	1.76	3.61	5.44	7.24	9.04	10.85	10.38
12	-	0.40	0.81	1.22	1.62	2.02	2.42	2.32
13	-	1.40	2.83	4.27	5.69	7.11	8.52	8.16
14	-	2.09	4.20	6.33	8.43	10.53	12.63	12.08
15	-	1.53	3.03	4.58	6.09	7.61	9.13	8.74
16	-	2.12	4.19	6.31	8.41	10.50	12.60	12.05
17	-	3.91	7.72	11.64	15.50	19.36	23.22	22.22
18	-	4.03	7.90	11.91	15.87	19.82	23.77	22.75
19	-	9.08	17.47	26.33	35.07	43.81	52.54	50.28
20	-	6.62	12.73	19.19	25.56	31.93	38.29	36.64
21	-	0.70	1.36	2.04	2.72	3.40	4.08	3.90
22	-	2.99	5.64	8.50	11.32	14.14	16.96	16.23
23	-	4.62	8.70	13.11	17.46	21.81	26.17	25.04
24	-	3.84	7.23	10.89	14.50	18.11	21.73	20.79
25	-	3.29	6.19	9.33	12.43	15.53	18.62	17.82
26	-	0.99	1.84	2.76	3.68	4.60	5.52	5.28
27	-	2.87	5.28	7.95	10.59	13.23	15.87	15.18
28	-	0.48	0.88	1.32	1.76	2.20	2.64	2.53
29	-	1.00	2.02	3.04	4.05	5.06	6.07	5.81

Table 17: Shear Forces in Each Wall

For a complete table of each wall, see Appendix C.

Building Torsion in East/West Direction					
Level	**Fx (kips)**	**L**	e_{acc}	e_i	M_T **(k-ft)**
Roof	357	210	10.5	22.91	11915.3
7	373	210	10.5	22.91	12470.1
6	311	210	10.5	22.91	10391.8
5	249	210	10.5	22.91	8313.4
4	187	210	10.5	22.91	6235.1
3	124	210	10.5	22.91	4156.7
2	62	210	10.5	22.91	2078.4
1	-	-	-	-	-
				TOTAL: (ft-kips) =	**55560.8**

Table 18: Building Torsion in East/West Direction

SHEAR STRENGTH CHECK

It is the responsibility of the designer to verify that the masonry shear walls designed have adequate capacity to resist shear forces acting on the walls either by the masonry itself or by shear reinforcing. Under flexural tension, the applied shear force on masonry shear walls is determined as follows:

$$f_v = \frac{V}{bd}$$

Designed shear stresses were calculated to resist 1.5 times the calculated force as required by code for shear walls which resist seismic forces.

For shear walls, the allowable shear stress F_v is determined in accordance with the following when reinforcement is not provided to resist to entire shear stress. Moreover, the allowable shear can be increased by 1/3 allowed by code when seismic (or wind) loads control.

Where M/Vd <1,

$$F_v = \left(\frac{1}{3}\right)\left[4 - \left(\frac{M}{Vd}\right)\right]\sqrt{f'm} \leq 80 - 45\left(\frac{M}{Vd}\right)$$

Where M/Vd ≥ 1,

$$F_v = \sqrt{f'm} \leq 35 \text{ psi}$$

Where shear reinforcement is provided, the minimum is determined as follows:

$$A_s = VS/(F_s d)$$

The tables below show the shear strength check on level 1 and on level 5 in both transverse and longitudinal direction. For both levels, all walls in transverse and longitudinal direction have adequate capacity to resist the applied shear forces. Therefore, no shear reinforcing is needed.

Shear Strength Check on Level 1, Longitudinal Direction									
Wall No.	L (in)	M (kip-in)	V (k)	d (in)	M/Vd	f_v (psi)	Fv (psi) w/out reinf [min of two #]		Check
A	168	634.3	13	165	0.30	10	95	67	OK
AA	168	634.3	13	165	0.30	10	95	67	OK
B	132	398.4	8	129	0.38	8	93	63	OK
BB	132	398.4	8	129	0.38	8	93	63	OK
C	576	3454.2	70	573	0.09	16	100	76	OK
D	768	4718.5	96	765	0.06	16	101	77	OK
E	840	5187.7	106	837	0.06	17	101	77	OK
F	768	4718.5	96	765	0.06	16	101	77	OK
G	540	3214.1	66	537	0.09	16	100	76	OK
H	264	1313.1	27	261	0.19	13	97	72	OK
I	552	3294.2	67	549	0.09	16	100	76	OK
J	864	5343.7	109	861	0.06	17	101	77	OK
K	1128	7049.5	144	1125	0.04	17	101	78	OK
L	1056	6585.7	134	1053	0.05	17	101	78	OK
M	984	6121.0	125	981	0.05	17	101	78	OK
N	768	4718.5	96	765	0.06	16	101	77	OK
O	240	1435.9	29	237	0.21	16	97	71	OK
P	408	2918.2	59	405	0.12	19	99	75	OK
Q	648	5549.8	113	645	0.08	23	100	77	OK
R	144	704.3	14	141	0.35	13	93	64	OK
S	264	1564.7	32	261	0.19	16	97	72	OK
T	348	2314.4	47	345	0.14	18	99	74	OK
U	168	840.5	17	165	0.30	14	95	67	OK
V	288	1801.9	37	285	0.17	17	98	72	OK
W	396	2718.4	55	393	0.12	18	99	74	OK
X	168	746.9	15	165	0.30	12	95	67	OK
Y	120	369.2	8	117	0.42	8	92	61	OK
Z	276	1685.4	34	273	0.18	16	98	72	OK
XX	168	746.9	15	165	0.30	12	95	67	OK
ZZ	420	2922.6	60	417	0.12	19	99	75	OK
YY	288	1626.6	33	285	0.17	15	98	72	OK
WW	288	1626.6	33	285	0.17	15	98	72	OK

Shear Strength Check on Level 1, Transverse Direction									
Wall No.	L (in)	M (kip-in)	V (k)	d (in)	M/Vd	f_v (psi)	Fv (psi) w/out reinf (X 1.33) [min of two #]		Check
1	300	2658	54	297	0.2	24	98	73	OK
2	168	1075	22	165	0.3	17	95	67	OK
3	480	4763	97	477	0.1	27	100	75	OK
4	156	937	19	153	0.3	16	94	66	OK
5	204	1501	31	201	0.2	20	96	69	OK
6	228	1790	36	225	0.2	21	97	70	OK
7	156	937	19	153	0.3	16	94	66	OK
8	300	2658	54	297	0.2	24	98	73	OK
9	192	1357	28	189	0.3	19	96	68	OK
10	300	2755	56	297	0.2	25	98	73	OK
11	288	2372	48	285	0.2	22	98	72	OK
12	120	530	11	117	0.4	12	92	61	OK
13	240	1864	38	237	0.2	21	97	71	OK
14	312	2762	56	309	0.2	24	98	73	OK
15	240	1997	41	237	0.2	23	97	71	OK
16	300	2755	56	297	0.2	25	98	73	OK
17	492	5080	104	489	0.1	28	100	75	OK
18	492	5200	106	489	0.1	28	100	75	OK
19	972	11495	235	969	0.1	32	101	78	OK
20	720	8378	171	717	0.1	31	101	77	OK
21	144	892	18	141	0.3	17	93	64	OK
22	336	3711	76	333	0.1	30	98	73	OK
23	480	5725	117	477	0.1	32	100	75	OK
24	408	4754	97	405	0.1	31	99	75	OK
25	360	4075	83	357	0.1	31	99	74	OK
26	156	1208	25	153	0.3	21	94	66	OK
27	300	3473	71	297	0.2	31	98	73	OK
28	108	578	12	105	0.5	15	90	59	OK
29	192	1327	27	189	0.3	19	96	68	OK

Table 19: Shear Strength Check at Level 1 in Longitudinal and Transverse direction

Shear Strength Check on Level 5, Longitudinal Direction									
Wall No.	L (in)	M (kip-in)	V (k)	d (in)	M/Vd	f_v (psi)	Fv (psi) w/out reinf [min of two #]		Check
A	168	165.4	10	165	0.10	8	100	76	OK
AA	168	165.4	10	165	0.10	8	100	76	OK
B	132	103.9	6	129	0.13	6	99	74	OK
BB	132	103.9	6	129	0.13	6	99	74	OK
C	576	900.9	55	573	0.03	12	102	79	OK
D	768	1230.7	75	765	0.02	13	102	79	OK
E	840	1353.0	82	837	0.02	13	102	79	OK
F	768	1230.7	75	765	0.02	13	102	79	OK
G	540	838.3	51	537	0.03	12	101	79	OK
H	264	342.5	21	261	0.06	10	101	77	OK
I	552	859.2	52	549	0.03	12	101	79	OK
J	864	1393.7	84	861	0.02	13	102	79	OK
K	1128	1838.6	111	1125	0.01	13	102	79	OK
L	1056	1717.7	104	1053	0.02	13	102	79	OK
M	984	1596.5	97	981	0.02	13	102	79	OK
N	768	1230.7	75	765	0.02	13	102	79	OK
O	240	374.5	23	237	0.07	13	100	77	OK
P	408	761.1	46	405	0.04	15	101	78	OK
Q	648	1447.5	88	645	0.03	18	102	79	OK
R	144	183.7	11	141	0.12	10	99	75	OK
S	264	408.1	25	261	0.06	12	101	77	OK
T	348	603.6	37	345	0.05	14	101	78	OK
U	168	219.2	13	165	0.10	11	100	76	OK
V	288	470.0	28	285	0.06	13	101	77	OK
W	396	709.0	43	393	0.04	14	101	78	OK
X	168	194.8	12	165	0.10	9	100	76	OK
Y	120	96.3	6	117	0.14	7	99	74	OK
Z	276	439.6	27	273	0.06	13	101	77	OK
XX	168	194.8	12	165	0.10	9	100	76	OK
ZZ	420	762.2	46	417	0.04	15	101	78	OK
YY	288	424.3	26	285	0.06	12	101	77	OK
WW	288	424.3	26	285	0.06	12	101	77	OK

Shear Strength Check on Level 5, Transverse Direction									
Wall No.	L (in)	M (kip-in)	V (k)	d (in)	M/Vd	f_v (psi)	Fv (psi) w/out reinf (X 1.33) [min of two #]		Check
1	300	693	42	297	0.06	19	101	78	OK
2	168	280	17	165	0.10	13	100	76	OK
3	480	1242	75	477	0.03	21	101	78	OK
4	156	245	15	153	0.11	13	99	75	OK
5	204	391	24	201	0.08	15	100	76	OK
6	228	467	28	225	0.07	16	100	77	OK
7	156	245	15	153	0.11	13	99	75	OK
8	300	693	42	297	0.06	19	101	78	OK
9	192	354	21	189	0.09	15	100	76	OK
10	300	719	44	297	0.06	19	101	78	OK
11	288	619	38	285	0.06	17	101	77	OK
12	120	138	8	117	0.14	9	99	74	OK
13	240	486	29	237	0.07	16	100	77	OK
14	312	720	44	309	0.05	19	101	78	OK
15	240	521	32	237	0.07	17	100	77	OK
16	300	719	44	297	0.06	19	101	78	OK
17	492	1325	80	489	0.03	22	101	78	OK
18	492	1356	82	489	0.03	22	101	78	OK
19	972	2997	182	969	0.02	25	102	79	OK
20	720	2184	132	717	0.02	24	102	79	OK
21	144	232	14	141	0.12	13	99	75	OK
22	336	967	59	333	0.05	23	101	78	OK
23	480	1493	90	477	0.03	25	101	78	OK
24	408	1239	75	405	0.04	24	101	78	OK
25	360	1062	64	357	0.05	24	101	78	OK
26	156	315	19	153	0.11	16	99	75	OK
27	300	905	55	297	0.06	24	101	78	OK
28	108	151	9	105	0.16	11	98	73	OK
29	192	346	21	189	0.09	15	100	76	OK

Table 20: Shear Strength Check at Level 5 in Longitudinal and transverse direction

DRIFT CALCULATIONS

The lateral deflection (drift) of all the stories and of the building is calculated under full lateral load and is checked against the appropriate code limit. A drift limit of 0.25 % of the story or building height (H/400) is a typical value for seismic loading for structures having a fundamental period of less than 0.7 s. The allowable building drift is $0.010H_{sx}$ for seismic loads with occupancy category III. In this report, the drift in the longitudinal direction is considered because the overturning moment is higher and the rigidity is smaller. Based on the linear elastic response and assuming all walls act as cantilevers, the top story deflection is calculated. The relative amount of shear deformation is ignored because it is small and the lowest height-to-length ratio is 70/54 = 1.29.

Limits:

$$\Delta_{\text{wind}} = \frac{\text{L}}{400} \text{ or } \frac{\text{L}}{500}$$

$\Delta_{\text{Seismic}} = 0.010h_{SX}$ for Occupancy Category III & Masonry cantilever shear walls

Top Story Drift: the top story drift is

$$\Delta_{top} = \int_0^H \left(\frac{M}{EI}\right) d_z\, d_z \quad where I_{xi} = \frac{tL^3}{12} \quad ; \; and \; I = \sum I_{xi} = 237{,}065\ ft\text{^}4$$

We can approximate the concentrated loads at the floor levels by a triangular loading with a maximum intensity of

$$P = \left(\frac{2V_x}{H}\right) = 2 * \frac{1663}{70} = 47.51\frac{kips}{ft}$$

$$E_m = 900f'_m = 900*6000 = 5400 \text{ ksi} = 777{,}600 \text{ kips/ft}^2$$

By applying the moment-area method,

M = 1663((2/3)(70)) – 1663z + (47.51/70)(z)(z/2)(z/3)

M = 77,607 – 1663z + (47.51/70)(z)(z/2)(z/3)

$$\Delta = \frac{1}{EI} \iint M \; d_z d_z$$

$$\Delta = \frac{1}{EI}\left[\left(\frac{77607z^2}{2}\right) - \left(\frac{1663z^3}{6}\right) + (0.678)\left(\frac{z^5}{6}\right)\left(\frac{1}{20}\right)\right]_0^{70} = \frac{1.046*10^8}{EI} = 0.00057\,ft = 0.0068\,in$$

Since the walls are reinforced, we expect cracking to occur; therefore, the moment of inertia of the cracked sections should be used. We can approximate it as being 30% of the uncracked section value. On the basis, the maximum drift at the top of the building would be:

Δ = 0.0068/0.30 = 0.023 in which is considerable less than the H/400 limit;

Δ_{limit} = 0.010(70) = 0.7 in ≥ 0.023 ∴ ok

First Story Drift:

From the previous calculations, it might be deduced that inter-story drift is not critical; however, the first story will be checked using the moment-area method:

$$\Delta_1 = \left(\frac{1}{EI}\right)\left[(64944)(10)(5) + \left(\frac{1}{2}\right)(81574 - 64944)(10)(6.67)\right]$$

$$= \frac{(3801811)(12000)(12^2)}{(5400000)(237065)(12^4)} = 0.00025 \; \leq 0.7 \text{ in } \therefore \text{ok}$$

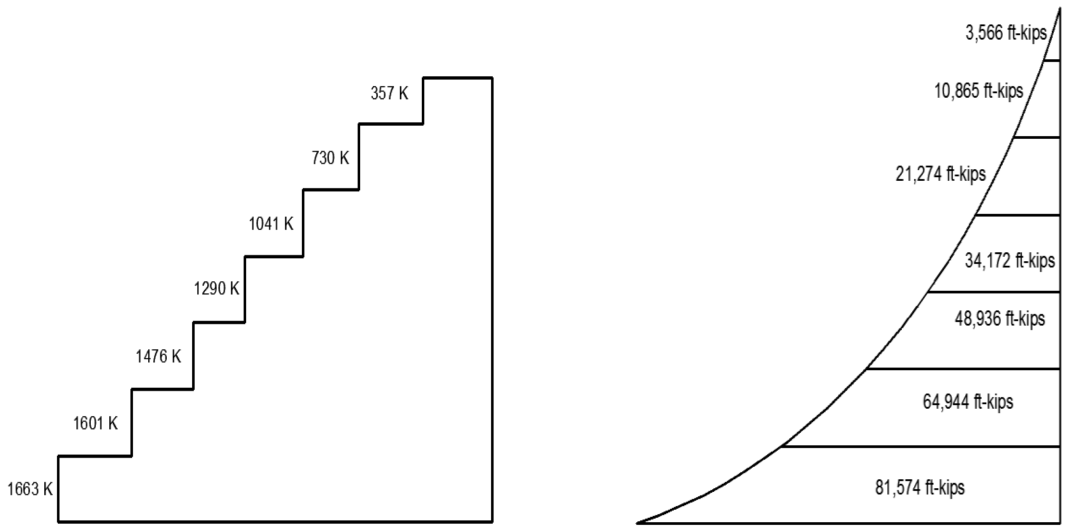


Figure 21: Shear and Moments due to Seismic Loads

CONSTRUCTION BREADTH

For minimum interruption of the construction process, precast hollow core concrete planks are often used with loadbearing masonry walls. There are many advantages of using precast hollow core planks such as quick erection time, cost savings, quality control, etc… In addition, prefabrication permits to avoid complex steel connections.

COST

In this comparison, the gravity and lateral resisting system of the existing structure are compared with the masonry shear walls that carry the gravity and lateral loads in the new system. The existing building lateral system has very complex comment connections to take the loads in both transverse and longitudinal direction. The proposed system uses reinforced loadbearing walls as shear walls to carry gravity loads and resist lateral loads.

Since both structures have the same square footages per floor, the cost of the building was evaluated on a typical floor for each system. For the existing system, materials such as beams, columns, open web bar joists, concrete topping, welded wire fabric, high strength bolts, and concrete forms are included in the total cost. In addition, labor for field welding is included. Similarly, precast planks, 2" concrete topping, rebar, and masonry blocks constitute the materials for the new system. It was found that the existing system's total cost per floor is around $ 637,695.88 compared to $ 526,276.48 for the new system, which constitute a total saving of $ 111,419.40 per floor. However, the overall cost of the proposed structure is slightly higher than that of the existing. It was determined that the proposed building total project cost is $ 1,133,151.84 addition as compared to the existing building when taking in account the additional three floors. Both cost estimates include overhead and profit.

Cost Comparison per Floor			
	SF	Cost	% Difference
Exisiting	24380	$637,695.88	
Proposed	24380	$526,276.48	17.50%
Saving		$111,419.40	

Cost Estimate		
	# of Stories	Total W/ O&P
Existing 4 Stories	4 Stories	$ 2,550,783.52
Equivalent Reinforced Masonry	4 Stories	$ 2,105,105.92
Proposed Reinforced Masonry	7 Stories	$ 3,683,935.36

Table 21: Cost Comparison

Please note that this analysis was recreated base on available details and that the actual cost of the building was not provided at the time the analysis was being completed. A breakdown of all material costs can be found in Appendix F

Existing System																
LineNumber	Quantity	Unit	Description	Crew	Daily Output	Labor Hours	Days to Complete	Mat. O&P	Labor O&P	Equip. O&P	Total O&P	Ext. Mat. O&P	Ext. Labor O&P	Ext. Equip. O&P	Ext. Total O&P	Labor Type
51223750360	2080.43	L.F.	W8x24 Columns	E2	550	0.102	3.78	$ 32.19	$ 8.60	$ 3.40	$ 44.19	$ 66,969.04	$ 17,891.70	$ 7,073.46	$ 91,934.20	STD
51223755300	3575.73	L.F.	W24x68 Beams	E5	1110	0.072	3.22	$ 90.85	$ 6.25	$ 1.82	$ 98.92	$ 324,855.07	$ 22,348.31	$ 6,507.83	$ 353,711.21	STD
52119100540	487.599	L.F.	Open Web Bar joists	E7	2000	0.04	0.24	$7.25	$3.24	$1.17	$11.67	$ 3,535.09	$ 1,579.82	$ 570.49	$ 5,690.28	STD
50521901500	264	L.F.	Field Welding - 1/4" thick	E14	50	0.16	5.28	$0.66	$14.00	$3.36	$18.02	$ 174.24	$ 3,696.00	$ 887.04	$ 4,757.28	STD
50523250300	44	Ea	High Strength Bolts - 3/4" dis. A325	1 Sswk	105	0.076	0.42	$1.60	$6.35	$ -	$7.95	$ 70.40	$ 279.40	$ -	$ 349.80	STD
33053405001	24380	S.F.	4" thick Structural concrete	C14G	2873	0.019	8.49	$ 1.10	$ 0.85	$ 0.01	$ 1.96	$ 26,818.00	$ 20,723.00	$ 243.80	$ 47,784.80	STD
32205500500	243.8	C.S.F.	Welded wire fabric, sheets, 4 x 4	2 Rodm	31	0.516	7.86	$ 21.71	$ 27.74	$ -	$ 49.45	$ 5,292.90	$ 6,763.01	$ -	$ 12,055.91	STD
31113351500	24380	S.F.	C.I.P. concrete forms	C2	495	0.097	49.25	$ 1.02	$ 3.96	$ -	$ 4.98	$ 24,867.60	$ 96,544.80	$ -	$ 121,412.40	STD
							78.55									
Total												$ 452,582.34	$ 169,826.04	$ 15,282.62	$ 637,695.88	

New System																
LineNumber	Quantity	Unit	Description	Crew	Daily Output	Labor Hours	Days to Complete	Mat. O&P	Labor O&P	Equip. O&P	Total O&P	Ext. Mat. O&P	Ext. Labor O&P	Ext. Equip. O&P	Ext. Total O&P	Labor Type
034113500100	24380	S.F.	8" Hollowcore, untoped	C11	3200	0.023	7.62	$ 7.48	$ 2.02	$ 0.72	$ 10.22	$ 182,362.40	$ 49,247.60	$ 17,553.60	$ 249,163.60	STD
033105350416	150.5	C.Y.	2" topping	C14B	260	0.8	0.58	$ 86.25	$ -	$ -	$ 86.25	$ 12,980.63	$ -	$ -	$ 12,980.63	STD
032110600150	39.05	Ton	2 #8's Rebar at 16" o.c.	4 Rodm	2.7	11.852	14.46	$1,037.38	$ 637.05	$ -	$1,674.43	$ 40,509.69	$ 24,876.80	$ -	$ 65,386.49	STD
042210280600	19504	S.F.	8" High Strength Hollow Concrete Bl	D8	360	0.111	54.18	$ 3.89	$ 6.30	$ -	$ 10.19	$ 75,870.56	$ 122,875.20	$ -	$ 198,745.76	STD
							76.84									
Total												$ 311,723.28	$ 196,999.60	$ 17,553.60	$ 526,276.48	

Table 22: Detailed Cost Analysis

SCHEDULE

The existing system is very labor intensive. It takes time to finish the moment connections before the system could be done. Likewise, the reinforced loadbearing walls needs to be started ahead of time, have connection plates set, and have concrete cured before the next level up can be built. Both systems require a strict collaboration between the teams to accomplish their task on time. In the existing system, if the columns' and beams' crew or connection crew does not finish their task on time, the concrete crew cannot proceed. Similarly, in the proposed system, the masonry crew needs to finish their part before the floor crew can start their task. In most cases, the activities are directly related. The following schedules show the critical paths in both schedules. Based on the crew type, labor hours, and quantity obtained from RSMeans, it was found that the new system will take 76.84 days to complete as opposed to 78.55 days for the existing system without fireproofing per floor level. The total cost with fireproofing of the existing is 94.38 days per floor level. When taking in account the three floors, the new structure will take 160.36 days additional to completion.

Existing Schedule per Floor											
Coordination	**Task**	**Amount**	**Crews**	**Daily Output**	**Days Steel Frame**	**Comment connections**	**Floor joists**	**Concrete Placment/ Forwork**	**Fireproofing**	**Total Days of Work**	**Total per Floor**
Complete Before Beams	Columns-W8's	2080.43	1	550	3.78					7.00	78.13
Complete Before Connections	Beams - W24's	3575.73	1	1110	3.22						
Moment Connection	Bolting	44	1	105		0.42				0.42	
	Welding	264	1	50		5.28				5.28	
After Welding	Open Bar Joists	487.599	1	2000			0.24			0.24	
Complete Before Placing Concrete	Formwork	24380	1	495				49.25		65.60	
	Welded wire fabric	243.8	1	31				7.86			
1 week allowance	Placing Concrete	24380	1	2873				8.49			
After Floor is Done	Fireproofing	24380	1	1500					16.25	16.25	16.25
Total											**94.38**

Proposed Schedule per Floor									
Coordination	**Task**	**Amount**	**Crews**	**Daily Output**	**Wall Construction**	**Floor Placement/ Formwork**	**Topping**	**Total Days of Work**	**Total per Floor**
8" CMU	Wall placement	19504	1	360	54.18			68.64	76.84
	Reinforcement	39.05	1	2.7	14.46				
Floor Before topping	Hollowcore Planks	24380	1	3200		7.62		7.62	
2" Topping	Placement	150.5	1	260			0.58	0.58	
Total									**76.84**

Table 23: Detailed Schedule

ARCHITECTURAL BREADTH

The design of loadbearing masonry buildings has been expanded in practical due to the availability of high strength masonry units, improved grouting, reinforcing techniques, and the contribution of building codes.

In this report, the goal for the architectural breadth is to modify the existing floor plans to align the loadbearing walls in view of creating the most effective way to transfer the vertical loads to the foundation. This cannot be done to the existing layout due to the large span (>40) of the corridor walls and the exterior walls. For a span larger than 40, the proposed precast hollow core planks will not work properly or could generate serious deflection problems.

The proposed floors plans started with the desire to limit the span of the hollow core planks, to reduce the length of the 300 ft long double loaded corridor, to improve student collaboration, and to maximize the space. Two central corridors were created and a lot of student study rooms and toilets were placed in the middle as shown in the floor plans below. The overall height of the building was kept the same; however, the floor to ceiling height was reduced to 10 ft. This procedure permits the addition of 3 supplementary stories to the proposed building without increasing the overall height of the building.

This redesign incorporated a lot of the code issues such as dead-ends; travel distances, exits, corridor width, etc. The diagrams below show the provisions implemented in the redesign such as a minimum of 44" stairwell exit, a minimum of 32" door width, and a minimum of 6' corridor width.

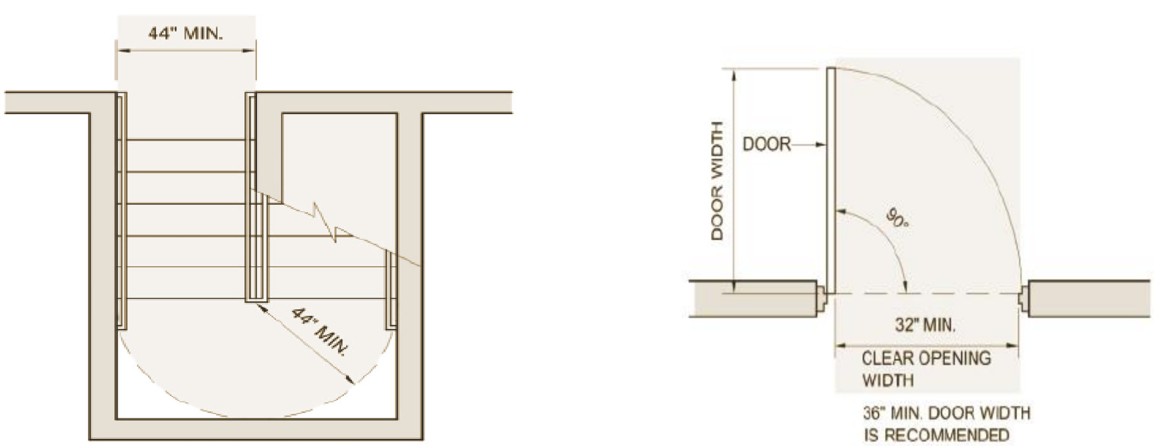


Figure 22: Clearance Details (Courtesy of FBC)

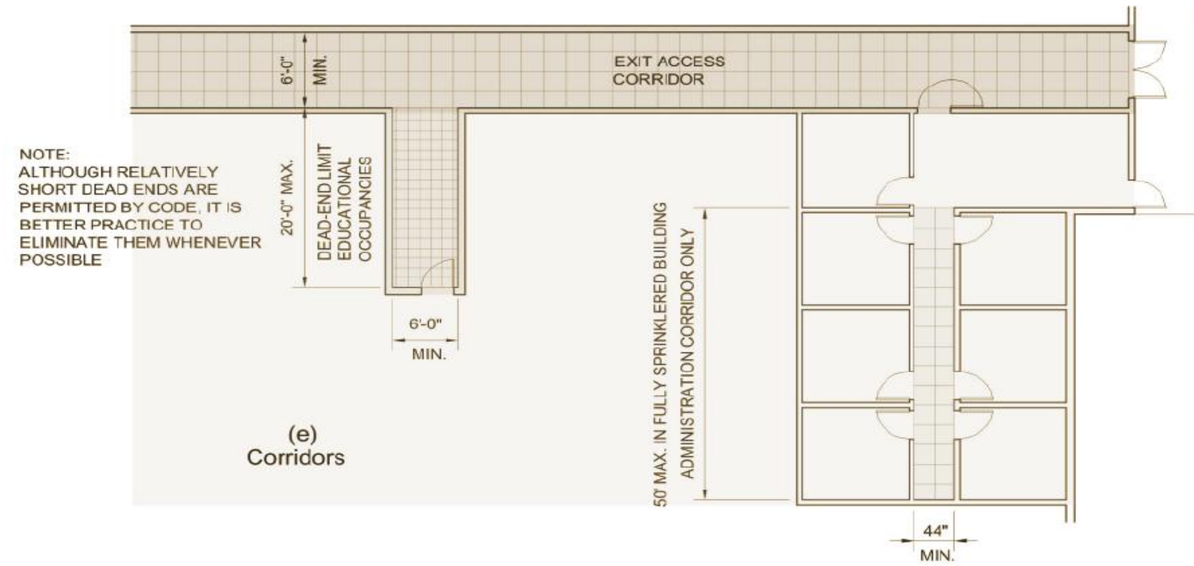


Figure 23: Corridor and Dead-End Detail (Courtesy of FBC)

Since the proposed building has trees more stories than the existing building without the increased of the height of the building, the total number of occupancy has increased from 268 to 392 student rooms. The minimum numbers of exists is more than satisfactory by code which requires 2 exits per story per occupancy of under 500.   Travel distances were another important factor of the code that was considered. For the proposed building, the travel distance was kept less than 150 ft from any point in the building.

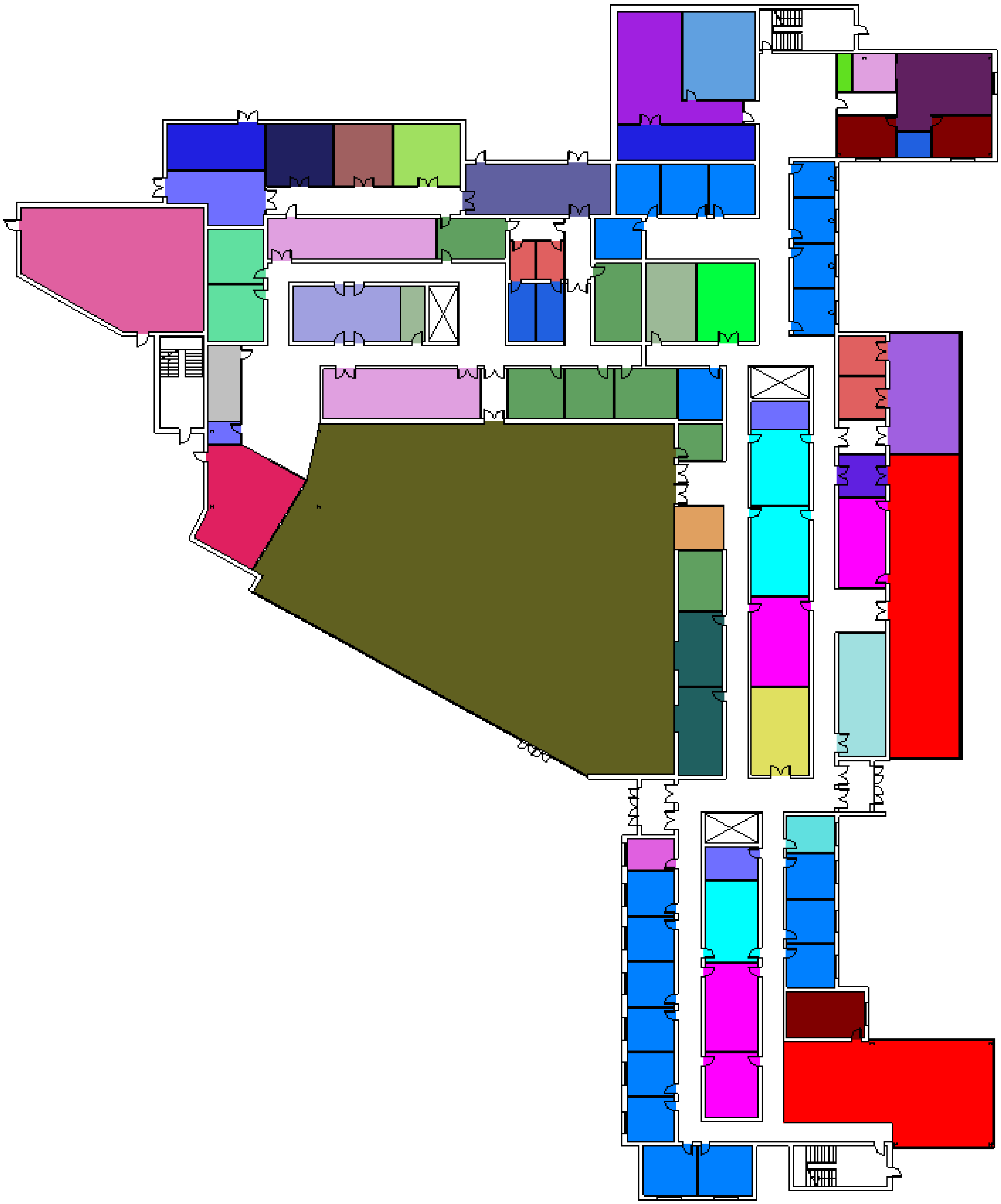


Figure 24: Proposed Upper Floor Plans

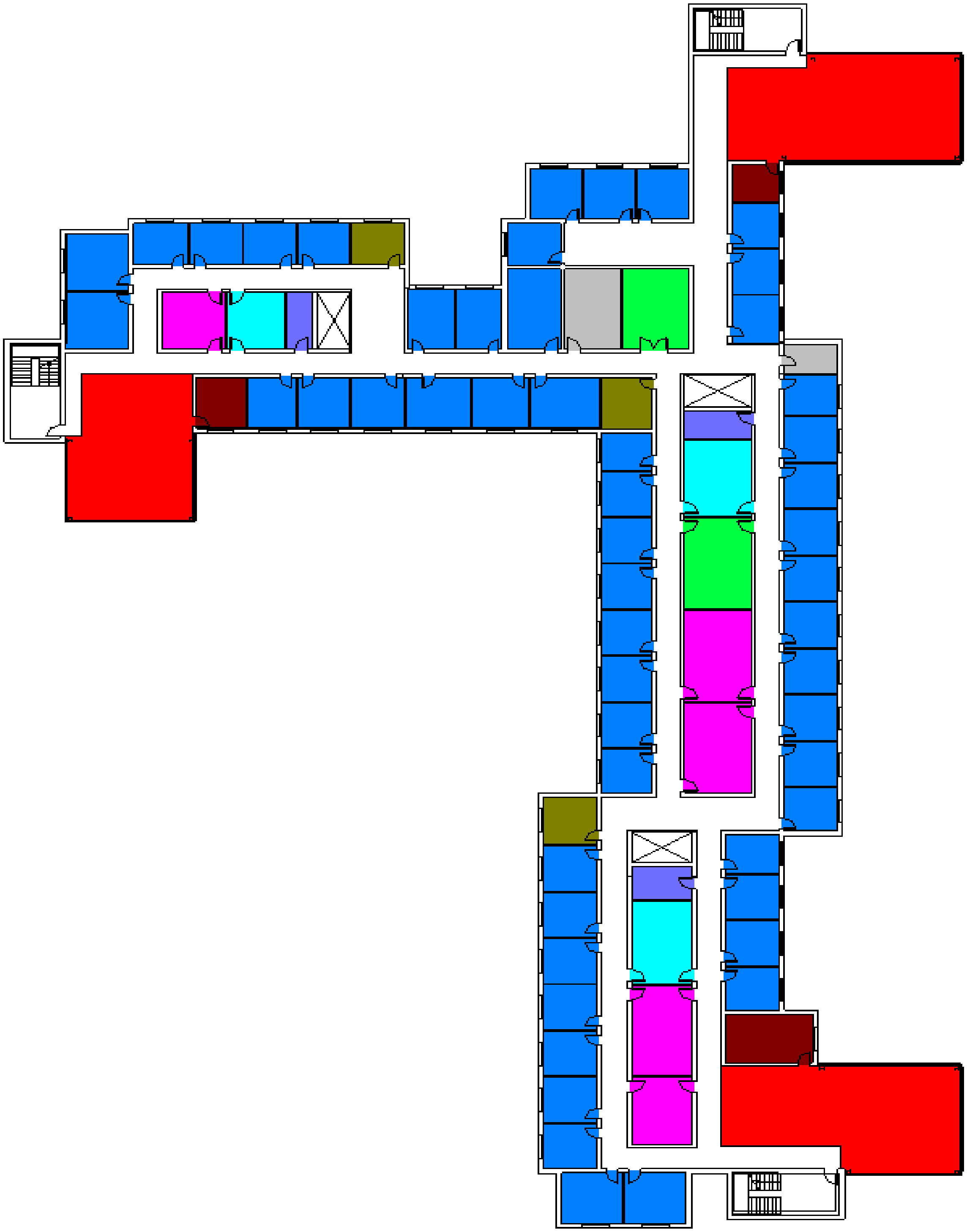


Figure 25: Upper Floor Plans

Facades:

Figure 26: South Façade

Figure 27: Perspective view

Figure 28: Perspective view

Figure 29: Perspective view

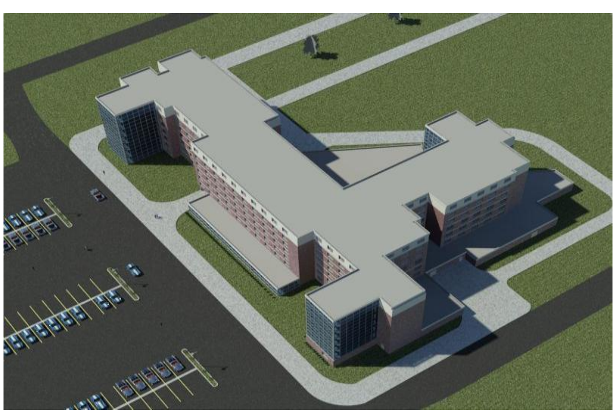


Figure 30: Perspective view

CONCLUSION

The overall focus of this report was to redesign the structure of the Dauphin Hall using reinforced masonry and determine if the alternative design is feasible in terms of overall design and cost. Since the existing design has a potential to include more floors, the proposed design was analyzed with the consideration of three additional floors.

The main goal for the depth of the proposal was met through the design of the reinforced masonry structure. It was determined that a 8” x 4’-0” precast hollow core plank floor system would be adequate for the floor design. High strength (6000 psi) 8” concrete masonry reinforced at 16” on center vertically would provide sufficient lateral support against the lateral forces experienced by the building. No horizontal shear reinforcement is needed.

The effects of these changes were then quantified by performing a cost and schedule analysis for the construction management breadth. It was determined that the proposed design was slightly more expensive than the existing structure when taking into account the additional three floors. With the additional three floors, the total cost of the project when considering only labor, materials, equipment, and overhead and profit was determined to be $ 3,683,935.36, which is only $ 1,133,151.84 more than the cost of the existing system. In addition, it was also found that the proposed structure would be completed 160.36 days later compared to the existing. However, when analyzing both structures per floor, it was found that the proposed building would be completed 17.54 days earlier with a savings of $ 111,419.40 per floor.

The floor plans of the existing structure were also redesign as part of the proposed building to provide the continuity of the lateral system. This alteration was necessary to allow a proper redistribution of the loads to the shear walls and to the foundation. Therefore, the proposed structure provides a total amount of 392 student rooms which is 124 more than the existing. Other changes were the room locations and the addition of more study rooms per floor to promote student collaboration.

APPENDIX

APPENDIX A:

WIND CALCULATIONS (MWFRS: ASCE 7-05)

Risk Category: III (Table 1.5-1)

Basic Wind Speed: V= 90 mph (Figure 26.5-1)

Importance Factor: I = 1.15 (Table 6-1)

Directionality factor: Kd = 1.0 (Table 6-4)

Exposure Category: C

Topographic Factor: Kzt = 1.0 (Figure 6-4)

Gust Effect Factor: G = 0.85 (Rigid building)

Enclosure Classification: Enclosed

Internal Pressure Coefficient: (GCpi) = +/-0.18 (Figure 6-5)

Design Wind pressures for MWFRS

Design wind pressures are determined using the equation:

P = qGCp – qi(GCpi) (Equation 6-17)

External Pressure Coeff. Cp in the North/South Direction

L/B = (93+117)/316 = 0.66

h/L = 70/210 = 0.33 ≤ 0.5

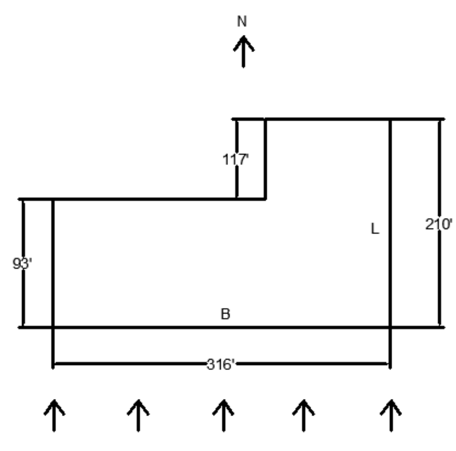


Table 3 : WIND PRESSURE COEFFICIENTS North/South						
Height (ft)	G	Windward Cp	q_h	GC_{pi}	Internal presure (+/- psf)	Leeward Cp
Roof	0.85	0.8	24.3	+/- 0.18	4.4	-0.5
7	0.85	0.8	23.4	+/- 0.18	4.4	-0.5
6	0.85	0.8	22.6	+/- 0.18	4.4	-0.5
5	0.85	0.8	21.6	+/- 0.18	4.4	-0.5
4	0.85	0.8	20.3	+/- 0.18	4.4	-0.5
3	0.85	0.8	18.7	+/- 0.18	4.4	-0.5
2	0.85	0.8	17.6	+/- 0.18	4.4	-0.5
1	0.85	0.8	17.6	+/- 0.18	4.4	-0.5

ROOF		
Windward Edge	C_p	Pressure (psf)
0 - 70	-0.9	-18.6
70 - 140	-0.5	-10.3
> 140	-0.3	-6.2

$q_z = 0.00256 k_z k_{zt} k_d v^2 = (0.00256)(1.17)(1.0)(1.0)(90^2) = 24.26\, psf$

Since h≥ 60 ft, we will use the MWFRS

MWFRS Pressures at 70 ft

Windward wall: P = 24.3(0.85)(0.8) – 24.3(±0.18) = 16.5 ± 4.4 psf

Leeward Wall: P = 24.3(0.85)(-0.5) – 24.3(± 0.18) = -10.3 ± 4.4 psf

Side walls: Cp = -0.7; P = 24.3(0.85)(-0.7) – 24.3(± 0.18) = 14.5 ± 4.4 psf

Roof: P = 24.3(0.85)(-0.9) -24.3(±0.18) = -18.6 ± 4.4 from 0- 70ft

P = 24.3(0.85)(-0.5) ± 4.4 = -10.3 ± 4.4 from 70ft to 140 ft

P = 24.3(0.85)(-0.3) ± 4.4 = -6.2 ± 4.4 from 140 ft 316 ft

WIND PRESSURE (psf) North/South			
Level	Height (ft)	Windward	Leeward
Roof	70	16.5	-10.3
7	60	15.9	-10.3
6	50	15.4	-10.3
5	40	14.7	-10.3
4	30	13.8	-10.3
3	20	12.7	-10.3
2	10	12.0	-10.3
1	0	12.0	-10.3

WIND FORCE North/South			
Level	Height (ft)	Force (kips)	Overturning Moment (ft-k)
Roof	70	42.4	2968.0
7	60	41.4	2484.0
6	50	40.6	2030.0
5	40	39.5	1580.0
4	30	38.1	1143.0
3	20	36.4	728.0
2	10	35.2	352.0
1	0	0.0	0.0
	Base Shear =	**273.6**	**11285.0**

Table: Wind Forces and Pressures

External Pressure Coeff. Cp in the East/West Direction

L/B = 316/210 = 1.5 ≥ 1.0

h/L = 70/316 = 0.22 ≤ 0.5

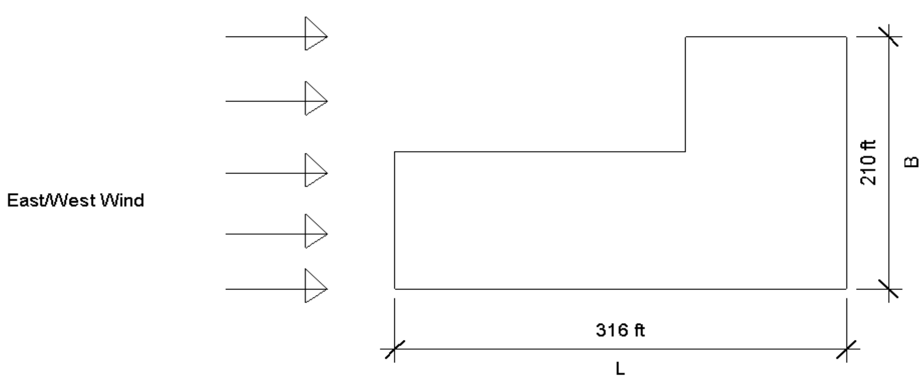


Figure: East/West Diagram

ROOF		
Windward Edge	**Cp**	**Pressure (psf)**
0 - 70	-0.9	-18.6
70 - 140	-0.5	-10.3
> 140	-0.3	-6.2

Table 3 : WIND PRESSURE COEFFICIENTS EAST/WEST						
Height (ft)	G	Windward Cp	q_h	GC_{pi}	Internal presure (+/- psf)	Leeward Cp
Roof	0.85	0.8	24.3	+/- 0.18	4.4	-0.4
7	0.85	0.8	23.4	+/- 0.18	4.4	-0.4
6	0.85	0.8	22.6	+/- 0.18	4.4	-0.4
5	0.85	0.8	21.6	+/- 0.18	4.4	-0.4
4	0.85	0.8	20.3	+/- 0.18	4.4	-0.4
3	0.85	0.8	18.7	+/- 0.18	4.4	-0.4
2	0.85	0.8	17.6	+/- 0.18	4.4	-0.4
1	0.85	0.8	17.6	+/- 0.18	4.4	-0.4

<u>MWFRS Pressures at 70 ft</u>

Windward wall: P = 24.3(0.85)(0.8) – 24.3(±0.18) = 16.5 ± 4.4 psf

Leeward Wall: P = 24.3(0.85)(-0.4) – 24.3(± 0.18) = -8.3 ± 4.4 psf

Side walls: Cp = -0.7; P = 24.3(0.85)(-0.7) – 24.3(± 0.18) = 14.5 ± 4.4 psf

Roof: P = 24.3(0.85)(-0.9) -24.3(±0.18) = -18.6 ± 4.4 from 0- 70ft

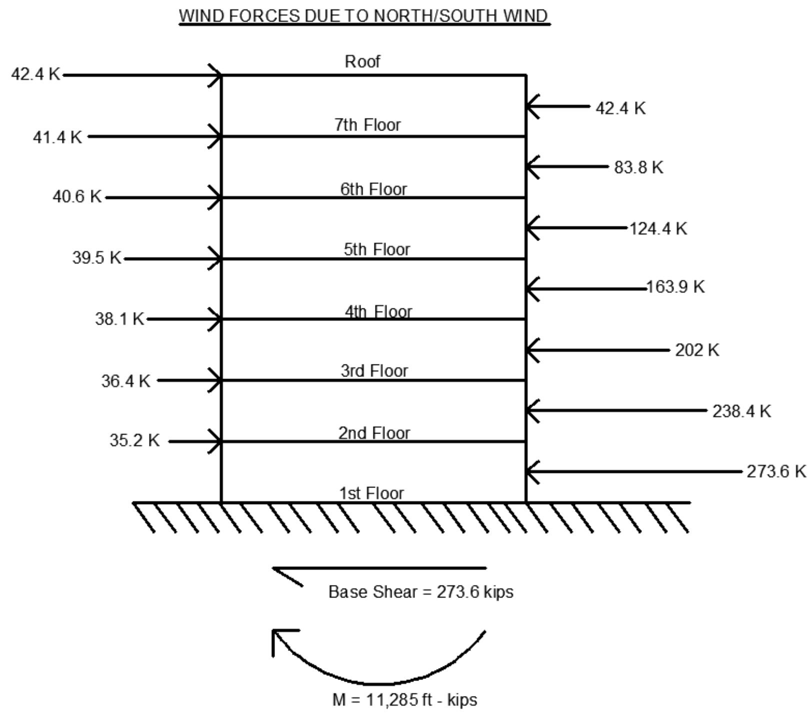
P = 24.3(0.85)(-0.5) ± 4.4 = -10.3 ± 4.4 from 70ft to 140 ft

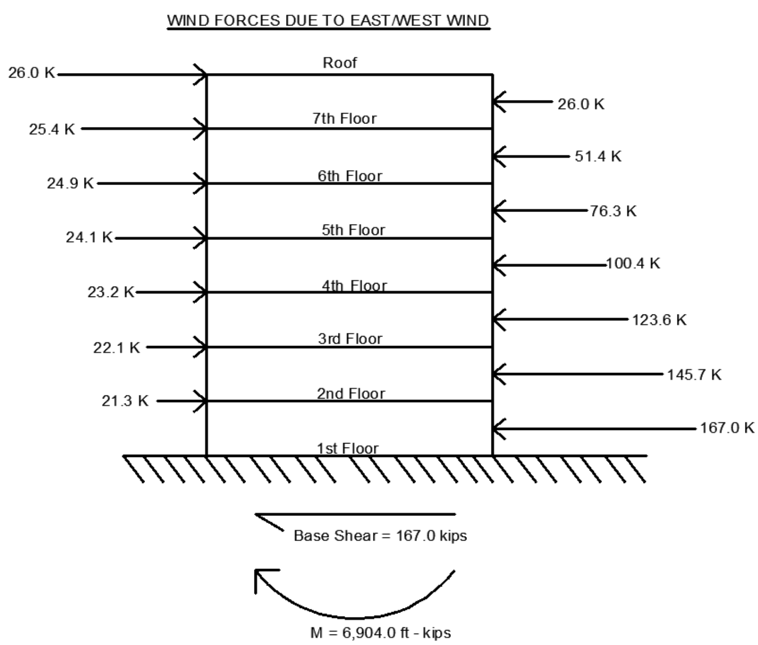
P = 24.3(0.85)(-0.3) ± 4.4 = -6.2 ± 4.4 from 140 ft 316 ft

WIND PRESSURE (psf) EAST/WEST			
Level	Height (ft)	Windward	Leeward
Roof	70	16.5	-8.3
7	60	15.9	-8.3
6	50	15.4	-8.3
5	40	14.7	-8.3
4	30	13.8	-8.3
3	20	12.7	-8.3
2	10	12.0	-8.3
1	0	12.0	-8.3

WIND FORCE East/West			
Level	Height (ft)	Force (kips)	Overturning Moment (ft-k)
Roof	70	26.0	1820.0
7	60	25.4	1524.0
6	50	24.9	1245.0
5	40	24.1	964.0
4	30	23.2	696.0
3	20	22.1	442.0
2	10	21.3	213.0
1	0	0.0	0.0
	Base Shear =	167.0	6904.0

Table: Wind Forces and Pressures





APPENDIX B

Seismic Calculations (ASCE 7-05 & IBC 2009)

Site class D (Stiff soil - from section 20.1)

Mapped maximum considered Earthquake spectral response acceleration at short periods: S_s = 18% for PA (Figure 22.1)

Mapped maximum considered Earthquake spectral response acceleration at 1-second period: S_1 = 6% for PA (Figure 22-2)

Earthquake spectral response acceleration parameters:

- Adjusted maximum at short period:
  - $S_{ms} = F_a S_s = (1.6)(0.18) = 0.288$ (Equation 11.4-1)
- Adjusted maximum at 1-sec. period:
  - $S_{m1} = F_v S_1 = (2.4)(0.06) = 0.144$ (Equation 11.4-2)
- Site Coefficients:
  - $F_a = 1.6$ (Table 11.4-1; $S_s < 0.25$ & site class D)
  - $F_v = 2.4$ (Table 11.4-2; for $S_1 < 0.1$ & site class D)

Design spectral response:

- at short periods $S_{DS} = (2/3)(S_{ms}) = (2/3)(0.288) = 0.192$ (Equation 11.4.4)
- at 1-second period: SD1 = (2/3) Sm1 = (2/3)(0.144) = 0.096 (Equation 11.4-4)

Risk Category III (Table 1-1)

Occupancy Importance Factor: $I_e = 1.25$

Seismic Design Category:

- For $SD_S = 0.192$ & Occupancy category II; SDC = “B” (Table 16.6-1)
- For $SD_1 = 0.096$ & Occupancy category II; SDC = “B” (Table 16.6-2)

Equivalent Lateral Force Procedure for Both directions

Seismic base Shear

$V = C_s W$ (Equation 12.8-1)

R = 3.5 for Intermediate reinforced masonry shear walls (Table 12.2-1)

C_t = 0.02 for “other structural system” (Table 12.8-7)

X = 0.75

Fundamental period:

- $Ta = C_t(h_n)$^x = (0.02)(70)^(0.75) = 0.48
- T = CuTa = (1.7)(0.48) = 0.816 ≥ T

T = 0.48 ≤ T_L = 6 sec; therefore, $C_s = \frac{S_{DS}}{\frac{R}{I_e}} = \frac{0.192}{\frac{3.5}{1.25}} = 0.069 > 0.01 \therefore ok$

$$C_s = \frac{S_{D1}}{T\frac{R}{I_e}} = \frac{0.096}{0.48 * \frac{3.5}{1.25}} = 0.07 > 0.01 < 0.069 \therefore ok$$

An Excel Spreadsheet was used intensively to determine de building weights.

Weight of wall = (51 psf)(10 ft) = 510 plf

Parapet = (1300 ft)(2.5 ft)(51 psf0 = 166 kips

Partion = (10 ft)(23350 ft) = 234 kips

Floor and roof = (88 psf + 18 psf)(17460.4 ft^2) = 1850 kips/floor

Total building weight

Weight of wall = 1850 + 1336 +234 = 3420 kips

Weight of roof = 1850 + (1/2)(1336 + 234) + 166 = 2801

Wtotal = 7(1850 + 1336 + 234) + 166 = 24,106 kips

Where W_x = floor slab + ½ wall weight above + ½ wall weight below + partitions

W_{roof} = roof slab + ½ wall weight below + ½ partitions

Seismic base shear = C_s W = (0.069)(24106) = 1663 kips

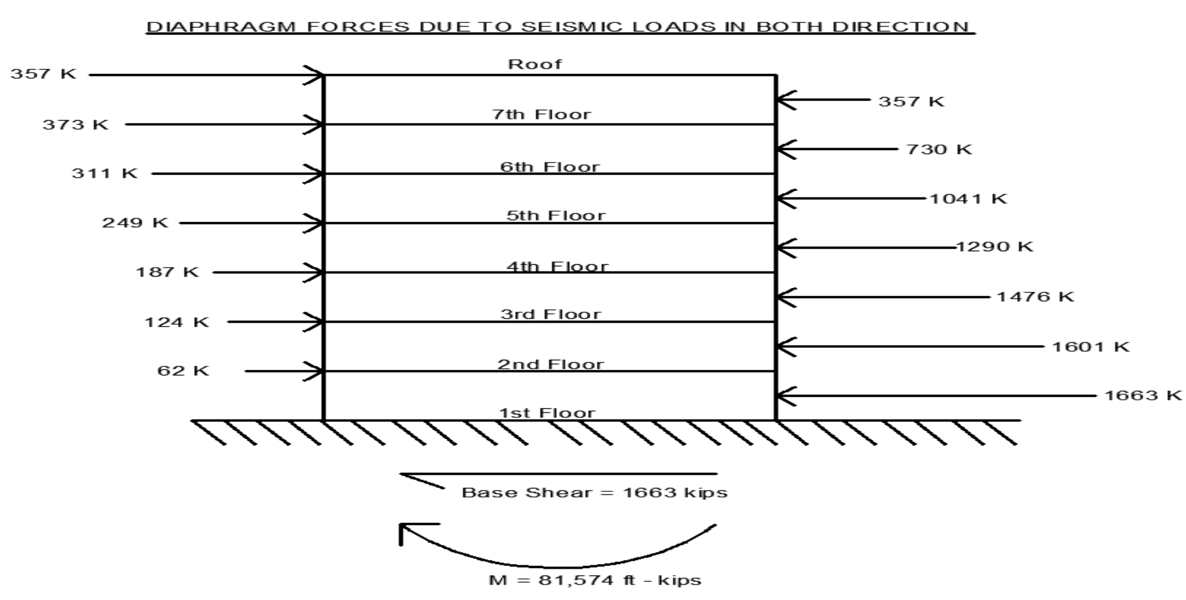
Shear distribution at each floor level:

The shear distribution at each story is computer as follows: $F_x = \frac{W_x h_x}{\sum_{i=1}^{n} w_i h_i}(V - F_t)$

Where F_t = 0 for t < 0.7 sec

Table 2: SHEAR DISTRIBUTION AT EACH FLOOR LEVEL							
Level	Wx (kips)	hx (ft)	Wx*hx^k (k-ft)	(wxhi)/∑(wihi)^k	Fx (kips)	Vx (kips)	Moment (ft-kips)
Roof	2801	70	196070	0.21	357	-	24965
7	3420	60	205200	0.22	373	357	22395
6	3420	50	171000	0.19	311	730	15552
5	3420	40	136800	0.15	249	1041	9953
4	3420	30	102600	0.11	187	1290	5599
3	3420	20	68400	0.07	124	1476	2488
2	3420	10	34200	0.04	62	1601	622
1	3420	0	0	0.00	0	1663	0
	23321		**914270**	**1.00**	**1663**		**81574**

Total Overturning moment = 81,574 ft-kips	
Base Shear = 1663 kips	



Seismic Forces Diagram

APPENDIX C:

DIRECT/TORSIONAL SHEAR AND TORTIONAL MOMENT CALCULATIONS

Direct Shear in North/South Direction At Level 2/base				
Wall Name	Rx	Vi (Kips)	Ri/ΣRi	V_{di}
A	9809968.9	62	0.008	0.482
AA	9809968.9	62	0.008	0.482
B	6161606.9	62	0.005	0.303
BB	6161606.9	62	0.005	0.303
C	53422966	62	0.042	2.625
D	72977204	62	0.058	3.586
E	80233852	62	0.064	3.942
F	72977204	62	0.058	3.586
G	49709367	62	0.039	2.442
H	20308017	62	0.016	0.998
I	50949378	62	0.040	2.503
J	82646186	62	0.065	4.061
K	109029146	62	0.086	5.357
L	101856326	62	0.081	5.004
M	94668503	62	0.075	4.651
N	72977204	62	0.058	3.586
O	17660804	62	0.014	0.868
P	35891429	62	0.028	1.763
Q	60798882	62	0.048	2.987
R	7336026.3	62	0.006	0.360
S	20308017	62	0.016	0.998
T	29471731	62	0.023	1.448
U	9809968.9	62	0.008	0.482
V	22945766	62	0.018	1.127
W	34615561	62	0.027	1.701
X	9809968.9	62	0.008	0.482
Y	5045944	62	0.004	0.248
Z	21628485	62	0.017	1.063
XX	9809968.9	62	0.008	0.482
ZZ	37163532	62	0.029	1.826
YY	22945766	62	0.018	1.127
WW	22945766	62	0.018	1.127
	1.262E+09			

Direct Shear in East/West Direction At Level 2/base				
Wall Name	Rx	Vi (Kips)	Ri/ΣRi	V_{di}
1	24259346.23	62	0.033	2.020
2	9809968.894	62	0.013	0.817
3	43472748.45	62	0.058	3.620
4	8555851.492	62	0.011	0.712
5	13696532.02	62	0.018	1.140
6	16336541.48	62	0.022	1.360
7	8555851.492	62	0.011	0.712
8	24259346.23	62	0.033	2.020
9	12386755.72	62	0.017	1.031
10	24259346.23	62	0.033	2.020
11	22945766.48	62	0.031	1.911
12	5045944.017	62	0.007	0.420
13	17660804.06	62	0.024	1.471
14	25568887.33	62	0.034	2.129
15	17660804.06	62	0.024	1.471
16	24259346.23	62	0.033	2.020
17	44725345.45	62	0.060	3.724
18	44725345.45	62	0.060	3.724
19	93468857.94	62	0.126	7.783
20	68120244.23	62	0.091	5.672
21	7336026.301	62	0.010	0.611
22	28175143.22	62	0.038	2.346
23	43472748.45	62	0.058	3.620
24	35891429.3	62	0.048	2.988
25	30763981.26	62	0.041	2.562
26	8555851.492	62	0.011	0.712
27	24259346.23	62	0.033	2.020
28	4004580.454	62	0.005	0.333
29	12386755.72	62	0.017	1.031
	744619495.9			

Direct Shear in East/West Direction At Level 3				
Wall Name	Rx	Vi (Kips)	Ri/ΣRi	V_{di}
A	9809968.9	124	0.008	0.964
AA	9809968.9	124	0.008	0.964
B	6161606.9	124	0.005	0.605
BB	6161606.9	124	0.005	0.605
C	53422966	124	0.042	5.250
D	72977204	124	0.058	7.171
E	80233852	124	0.064	7.884
F	72977204	124	0.058	7.171
G	49709367	124	0.039	4.885
H	20308017	124	0.016	1.996
I	50949378	124	0.040	5.007
J	82646186	124	0.065	8.121
K	109029146	124	0.086	10.714
L	101856326	124	0.081	10.009
M	94668503	124	0.075	9.303
N	72977204	124	0.058	7.171
O	17660804	124	0.014	1.735
P	35891429	124	0.028	3.527
Q	60798882	124	0.048	5.974
R	7336026.3	124	0.006	0.721
S	20308017	124	0.016	1.996
T	29471731	124	0.023	2.896
U	9809968.9	124	0.008	0.964
V	22945766	124	0.018	2.255
W	34615561	124	0.027	3.402
X	9809968.9	124	0.008	0.964
Y	5045944	124	0.004	0.496
Z	21628485	124	0.017	2.125
XX	9809968.9	124	0.008	0.964
ZZ	37163532	124	0.029	3.652
YY	22945766	124	0.018	2.255
WW	22945766	124	0.018	2.255
	1.262E+09			

Direct Shear in North/South Direction At Level 3				
Wall Name	Rx	Vi (Kips)	Ri/ΣRi	V_{di}
1	24259346.23	124	0.033	4.040
2	9809968.894	124	0.013	1.634
3	43472748.45	124	0.058	7.239
4	8555851.492	124	0.011	1.425
5	13696532.02	124	0.018	2.281
6	16336541.48	124	0.022	2.720
7	8555851.492	124	0.011	1.425
8	24259346.23	124	0.033	4.040
9	12386755.72	124	0.017	2.063
10	24259346.23	124	0.033	4.040
11	22945766.48	124	0.031	3.821
12	5045944.017	124	0.007	0.840
13	17660804.06	124	0.024	2.941
14	25568887.33	124	0.034	4.258
15	17660804.06	124	0.024	2.941
16	24259346.23	124	0.033	4.040
17	44725345.45	124	0.060	7.448
18	44725345.45	124	0.060	7.448
19	93468857.94	124	0.126	15.565
20	68120244.23	124	0.091	11.344
21	7336026.301	124	0.010	1.222
22	28175143.22	124	0.038	4.692
23	43472748.45	124	0.058	7.239
24	35891429.3	124	0.048	5.977
25	30763981.26	124	0.041	5.123
26	8555851.492	124	0.011	1.425
27	24259346.23	124	0.033	4.040
28	4004580.454	124	0.005	0.667
29	12386755.72	124	0.017	2.063
	744619495.9			

Direct Shear in East/West Direction At Level 4				
Wall Name	Rx	Vi (Kips)	Ri/ΣRi	V_{di}
A	9809969	187	0.008	1.454
AA	9809969	187	0.008	1.454
B	6161607	187	0.005	0.913
BB	6161607	187	0.005	0.913
C	53422966	187	0.042	7.917
D	72977204	187	0.058	10.815
E	80233852	187	0.064	11.890
F	72977204	187	0.058	10.815
G	49709367	187	0.039	7.366
H	20308017	187	0.016	3.009
I	50949378	187	0.040	7.550
J	82646186	187	0.065	12.247
K	1.09E+08	187	0.086	16.157
L	1.02E+08	187	0.081	15.094
M	94668503	187	0.075	14.029
N	72977204	187	0.058	10.815
O	17660804	187	0.014	2.617
P	35891429	187	0.028	5.319
Q	60798882	187	0.048	9.010
R	7336026	187	0.006	1.087
S	20308017	187	0.016	3.009
T	29471731	187	0.023	4.367
U	9809969	187	0.008	1.454
V	22945766	187	0.018	3.400
W	34615561	187	0.027	5.130
X	9809969	187	0.008	1.454
Y	5045944	187	0.004	0.748
Z	21628485	187	0.017	3.205
XX	9809969	187	0.008	1.454
ZZ	37163532	187	0.029	5.507
YY	22945766	187	0.018	3.400
WW	22945766	187	0.018	3.400
	1.26E+09			

Direct Shear in North/South Direction At Level 4				
Wall Name	Rx	Vi (Kips)	Ri/ΣRi	V_{di}
1	24259346	187	0.033	6.092
2	9809969	187	0.013	2.464
3	43472748	187	0.058	10.918
4	8555851	187	0.011	2.149
5	13696532	187	0.018	3.440
6	16336541	187	0.022	4.103
7	8555851	187	0.011	2.149
8	24259346	187	0.033	6.092
9	12386756	187	0.017	3.111
10	24259346	187	0.033	6.092
11	22945766	187	0.031	5.762
12	5045944	187	0.007	1.267
13	17660804	187	0.024	4.435
14	25568887	187	0.034	6.421
15	17660804	187	0.024	4.435
16	24259346	187	0.033	6.092
17	44725345	187	0.060	11.232
18	44725345	187	0.060	11.232
19	93468858	187	0.126	23.473
20	68120244	187	0.091	17.107
21	7336026	187	0.010	1.842
22	28175143	187	0.038	7.076
23	43472748	187	0.058	10.918
24	35891429	187	0.048	9.014
25	30763981	187	0.041	7.726
26	8555851	187	0.011	2.149
27	24259346	187	0.033	6.092
28	4004580	187	0.005	1.006
29	12386756	187	0.017	3.111
	7.45E+08			

Direct Shear in East/West Direction At Level 5				
Wall Name	Rx	Vi (Kips)	Ri/ΣRi	V_{di}
A	9809969	249	0.008	1.936
AA	9809969	249	0.008	1.936
B	6161607	249	0.005	1.216
BB	6161607	249	0.005	1.216
C	53422966	249	0.042	10.542
D	72977204	249	0.058	14.400
E	80233852	249	0.064	15.832
F	72977204	249	0.058	14.400
G	49709367	249	0.039	9.809
H	20308017	249	0.016	4.007
I	50949378	249	0.040	10.054
J	82646186	249	0.065	16.308
K	1.09E+08	249	0.086	21.514
L	1.02E+08	249	0.081	20.099
M	94668503	249	0.075	18.680
N	72977204	249	0.058	14.400
O	17660804	249	0.014	3.485
P	35891429	249	0.028	7.082
Q	60798882	249	0.048	11.997
R	7336026	249	0.006	1.448
S	20308017	249	0.016	4.007
T	29471731	249	0.023	5.815
U	9809969	249	0.008	1.936
V	22945766	249	0.018	4.528
W	34615561	249	0.027	6.830
X	9809969	249	0.008	1.936
Y	5045944	249	0.004	0.996
Z	21628485	249	0.017	4.268
XX	9809969	249	0.008	1.936
ZZ	37163532	249	0.029	7.333
YY	22945766	249	0.018	4.528
WW	22945766	249	0.018	4.528
	1.26E+09			

Direct Shear in North/South Direction At Level 5				
Wall Name	Rx	Vi (Kips)	Ri/ΣRi	V_{di}
1	24259346	249	0.033	8.112
2	9809969	249	0.013	3.280
3	43472748	249	0.058	14.537
4	8555851	249	0.011	2.861
5	13696532	249	0.018	4.580
6	16336541	249	0.022	5.463
7	8555851	249	0.011	2.861
8	24259346	249	0.033	8.112
9	12386756	249	0.017	4.142
10	24259346	249	0.033	8.112
11	22945766	249	0.031	7.673
12	5045944	249	0.007	1.687
13	17660804	249	0.024	5.906
14	25568887	249	0.034	8.550
15	17660804	249	0.024	5.906
16	24259346	249	0.033	8.112
17	44725345	249	0.060	14.956
18	44725345	249	0.060	14.956
19	93468858	249	0.126	31.256
20	68120244	249	0.091	22.779
21	7336026	249	0.010	2.453
22	28175143	249	0.038	9.422
23	43472748	249	0.058	14.537
24	35891429	249	0.048	12.002
25	30763981	249	0.041	10.287
26	8555851	249	0.011	2.861
27	24259346	249	0.033	8.112
28	4004580	249	0.005	1.339
29	12386756	249	0.017	4.142
	7.45E+08			

Direct Shear in East/West Direction At Level 6				
Wall Name	Rx	Vi (Kips)	Ri/ΣRi	V_{di}
A	9809969	311	0.008	2.418
AA	9809969	311	0.008	2.418
B	6161607	311	0.005	1.519
BB	6161607	311	0.005	1.519
C	53422966	311	0.042	13.166
D	72977204	311	0.058	17.986
E	80233852	311	0.064	19.774
F	72977204	311	0.058	17.986
G	49709367	311	0.039	12.251
H	20308017	311	0.016	5.005
I	50949378	311	0.040	12.557
J	82646186	311	0.065	20.369
K	1.09E+08	311	0.086	26.871
L	1.02E+08	311	0.081	25.103
M	94668503	311	0.075	23.332
N	72977204	311	0.058	17.986
O	17660804	311	0.014	4.353
P	35891429	311	0.028	8.846
Q	60798882	311	0.048	14.984
R	7336026	311	0.006	1.808
S	20308017	311	0.016	5.005
T	29471731	311	0.023	7.263
U	9809969	311	0.008	2.418
V	22945766	311	0.018	5.655
W	34615561	311	0.027	8.531
X	9809969	311	0.008	2.418
Y	5045944	311	0.004	1.244
Z	21628485	311	0.017	5.330
XX	9809969	311	0.008	2.418
ZZ	37163532	311	0.029	9.159
YY	22945766	311	0.018	5.655
WW	22945766	311	0.018	5.655
	1.26E+09			

Direct Shear in North/South Direction At Level 6				
Wall Name	Rx	Vi (Kips)	Ri/ΣRi	V_{di}
1	24259346.2	311	0.033	10.132
2	9809968.89	311	0.013	4.097
3	43472748.5	311	0.058	18.157
4	8555851.49	311	0.011	3.573
5	13696532	311	0.018	5.721
6	16336541.5	311	0.022	6.823
7	8555851.49	311	0.011	3.573
8	24259346.2	311	0.033	10.132
9	12386755.7	311	0.017	5.173
10	24259346.2	311	0.033	10.132
11	22945766.5	311	0.031	9.584
12	5045944.02	311	0.007	2.108
13	17660804.1	311	0.024	7.376
14	25568887.3	311	0.034	10.679
15	17660804.1	311	0.024	7.376
16	24259346.2	311	0.033	10.132
17	44725345.5	311	0.060	18.680
18	44725345.5	311	0.060	18.680
19	93468857.9	311	0.126	39.038
20	68120244.2	311	0.091	28.451
21	7336026.3	311	0.010	3.064
22	28175143.2	311	0.038	11.768
23	43472748.5	311	0.058	18.157
24	35891429.3	311	0.048	14.991
25	30763981.3	311	0.041	12.849
26	8555851.49	311	0.011	3.573
27	24259346.2	311	0.033	10.132
28	4004580.45	311	0.005	1.673
29	12386755.7	311	0.017	5.173
	744619496			

Direct Shear in East/West Direction At Level 7				
Wall Name	Rx	Vi (Kips)	Ri/ΣRi	V_{di}
A	9809969	373	0.008	2.900
AA	9809969	373	0.008	2.900
B	6161607	373	0.005	1.821
BB	6161607	373	0.005	1.821
C	53422966	373	0.042	15.791
D	72977204	373	0.058	21.571
E	80233852	373	0.064	23.716
F	72977204	373	0.058	21.571
G	49709367	373	0.039	14.694
H	20308017	373	0.016	6.003
I	50949378	373	0.040	15.060
J	82646186	373	0.065	24.429
K	1.09E+08	373	0.086	32.228
L	1.02E+08	373	0.081	30.108
M	94668503	373	0.075	27.983
N	72977204	373	0.058	21.571
O	17660804	373	0.014	5.220
P	35891429	373	0.028	10.609
Q	60798882	373	0.048	17.971
R	7336026	373	0.006	2.168
S	20308017	373	0.016	6.003
T	29471731	373	0.023	8.712
U	9809969	373	0.008	2.900
V	22945766	373	0.018	6.783
W	34615561	373	0.027	10.232
X	9809969	373	0.008	2.900
Y	5045944	373	0.004	1.492
Z	21628485	373	0.017	6.393
XX	9809969	373	0.008	2.900
ZZ	37163532	373	0.029	10.985
YY	22945766	373	0.018	6.783
WW	22945766	373	0.018	6.783
	1.26E+09			

Direct Shear in North/South Direction At Level 7				
Wall Name	Rx	Vi (Kips)	Ri/ΣRi	V_{di}
1	24259346	373	0.033	12.152
2	9809969	373	0.013	4.914
3	43472748	373	0.058	21.777
4	8555851	373	0.011	4.286
5	13696532	373	0.018	6.861
6	16336541	373	0.022	8.183
7	8555851	373	0.011	4.286
8	24259346	373	0.033	12.152
9	12386756	373	0.017	6.205
10	24259346	373	0.033	12.152
11	22945766	373	0.031	11.494
12	5045944	373	0.007	2.528
13	17660804	373	0.024	8.847
14	25568887	373	0.034	12.808
15	17660804	373	0.024	8.847
16	24259346	373	0.033	12.152
17	44725345	373	0.060	22.404
18	44725345	373	0.060	22.404
19	93468858	373	0.126	46.821
20	68120244	373	0.091	34.123
21	7336026	373	0.010	3.675
22	28175143	373	0.038	14.114
23	43472748	373	0.058	21.777
24	35891429	373	0.048	17.979
25	30763981	373	0.041	15.411
26	8555851	373	0.011	4.286
27	24259346	373	0.033	12.152
28	4004580	373	0.005	2.006
29	12386756	373	0.017	6.205
	7.45E+08			

Direct Shear in East/West Direction At Roof				
Wall Name	Rx	Vi (Kips)	Ri/ΣRi	V_{di}
A	9809969	357	0.008	2.775
AA	9809969	357	0.008	2.775
B	6161607	357	0.005	1.743
BB	6161607	357	0.005	1.743
C	53422966	357	0.042	15.114
D	72977204	357	0.058	20.646
E	80233852	357	0.064	22.699
F	72977204	357	0.058	20.646
G	49709367	357	0.039	14.063
H	20308017	357	0.016	5.745
I	50949378	357	0.040	14.414
J	82646186	357	0.065	23.381
K	1.09E+08	357	0.086	30.845
L	1.02E+08	357	0.081	28.816
M	94668503	357	0.075	26.783
N	72977204	357	0.058	20.646
O	17660804	357	0.014	4.996
P	35891429	357	0.028	10.154
Q	60798882	357	0.048	17.201
R	7336026	357	0.006	2.075
S	20308017	357	0.016	5.745
T	29471731	357	0.023	8.338
U	9809969	357	0.008	2.775
V	22945766	357	0.018	6.492
W	34615561	357	0.027	9.793
X	9809969	357	0.008	2.775
Y	5045944	357	0.004	1.428
Z	21628485	357	0.017	6.119
XX	9809969	357	0.008	2.775
ZZ	37163532	357	0.029	10.514
YY	22945766	357	0.018	6.492
WW	22945766	357	0.018	6.492
	1.26E+09			

Direct Shear in North/South Direction At Roof				
Wall Name	Rx	Vi (Kips)	Ri/ΣRi	V_{di}
1	24259346	357	0.033	11.631
2	9809969	357	0.013	4.703
3	43472748	357	0.058	20.843
4	8555851	357	0.011	4.102
5	13696532	357	0.018	6.567
6	16336541	357	0.022	7.832
7	8555851	357	0.011	4.102
8	24259346	357	0.033	11.631
9	12386756	357	0.017	5.939
10	24259346	357	0.033	11.631
11	22945766	357	0.031	11.001
12	5045944	357	0.007	2.419
13	17660804	357	0.024	8.467
14	25568887	357	0.034	12.259
15	17660804	357	0.024	8.467
16	24259346	357	0.033	11.631
17	44725345	357	0.060	21.443
18	44725345	357	0.060	21.443
19	93468858	357	0.126	44.813
20	68120244	357	0.091	32.660
21	7336026	357	0.010	3.517
22	28175143	357	0.038	13.508
23	43472748	357	0.058	20.843
24	35891429	357	0.048	17.208
25	30763981	357	0.041	14.749
26	8555851	357	0.011	4.102
27	24259346	357	0.033	11.631
28	4004580	357	0.005	1.920
29	12386756	357	0.017	5.939
	7.45E+08			

Torsional Shear in North/South At Level 2

Wall Name	Rx (k/in)	dx (in)	Yi (in)	(Xi)^2	(Yi)^2	Ri*(Yi)^2	Ri*(Xi)^2	J	M_T	V_{ti}
A	9809968.9	-2237	302	5004169	91204	8.95E+11	4.9E+13	1.60E+15	27910.8	-0.38
AA	9809968.9	-2237	-46	5004169	2116	2.08E+10	4.9E+13	1.60E+15	27910.8	-0.38
B	6161606.9	-2213	-154	4897369	23716	1.46E+11	3.0E+13	1.60E+15	27910.8	-0.24
BB	6161606.9	-2213	-454	4897369	206116	1.27E+12	3.0E+13	1.60E+15	27910.8	-0.24
C	53422966	-1565	338	2449225	114244	6.10E+12	1.3E+14	1.60E+15	27910.8	-1.46
D	72977204	-1565	194	2449225	37636	2.75E+12	1.8E+14	1.60E+15	27910.8	-1.99
E	80233852	-1577	110	2486929	12100	9.71E+11	2.0E+14	1.60E+15	27910.8	-2.21
F	72977204	-1577	110	2486929	12100	8.83E+11	1.8E+14	1.60E+15	27910.8	-2.01
G	49709367	-1421	-130	2019241	16900	8.40E+11	1.0E+14	1.60E+15	27910.8	-1.23
H	20308017	-1373	-298	1885129	88804	1.80E+12	3.8E+13	1.60E+15	27910.8	-0.49
I	50949378	-401	182	160801	33124	1.69E+12	8.2E+12	1.60E+15	27910.8	-0.36
J	82646186	-329	38	108241	1444	1.19E+11	8.9E+12	1.60E+15	27910.8	-0.47
K	109029146	-323	-22	104329	484	5.28E+10	1.1E+13	1.60E+15	27910.8	-0.62
L	101856326	-323	-226	104329	51076	5.20E+12	1.1E+13	1.60E+15	27910.8	-0.57
M	94668503	-323	-295.6	104329	87379.36	8.27E+12	9.9E+12	1.60E+15	27910.8	-0.53
N	72977204	-323	-295.6	104329	87379.36	6.38E+12	7.6E+12	1.60E+15	27910.8	-0.41
O	17660804	727	-306.4	528529	93880.96	1.66E+12	9.3E+12	1.60E+15	27910.8	0.22
P	35891429	727	-306.4	528529	93880.96	3.37E+12	1.9E+13	1.60E+15	27910.8	0.46
Q	60798882	1162.6	-44.8	1351638.8	2007.04	1.22E+11	8.2E+13	1.60E+15	27910.8	1.23
R	7336026.3	1369	-334	1874161	111556	8.18E+11	1.4E+13	1.60E+15	27910.8	0.18
S	20308017	541	-60.4	292681	3648.16	7.41E+10	5.9E+12	1.60E+15	27910.8	0.19
T	29471731	605.8	297.2	366993.64	88327.84	2.60E+12	1.1E+13	1.60E+15	27910.8	0.31
U	9809968.9	917.8	387.2	842356.84	149923.8	1.47E+12	8.3E+12	1.60E+15	27910.8	0.16
V	22945766	605.8	440	366993.64	193600	4.44E+12	8.4E+12	1.60E+15	27910.8	0.24
W	34615561	605.8	704	366993.64	495616	1.72E+13	1.3E+13	1.60E+15	27910.8	0.37
X	9809968.9	501.4	962	251401.96	925444	9.08E+12	2.5E+12	1.60E+15	27910.8	0.09
Y	5045944	371.8	2477.6	138235.24	6138502	3.10E+13	7.0E+11	1.60E+15	27910.8	0.03
Z	21628485	579.4	1446.8	335704.36	2093230	4.53E+13	7.3E+12	1.60E+15	27910.8	0.22
XX	9809968.9	501.4	1377.2	251401.96	1896680	1.86E+13	2.5E+12	1.60E+15	27910.8	0.09
ZZ	37163532	610.6	1635.2	372832.36	2673879	9.94E+13	1.4E+13	1.60E+15	27910.8	0.40
YY	22945766	272.2	1762.4	74092.84	3106054	7.13E+13	1.7E+12	1.60E+15	27910.8	0.11
WW	22945766	272.2	1635.2	74092.84	2673879	6.14E+13	1.7E+12	1.60E+15	27910.8	0.11
	1.262E+09					**4.05E+14**	**1.2E+15**			**-9.21**

Torsional Shear in East/West At Level 2

Wall Name	Rx (k/in)	Xi (in)	Yi (in)	(Xi)^2	(Yi)^2	Ri*(Yi)^2	Ri*(Xi)^2	J	V_{ey}	V_{ti}
1	24259346	-2292.2	-298	5254180.8	88804	2.15E+12	1.27E+14	1.17E+15	24940.8	-0.154
2	9809968.9	-2309	123.2	5331481	15178.24	1.49E+11	5.23E+13	1.17E+15	24940.8	0.026
3	43472748	-2141	-76	4583881	5776	2.51E+11	1.99E+14	1.17E+15	24940.8	-0.070
4	8555851.5	-2069	35.6	4280761	1267.36	1.08E+10	3.66E+13	1.17E+15	24940.8	0.006
5	13696532	-1809.8	-252.4	3275376	63705.76	8.73E+11	4.49E+13	1.17E+15	24940.8	-0.074
6	16336541	-1657.4	-252.4	2746974.8	63705.76	1.04E+12	4.49E+13	1.17E+15	24940.8	-0.088
7	8555851.5	-1196.6	32	1431851.6	1024	8.76E+09	1.23E+13	1.17E+15	24940.8	0.006
8	24259346	-1091	-287.2	1190281	82483.84	2.00E+12	2.89E+13	1.17E+15	24940.8	-0.148
9	12386756	-974.6	-118	949845.16	13924	1.72E+11	1.18E+13	1.17E+15	24940.8	-0.031
10	24259346	-966.2	195.2	933542.44	38103.04	9.24E+11	2.26E+13	1.17E+15	24940.8	0.101
11	22945766	427	-301.6	182329	90962.56	2.09E+12	4.18E+12	1.17E+15	24940.8	-0.147
12	5045944	980.2	-217.6	960792.04	47349.76	2.39E+11	4.85E+12	1.17E+15	24940.8	-0.023
13	17660804	1328.2	-196	1764115.2	38416	6.78E+11	3.12E+13	1.17E+15	24940.8	-0.074
14	25568887	1459	-76	2128681	5776	1.48E+11	5.44E+13	1.17E+15	24940.8	-0.041
15	17660804	980.2	170	960792.04	28900	5.10E+11	1.70E+13	1.17E+15	24940.8	0.064
16	24259346	807.4	195.2	651894.76	38103.04	9.24E+11	1.58E+13	1.17E+15	24940.8	0.101
17	44725345	676.6	195.2	457787.56	38103.04	1.70E+12	2.05E+13	1.17E+15	24940.8	0.186
18	44725345	400.6	326	160480.36	106276	4.75E+12	7.18E+12	1.17E+15	24940.8	0.311
19	93468858	333.4	653.6	111155.56	427193	3.99E+13	1.04E+13	1.17E+15	24940.8	1.302
20	68120244	163	653.6	26569	427193	2.91E+13	1.81E+12	1.17E+15	24940.8	0.949
21	7336026.3	613	582.8	375769	339655.8	2.49E+12	2.76E+12	1.17E+15	24940.8	0.091
22	28175143	818.2	1078.4	669451.24	1162947	3.28E+13	1.89E+13	1.17E+15	24940.8	0.647
23	43472748	664.6	1078.4	441693.16	1162947	5.06E+13	1.92E+13	1.17E+15	24940.8	0.999
24	35891429	598.6	1115.6	358321.96	1244563	4.47E+13	1.29E+13	1.17E+15	24940.8	0.853
25	30763981	412.6	1115.6	170238.76	1244563	3.83E+13	5.24E+12	1.17E+15	24940.8	0.731
26	8555851.5	818.2	1538	669451.24	2365444	2.02E+13	5.73E+12	1.17E+15	24940.8	0.280
27	24259346	400.6	1636.4	160480.36	2677805	6.50E+13	3.89E+12	1.17E+15	24940.8	0.846
28	4004580.5	129.4	1692.8	16744.36	2865572	1.15E+13	6.71E+10	1.17E+15	24940.8	0.144
29	12386756	224.2	-118	50265.64	13924	1.72E+11	6.23E+11	1.17E+15	24940.8	-0.031
	744619496					**3.53E+14**	**8.17E+14**			**6.760**

Torsional Shear in North/South At Level 3										
Wall Name	Rx (k/in)	Xi (in)	Yi (in)	(Xi)^2	(Yi)^2	Ri*(Yi)^2	Ri*(Xi)^2	J	Mex	Fti
A	9809968.9	-2237	302	5004169	91204	8.95E+11	4.9E+13	1.60E+15	55822.8	-0.766
AA	9809968.9	-2237	-46	5004169	2116	2.08E+10	4.9E+13	1.60E+15	55822.8	-0.766
B	6161606.9	-2213	-154	4897369	23716	1.46E+11	3.0E+13	1.60E+15	55822.8	-0.476
BB	6161606.9	-2213	-454	4897369	206116	1.27E+12	3.0E+13	1.60E+15	55822.8	-0.476
C	53422966	-1565	338	2449225	114244	6.10E+12	1.3E+14	1.60E+15	55822.8	-2.920
D	72977204	-1565	194	2449225	37636	2.75E+12	1.8E+14	1.60E+15	55822.8	-3.989
E	80233852	-1577	110	2486929	12100	9.71E+11	2.0E+14	1.60E+15	55822.8	-4.419
F	72977204	-1577	110	2486929	12100	8.83E+11	1.8E+14	1.60E+15	55822.8	-4.020
G	49709367	-1421	-130	2019241	16900	8.40E+11	1.0E+14	1.60E+15	55822.8	-2.467
H	20308017	-1373	-298	1885129	88804	1.80E+12	3.8E+13	1.60E+15	55822.8	-0.974
I	50949378	-401	182	160801	33124	1.69E+12	8.2E+12	1.60E+15	55822.8	-0.714
J	82646186	-329	38	108241	1444	1.19E+11	8.9E+12	1.60E+15	55822.8	-0.950
K	109029146	-323	-22	104329	484	5.28E+10	1.1E+13	1.60E+15	55822.8	-1.230
L	101856326	-323	-226	104329	51076	5.20E+12	1.1E+13	1.60E+15	55822.8	-1.149
M	94668503	-323	-295.6	104329	87379.36	8.27E+12	9.9E+12	1.60E+15	55822.8	-1.068
N	72977204	-323	-295.6	104329	87379.36	6.38E+12	7.6E+12	1.60E+15	55822.8	-0.823
O	17660804	727	-306.4	528529	93880.96	1.66E+12	9.3E+12	1.60E+15	55822.8	0.448
P	35891429	727	-306.4	528529	93880.96	3.37E+12	1.9E+13	1.60E+15	55822.8	0.911
Q	60798882	1162.6	-44.8	1351638.8	2007.04	1.22E+11	8.2E+13	1.60E+15	55822.8	2.469
R	7336026.3	1369	-334	1874161	111556	8.18E+11	1.4E+13	1.60E+15	55822.8	0.351
S	20308017	541	-60.4	292681	3648.16	7.41E+10	5.9E+12	1.60E+15	55822.8	0.384
T	29471731	605.8	297.2	366993.64	88327.84	2.60E+12	1.1E+13	1.60E+15	55822.8	0.624
U	9809968.9	917.8	387.2	842356.84	149923.8	1.47E+12	8.3E+12	1.60E+15	55822.8	0.314
V	22945766	605.8	440	366993.64	193600	4.44E+12	8.4E+12	1.60E+15	55822.8	0.486
W	34615561	605.8	704	366993.64	495616	1.72E+13	1.3E+13	1.60E+15	55822.8	0.732
X	9809968.9	501.4	962	251401.96	925444	9.08E+12	2.5E+12	1.60E+15	55822.8	0.172
Y	5045944	371.8	2477.6	138235.24	6138502	3.10E+13	7.0E+11	1.60E+15	55822.8	0.066
Z	21628485	579.4	1446.8	335704.36	2093230	4.53E+13	7.3E+12	1.60E+15	55822.8	0.438
XX	9809968.9	501.4	1377.2	251401.96	1896680	1.86E+13	2.5E+12	1.60E+15	55822.8	0.172
ZZ	37163532	610.6	1635.2	372832.36	2673879	9.94E+13	1.4E+13	1.60E+15	55822.8	0.793
YY	22945766	272.2	1762.4	74092.84	3106054	7.13E+13	1.7E+12	1.60E+15	55822.8	0.218
WW	22945766	272.2	1635.2	74092.84	2673879	6.14E+13	1.7E+12	1.60E+15	55822.8	0.218
	1.262E+09					**4.05E+14**	**1.2E+15**			**-18.414**

Torsional Shear in East/West At Level 3										
Wall Name	Rx (k/in)	Xi (in)	Yi (in)	(Xi)^2	(Yi)^2	Ri*(Yi)^2	Ri*(Xi)^2	J	Mey	Fti
1	24259346	-2292.2	-298	5254180.8	88804	2.15E+12	1.27E+14	1.60E+15	49880.4	-0.226
2	9809968.9	-2309	123.2	5331481	15178.24	1.49E+11	5.23E+13	1.60E+15	49880.4	0.038
3	43472748	-2141	-76	4583881	5776	2.51E+11	1.99E+14	1.60E+15	49880.4	-0.103
4	8555851.5	-2069	35.6	4280761	1267.36	1.08E+10	3.66E+13	1.60E+15	49880.4	0.010
5	13696532	-1809.8	-252.4	3275376	63705.76	8.73E+11	4.49E+13	1.60E+15	49880.4	-0.108
6	16336541	-1657.4	-252.4	2746974.8	63705.76	1.04E+12	4.49E+13	1.60E+15	49880.4	-0.129
7	8555851.5	-1196.6	32	1431851.6	1024	8.76E+09	1.23E+13	1.60E+15	49880.4	0.009
8	24259346	-1091	-287.2	1190281	82483.84	2.00E+12	2.89E+13	1.60E+15	49880.4	-0.217
9	12386756	-974.6	-118	949845.16	13924	1.72E+11	1.18E+13	1.60E+15	49880.4	-0.046
10	24259346	-966.2	195.2	933542.44	38103.04	9.24E+11	2.26E+13	1.60E+15	49880.4	0.148
11	22945766	427	-301.6	182329	90962.56	2.09E+12	4.18E+12	1.60E+15	49880.4	-0.216
12	5045944	980.2	-217.6	960792.04	47349.76	2.39E+11	4.85E+12	1.60E+15	49880.4	-0.034
13	17660804	1328.2	-196	1764115.2	38416	6.78E+11	3.12E+13	1.60E+15	49880.4	-0.108
14	25568887	1459	-76	2128681	5776	1.48E+11	5.44E+13	1.60E+15	49880.4	-0.061
15	17660804	980.2	170	960792.04	28900	5.10E+11	1.70E+13	1.60E+15	49880.4	0.094
16	24259346	807.4	195.2	651894.76	38103.04	9.24E+11	1.58E+13	1.60E+15	49880.4	0.148
17	44725345	676.6	195.2	457787.56	38103.04	1.70E+12	2.05E+13	1.60E+15	49880.4	0.272
18	44725345	400.6	326	160480.36	106276	4.75E+12	7.18E+12	1.60E+15	49880.4	0.455
19	93468858	333.4	653.6	111155.56	427193	3.99E+13	1.04E+13	1.60E+15	49880.4	1.907
20	68120244	163	653.6	26569	427193	2.91E+13	1.81E+12	1.60E+15	49880.4	1.390
21	7336026.3	613	582.8	375769	339655.8	2.49E+12	2.76E+12	1.60E+15	49880.4	0.133
22	28175143	818.2	1078.4	669451.24	1162947	3.28E+13	1.89E+13	1.60E+15	49880.4	0.948
23	43472748	664.6	1078.4	441693.16	1162947	5.06E+13	1.92E+13	1.60E+15	49880.4	1.463
24	35891429	598.6	1115.6	358321.96	1244563	4.47E+13	1.29E+13	1.60E+15	49880.4	1.250
25	30763981	412.6	1115.6	170238.76	1244563	3.83E+13	5.24E+12	1.60E+15	49880.4	1.071
26	8555851.5	818.2	1538	669451.24	2365444	2.02E+13	5.73E+12	1.60E+15	49880.4	0.411
27	24259346	400.6	1636.4	160480.36	2677805	6.50E+13	3.89E+12	1.60E+15	49880.4	1.239
28	4004580.5	129.4	1692.8	16744.36	2865572	1.15E+13	6.71E+10	1.60E+15	49880.4	0.212
29	12386756	224.2	-118	50265.64	13924	1.72E+11	6.23E+11	1.60E+15	49880.4	-0.046
	744619496					**3.53E+14**	**8.17E+14**			**9.903**

Torsional Shear in North/South At Level 4										
Wall Name	Rx (k/in)	Xi (in)	Yi (in)	(Xi)^2	(Yi)^2	Ri*(Yi)^2	Ri*(Xi)^2	J	Vex	Vti
A	9809969	-2237	302	5004169	91204	8.95E+11	4.9E+13	1.60E+15	83733.6	-1.150
AA	9809969	-2237	-46	5004169	2116	2.08E+10	4.9E+13	1.60E+15	83733.6	-1.150
B	6161607	-2213	-154	4897369	23716	1.46E+11	3.0E+13	1.60E+15	83733.6	-0.714
BB	6161607	-2213	-454	4897369	206116	1.27E+12	3.0E+13	1.60E+15	83733.6	-0.714
C	53422966	-1565	338	2449225	114244	6.10E+12	1.3E+14	1.60E+15	83733.6	-4.380
D	72977204	-1565	194	2449225	37636	2.75E+12	1.8E+14	1.60E+15	83733.6	-5.984
E	80233852	-1577	110	2486929	12100	9.71E+11	2.0E+14	1.60E+15	83733.6	-6.629
F	72977204	-1577	110	2486929	12100	8.83E+11	1.8E+14	1.60E+15	83733.6	-6.029
G	49709367	-1421	-130	2019241	16900	8.40E+11	1.0E+14	1.60E+15	83733.6	-3.701
H	20308017	-1373	-298	1885129	88804	1.80E+12	3.8E+13	1.60E+15	83733.6	-1.461
I	50949378	-401	182	160801	33124	1.69E+12	8.2E+12	1.60E+15	83733.6	-1.070
J	82646186	-329	38	108241	1444	1.19E+11	8.9E+12	1.60E+15	83733.6	-1.425
K	1.09E+08	-323	-22	104329	484	5.28E+10	1.1E+13	1.60E+15	83733.6	-1.845
L	1.02E+08	-323	-226	104329	51076	5.20E+12	1.1E+13	1.60E+15	83733.6	-1.724
M	94668503	-323	-295.6	104329	87379.36	8.27E+12	9.9E+12	1.60E+15	83733.6	-1.602
N	72977204	-323	-295.6	104329	87379.36	6.38E+12	7.6E+12	1.60E+15	83733.6	-1.235
O	17660804	727	-306.4	528529	93880.96	1.66E+12	9.3E+12	1.60E+15	83733.6	0.673
P	35891429	727	-306.4	528529	93880.96	3.37E+12	1.9E+13	1.60E+15	83733.6	1.367
Q	60798882	1162.6	-44.8	1351639	2007.04	1.22E+11	8.2E+13	1.60E+15	83733.6	3.703
R	7336026	1369	-334	1874161	111556	8.18E+11	1.4E+13	1.60E+15	83733.6	0.526
S	20308017	541	-60.4	292681	3648.16	7.41E+10	5.9E+12	1.60E+15	83733.6	0.576
T	29471731	605.8	297.2	366993.6	88327.84	2.60E+12	1.1E+13	1.60E+15	83733.6	0.935
U	9809969	917.8	387.2	842356.8	149923.8	1.47E+12	8.3E+12	1.60E+15	83733.6	0.472
V	22945766	605.8	440	366993.6	193600	4.44E+12	8.4E+12	1.60E+15	83733.6	0.728
W	34615561	605.8	704	366993.6	495616	1.72E+13	1.3E+13	1.60E+15	83733.6	1.099
X	9809969	501.4	962	251402	925444	9.08E+12	2.5E+12	1.60E+15	83733.6	0.258
Y	5045944	371.8	2477.6	138235.2	6138502	3.10E+13	7.0E+11	1.60E+15	83733.6	0.098
Z	21628485	579.4	1446.8	335704.4	2093230	4.53E+13	7.3E+12	1.60E+15	83733.6	0.657
XX	9809969	501.4	1377.2	251402	1896680	1.86E+13	2.5E+12	1.60E+15	83733.6	0.258
ZZ	37163532	610.6	1635.2	372832.4	2673879	9.94E+13	1.4E+13	1.60E+15	83733.6	1.189
YY	22945766	272.2	1762.4	74092.84	3106054	7.13E+13	1.7E+12	1.60E+15	83733.6	0.327
WW	22945766	272.2	1635.2	74092.84	2673879	6.14E+13	1.7E+12	1.60E+15	83733.6	0.327
	1.26E+09					**4.05E+14**	**1.2E+15**			**-27.620**

Torsional Shear in East/West At Level 4										
Wall Name	Rx (k/in)	Xi (in)	Yi (in)	(Xi)^2	(Yi)^2	Ri*(Yi)^2	Ri*(Xi)^2	J	Vey	Vti
1	24259346	-2292.2	-298	5254181	88804	2.15E+12	1.27E+14	1.60E+15	74821.2	-0.338
2	9809969	-2309	123.2	5331481	15178.24	1.49E+11	5.23E+13	1.60E+15	74821.2	0.057
3	43472748	-2141	-76	4583881	5776	2.51E+11	1.99E+14	1.60E+15	74821.2	-0.155
4	8555851	-2069	35.6	4280761	1267.36	1.08E+10	3.66E+13	1.60E+15	74821.2	0.014
5	13696532	-1809.8	-252.4	3275376	63705.76	8.73E+11	4.49E+13	1.60E+15	74821.2	-0.162
6	16336541	-1657.4	-252.4	2746975	63705.76	1.04E+12	4.49E+13	1.60E+15	74821.2	-0.193
7	8555851	-1196.6	32	1431852	1024	8.76E+09	1.23E+13	1.60E+15	74821.2	0.013
8	24259346	-1091	-287.2	1190281	82483.84	2.00E+12	2.89E+13	1.60E+15	74821.2	-0.326
9	12386756	-974.6	-118	949845.2	13924	1.72E+11	1.18E+13	1.60E+15	74821.2	-0.068
10	24259346	-966.2	195.2	933542.4	38103.04	9.24E+11	2.26E+13	1.60E+15	74821.2	0.222
11	22945766	427	-301.6	182329	90962.56	2.09E+12	4.18E+12	1.60E+15	74821.2	-0.324
12	5045944	980.2	-217.6	960792	47349.76	2.39E+11	4.85E+12	1.60E+15	74821.2	-0.051
13	17660804	1328.2	-196	1764115	38416	6.78E+11	3.12E+13	1.60E+15	74821.2	-0.162
14	25568887	1459	-76	2128681	5776	1.48E+11	5.44E+13	1.60E+15	74821.2	-0.091
15	17660804	980.2	170	960792	28900	5.10E+11	1.70E+13	1.60E+15	74821.2	0.141
16	24259346	807.4	195.2	651894.8	38103.04	9.24E+11	1.58E+13	1.60E+15	74821.2	0.222
17	44725345	676.6	195.2	457787.6	38103.04	1.70E+12	2.05E+13	1.60E+15	74821.2	0.409
18	44725345	400.6	326	160480.4	106276	4.75E+12	7.18E+12	1.60E+15	74821.2	0.683
19	93468858	333.4	653.6	111155.6	427193	3.99E+13	1.04E+13	1.60E+15	74821.2	2.860
20	68120244	163	653.6	26569	427193	2.91E+13	1.81E+12	1.60E+15	74821.2	2.084
21	7336026	613	582.8	375769	339655.8	2.49E+12	2.76E+12	1.60E+15	74821.2	0.200
22	28175143	818.2	1078.4	669451.2	1162947	3.28E+13	1.89E+13	1.60E+15	74821.2	1.422
23	43472748	664.6	1078.4	441693.2	1162947	5.06E+13	1.92E+13	1.60E+15	74821.2	2.195
24	35891429	598.6	1115.6	358322	1244563	4.47E+13	1.29E+13	1.60E+15	74821.2	1.874
25	30763981	412.6	1115.6	170238.8	1244563	3.83E+13	5.24E+12	1.60E+15	74821.2	1.607
26	8555851	818.2	1538	669451.2	2365444	2.02E+13	5.73E+12	1.60E+15	74821.2	0.616
27	24259346	400.6	1636.4	160480.4	2677805	6.50E+13	3.89E+12	1.60E+15	74821.2	1.858
28	4004580	129.4	1692.8	16744.36	2865572	1.15E+13	6.71E+10	1.60E+15	74821.2	0.317
29	12386756	224.2	-118	50265.64	13924	1.72E+11	6.23E+11	1.60E+15	74821.2	-0.068
	7.45E+08					**3.53E+14**	**8.17E+14**			**14.854**

Torsional Shear in North/South At Level 5										
Wall Name	Rx (k/in)	Xi (in)	Yi (in)	(Xi)^2	(Yi)^2	Ri*(Yi)^2	Ri*(Xi)^2	J	V_{ex}	V_{ti}
A	9809969	-2237	302	5004169	91204	8.95E+11	4.9E+13	1.60E+15	111645.6	-1.533
AA	9809969	-2237	-46	5004169	2116	2.08E+10	4.9E+13	1.60E+15	111645.6	-1.533
B	6161607	-2213	-154	4897369	23716	1.46E+11	3.0E+13	1.60E+15	111645.6	-0.953
BB	6161607	-2213	-454	4897369	206116	1.27E+12	3.0E+13	1.60E+15	111645.6	-0.953
C	53422966	-1565	338	2449225	114244	6.10E+12	1.3E+14	1.60E+15	111645.6	-5.840
D	72977204	-1565	194	2449225	37636	2.75E+12	1.8E+14	1.60E+15	111645.6	-7.978
E	80233852	-1577	110	2486929	12100	9.71E+11	2.0E+14	1.60E+15	111645.6	-8.839
F	72977204	-1577	110	2486929	12100	8.83E+11	1.8E+14	1.60E+15	111645.6	-8.039
G	49709367	-1421	-130	2019241	16900	8.40E+11	1.0E+14	1.60E+15	111645.6	-4.934
H	20308017	-1373	-298	1885129	88804	1.80E+12	3.8E+13	1.60E+15	111645.6	-1.948
I	50949378	-401	182	160801	33124	1.69E+12	8.2E+12	1.60E+15	111645.6	-1.427
J	82646186	-329	38	108241	1444	1.19E+11	8.9E+12	1.60E+15	111645.6	-1.899
K	1.09E+08	-323	-22	104329	484	5.28E+10	1.1E+13	1.60E+15	111645.6	-2.460
L	1.02E+08	-323	-226	104329	51076	5.20E+12	1.1E+13	1.60E+15	111645.6	-2.298
M	94668503	-323	-295.6	104329	87379.36	8.27E+12	9.9E+12	1.60E+15	111645.6	-2.136
N	72977204	-323	-295.6	104329	87379.36	6.38E+12	7.6E+12	1.60E+15	111645.6	-1.647
O	17660804	727	-306.4	528529	93880.96	1.66E+12	9.3E+12	1.60E+15	111645.6	0.897
P	35891429	727	-306.4	528529	93880.96	3.37E+12	1.9E+13	1.60E+15	111645.6	1.823
Q	60798882	1162.6	-44.8	1351639	2007.04	1.22E+11	8.2E+13	1.60E+15	111645.6	4.938
R	7336026	1369	-334	1874161	111556	8.18E+11	1.4E+13	1.60E+15	111645.6	0.702
S	20308017	541	-60.4	292681	3648.16	7.41E+10	5.9E+12	1.60E+15	111645.6	0.767
T	29471731	605.8	297.2	366993.6	88327.84	2.60E+12	1.1E+13	1.60E+15	111645.6	1.247
U	9809969	917.8	387.2	842356.8	149923.8	1.47E+12	8.3E+12	1.60E+15	111645.6	0.629
V	22945766	605.8	440	366993.6	193600	4.44E+12	8.4E+12	1.60E+15	111645.6	0.971
W	34615561	605.8	704	366993.6	495616	1.72E+13	1.3E+13	1.60E+15	111645.6	1.465
X	9809969	501.4	962	251402	925444	9.08E+12	2.5E+12	1.60E+15	111645.6	0.344
Y	5045944	371.8	2477.6	138235.2	6138502	3.10E+13	7.0E+11	1.60E+15	111645.6	0.131
Z	21628485	579.4	1446.8	335704.4	2093230	4.53E+13	7.3E+12	1.60E+15	111645.6	0.875
XX	9809969	501.4	1377.2	251402	1896680	1.86E+13	2.5E+12	1.60E+15	111645.6	0.344
ZZ	37163532	610.6	1635.2	372832.4	2673879	9.94E+13	1.4E+13	1.60E+15	111645.6	1.585
YY	22945766	272.2	1762.4	74092.84	3106054	7.13E+13	1.7E+12	1.60E+15	111645.6	0.436
WW	22945766	272.2	1635.2	74092.84	2673879	6.14E+13	1.7E+12	1.60E+15	111645.6	0.436
	1.26E+09					4.05E+14	1.2E+15			-36.827

Torsional Shear in East/West At Level 5										
Wall Name	Rx (k/in)	Xi (in)	Yi (in)	(Xi)^2	(Yi)^2	Ri*(Yi)^2	Ri*(Xi)^2	J	V_{ey}	V_{ti}
1	24259346	-2292.2	-298	5254181	88804	2.15E+12	1.27E+14	1.60E+15	99760.8	-0.451
2	9809969	-2309	123.2	5331481	15178.24	1.49E+11	5.23E+13	1.60E+15	99760.8	0.075
3	43472748	-2141	-76	4583881	5776	2.51E+11	1.99E+14	1.60E+15	99760.8	-0.206
4	8555851	-2069	35.6	4280761	1267.36	1.08E+10	3.66E+13	1.60E+15	99760.8	0.019
5	13696532	-1809.8	-252.4	3275376	63705.76	8.73E+11	4.49E+13	1.60E+15	99760.8	-0.216
6	16336541	-1657.4	-252.4	2746975	63705.76	1.04E+12	4.49E+13	1.60E+15	99760.8	-0.257
7	8555851	-1196.6	32	1431852	1024	8.76E+09	1.23E+13	1.60E+15	99760.8	0.017
8	24259346	-1091	-287.2	1190281	82483.84	2.00E+12	2.89E+13	1.60E+15	99760.8	-0.435
9	12386756	-974.6	-118	949845.2	13924	1.72E+11	1.18E+13	1.60E+15	99760.8	-0.091
10	24259346	-966.2	195.2	933542.4	38103.04	9.24E+11	2.26E+13	1.60E+15	99760.8	0.296
11	22945766	427	-301.6	182329	90962.56	2.09E+12	4.18E+12	1.60E+15	99760.8	-0.432
12	5045944	980.2	-217.6	960792	47349.76	2.39E+11	4.85E+12	1.60E+15	99760.8	-0.069
13	17660804	1328.2	-196	1764115	38416	6.78E+11	3.12E+13	1.60E+15	99760.8	-0.216
14	25568887	1459	-76	2128681	5776	1.48E+11	5.44E+13	1.60E+15	99760.8	-0.121
15	17660804	980.2	170	960792	28900	5.10E+11	1.70E+13	1.60E+15	99760.8	0.187
16	24259346	807.4	195.2	651894.8	38103.04	9.24E+11	1.58E+13	1.60E+15	99760.8	0.296
17	44725345	676.6	195.2	457787.6	38103.04	1.70E+12	2.05E+13	1.60E+15	99760.8	0.545
18	44725345	400.6	326	160480.4	106276	4.75E+12	7.18E+12	1.60E+15	99760.8	0.910
19	93468858	333.4	653.6	111155.6	427193	3.99E+13	1.04E+13	1.60E+15	99760.8	3.813
20	68120244	163	653.6	26569	427193	2.91E+13	1.81E+12	1.60E+15	99760.8	2.779
21	7336026	613	582.8	375769	339655.8	2.49E+12	2.76E+12	1.60E+15	99760.8	0.267
22	28175143	818.2	1078.4	669451.2	1162947	3.28E+13	1.89E+13	1.60E+15	99760.8	1.897
23	43472748	664.6	1078.4	441693.2	1162947	5.06E+13	1.92E+13	1.60E+15	99760.8	2.926
24	35891429	598.6	1115.6	358322	1244563	4.47E+13	1.29E+13	1.60E+15	99760.8	2.499
25	30763981	412.6	1115.6	170238.8	1244563	3.83E+13	5.24E+12	1.60E+15	99760.8	2.142
26	8555851	818.2	1538	669451.2	2365444	2.02E+13	5.73E+12	1.60E+15	99760.8	0.821
27	24259346	400.6	1636.4	160480.4	2677805	6.50E+13	3.89E+12	1.60E+15	99760.8	2.478
28	4004580	129.4	1692.8	16744.36	2865572	1.15E+13	6.71E+10	1.60E+15	99760.8	0.423
29	12386756	224.2	-118	50265.64	13924	1.72E+11	6.23E+11	1.60E+15	99760.8	-0.091
	7.45E+08					3.53E+14	8.17E+14			19.805

Torsional Shear in North/South At Level 6										
Wall Name	Rx (k/in)	Xi (in)	Yi (in)	(Xi)^2	(Yi)^2	Ri*(Yi)^2	Ri*(Xi)^2	J	Vex	Vti
A	9809969	-2237	302	5004169	91204	8.95E+11	4.9E+13	1.60E+15	139556.4	-1.916
AA	9809969	-2237	-46	5004169	2116	2.08E+10	4.9E+13	1.60E+15	139556.4	-1.916
B	6161607	-2213	-154	4897369	23716	1.46E+11	3.0E+13	1.60E+15	139556.4	-1.191
BB	6161607	-2213	-454	4897369	206116	1.27E+12	3.0E+13	1.60E+15	139556.4	-1.191
C	53422966	-1565	338	2449225	114244	6.10E+12	1.3E+14	1.60E+15	139556.4	-7.300
D	72977204	-1565	194	2449225	37636	2.75E+12	1.8E+14	1.60E+15	139556.4	-9.973
E	80233852	-1577	110	2486929	12100	9.71E+11	2.0E+14	1.60E+15	139556.4	-11.048
F	72977204	-1577	110	2486929	12100	8.83E+11	1.8E+14	1.60E+15	139556.4	-10.049
G	49709367	-1421	-130	2019241	16900	8.40E+11	1.0E+14	1.60E+15	139556.4	-6.168
H	20308017	-1373	-298	1885129	88804	1.80E+12	3.8E+13	1.60E+15	139556.4	-2.435
I	50949378	-401	182	160801	33124	1.69E+12	8.2E+12	1.60E+15	139556.4	-1.784
J	82646186	-329	38	108241	1444	1.19E+11	8.9E+12	1.60E+15	139556.4	-2.374
K	1.09E+08	-323	-22	104329	484	5.28E+10	1.1E+13	1.60E+15	139556.4	-3.075
L	1.02E+08	-323	-226	104329	51076	5.20E+12	1.1E+13	1.60E+15	139556.4	-2.873
M	94668503	-323	-295.6	104329	87379.36	8.27E+12	9.9E+12	1.60E+15	139556.4	-2.670
N	72977204	-323	-295.6	104329	87379.36	6.38E+12	7.6E+12	1.60E+15	139556.4	-2.058
O	17660804	727	-306.4	528529	93880.96	1.66E+12	9.3E+12	1.60E+15	139556.4	1.121
P	35891429	727	-306.4	528529	93880.96	3.37E+12	1.9E+13	1.60E+15	139556.4	2.278
Q	60798882	1162.6	-44.8	1351639	2007.04	1.22E+11	8.2E+13	1.60E+15	139556.4	6.172
R	7336026	1369	-334	1874161	111556	8.18E+11	1.4E+13	1.60E+15	139556.4	0.877
S	20308017	541	-60.4	292681	3648.16	7.41E+10	5.9E+12	1.60E+15	139556.4	0.959
T	29471731	605.8	297.2	366993.6	88327.84	2.60E+12	1.1E+13	1.60E+15	139556.4	1.559
U	9809969	917.8	387.2	842356.8	149923.8	1.47E+12	8.3E+12	1.60E+15	139556.4	0.786
V	22945766	605.8	440	366993.6	193600	4.44E+12	8.4E+12	1.60E+15	139556.4	1.214
W	34615561	605.8	704	366993.6	495616	1.72E+13	1.3E+13	1.60E+15	139556.4	1.831
X	9809969	501.4	962	251402	925444	9.08E+12	2.5E+12	1.60E+15	139556.4	0.429
Y	5045944	371.8	2477.6	138235.2	6138502	3.10E+13	7.0E+11	1.60E+15	139556.4	0.164
Z	21628485	579.4	1446.8	335704.4	2093230	4.53E+13	7.3E+12	1.60E+15	139556.4	1.094
XX	9809969	501.4	1377.2	251402	1896680	1.86E+13	2.5E+12	1.60E+15	139556.4	0.429
ZZ	37163532	610.6	1635.2	372832.4	2673879	9.94E+13	1.4E+13	1.60E+15	139556.4	1.981
YY	22945766	272.2	1762.4	74092.84	3106054	7.13E+13	1.7E+12	1.60E+15	139556.4	0.545
WW	22945766	272.2	1635.2	74092.84	2673879	6.14E+13	1.7E+12	1.60E+15	139556.4	0.545
	1.26E+09					**4.05E+14**	**1.2E+15**			**-46.034**

Torsional Shear in East/West At Level 6										
Wall Name	Rx (k/in)	Xi (in)	Yi (in)	(Xi)^2	(Yi)^2	Ri*(Yi)^2	Ri*(Xi)^2	J	Vey	Vti
1	24259346	-2292.2	-298	5254181	88804	2.15E+12	1.27E+14	1.60E+15	124701.6	-0.564
2	9809969	-2309	123.2	5331481	15178.24	1.49E+11	5.23E+13	1.60E+15	124701.6	0.094
3	43472748	-2141	-76	4583881	5776	2.51E+11	1.99E+14	1.60E+15	124701.6	-0.258
4	8555851	-2069	35.6	4280761	1267.36	1.08E+10	3.66E+13	1.60E+15	124701.6	0.024
5	13696532	-1809.8	-252.4	3275376	63705.76	8.73E+11	4.49E+13	1.60E+15	124701.6	-0.270
6	16336541	-1657.4	-252.4	2746975	63705.76	1.04E+12	4.49E+13	1.60E+15	124701.6	-0.322
7	8555851	-1196.6	32	1431852	1024	8.76E+09	1.23E+13	1.60E+15	124701.6	0.021
8	24259346	-1091	-287.2	1190281	82483.84	2.00E+12	2.89E+13	1.60E+15	124701.6	-0.544
9	12386756	-974.6	-118	949845.2	13924	1.72E+11	1.18E+13	1.60E+15	124701.6	-0.114
10	24259346	-966.2	195.2	933542.4	38103.04	9.24E+11	2.26E+13	1.60E+15	124701.6	0.369
11	22945766	427	-301.6	182329	90962.56	2.09E+12	4.18E+12	1.60E+15	124701.6	-0.540
12	5045944	980.2	-217.6	960792	47349.76	2.39E+11	4.85E+12	1.60E+15	124701.6	-0.086
13	17660804	1328.2	-196	1764115	38416	6.78E+11	3.12E+13	1.60E+15	124701.6	-0.270
14	25568887	1459	-76	2128681	5776	1.48E+11	5.44E+13	1.60E+15	124701.6	-0.152
15	17660804	980.2	170	960792	28900	5.10E+11	1.70E+13	1.60E+15	124701.6	0.234
16	24259346	807.4	195.2	651894.8	38103.04	9.24E+11	1.58E+13	1.60E+15	124701.6	0.369
17	44725345	676.6	195.2	457787.6	38103.04	1.70E+12	2.05E+13	1.60E+15	124701.6	0.681
18	44725345	400.6	326	160480.4	106276	4.75E+12	7.18E+12	1.60E+15	124701.6	1.138
19	93468858	333.4	653.6	111155.6	427193	3.99E+13	1.04E+13	1.60E+15	124701.6	4.767
20	68120244	163	653.6	26569	427193	2.91E+13	1.81E+12	1.60E+15	124701.6	3.474
21	7336026	613	582.8	375769	339655.8	2.49E+12	2.76E+12	1.60E+15	124701.6	0.334
22	28175143	818.2	1078.4	669451.2	1162947	3.28E+13	1.89E+13	1.60E+15	124701.6	2.371
23	43472748	664.6	1078.4	441693.2	1162947	5.06E+13	1.92E+13	1.60E+15	124701.6	3.658
24	35891429	598.6	1115.6	358322	1244563	4.47E+13	1.29E+13	1.60E+15	124701.6	3.124
25	30763981	412.6	1115.6	170238.8	1244563	3.83E+13	5.24E+12	1.60E+15	124701.6	2.678
26	8555851	818.2	1538	669451.2	2365444	2.02E+13	5.73E+12	1.60E+15	124701.6	1.027
27	24259346	400.6	1636.4	160480.4	2677805	6.50E+13	3.89E+12	1.60E+15	124701.6	3.097
28	4004580	129.4	1692.8	16744.36	2865572	1.15E+13	6.71E+10	1.60E+15	124701.6	0.529
29	12386756	224.2	-118	50265.64	13924	1.72E+11	6.23E+11	1.60E+15	124701.6	-0.114
	7.45E+08					**3.53E+14**	**8.17E+14**			**24.757**

Torsional Shear in North/South At Level 7										
Wall Name	Rx (k/in)	Xi (in)	Yi (in)	(Xi)^2	(Yi)^2	Ri*(Yi)^2	Ri*(Xi)^2	J	Vex	Vti
A	9809969	-2237	302	5004169	91204	8.95E+11	4.9E+13	1.60E+15	167468.4	-2.299
AA	9809969	-2237	-46	5004169	2116	2.08E+10	4.9E+13	1.60E+15	167468.4	-2.299
B	6161607	-2213	-154	4897369	23716	1.46E+11	3.0E+13	1.60E+15	167468.4	-1.429
BB	6161607	-2213	-454	4897369	206116	1.27E+12	3.0E+13	1.60E+15	167468.4	-1.429
C	53422966	-1565	338	2449225	114244	6.10E+12	1.3E+14	1.60E+15	167468.4	-8.761
D	72977204	-1565	194	2449225	37636	2.75E+12	1.8E+14	1.60E+15	167468.4	-11.967
E	80233852	-1577	110	2486929	12100	9.71E+11	2.0E+14	1.60E+15	167468.4	-13.258
F	72977204	-1577	110	2486929	12100	8.83E+11	1.8E+14	1.60E+15	167468.4	-12.059
G	49709367	-1421	-130	2019241	16900	8.40E+11	1.0E+14	1.60E+15	167468.4	-7.402
H	20308017	-1373	-298	1885129	88804	1.80E+12	3.8E+13	1.60E+15	167468.4	-2.922
I	50949378	-401	182	160801	33124	1.69E+12	8.2E+12	1.60E+15	167468.4	-2.141
J	82646186	-329	38	108241	1444	1.19E+11	8.9E+12	1.60E+15	167468.4	-2.849
K	1.09E+08	-323	-22	104329	484	5.28E+10	1.1E+13	1.60E+15	167468.4	-3.690
L	1.02E+08	-323	-226	104329	51076	5.20E+12	1.1E+13	1.60E+15	167468.4	-3.447
M	94668503	-323	-295.6	104329	87379.36	8.27E+12	9.9E+12	1.60E+15	167468.4	-3.204
N	72977204	-323	-295.6	104329	87379.36	6.38E+12	7.6E+12	1.60E+15	167468.4	-2.470
O	17660804	727	-306.4	528529	93880.96	1.66E+12	9.3E+12	1.60E+15	167468.4	1.345
P	35891429	727	-306.4	528529	93880.96	3.37E+12	1.9E+13	1.60E+15	167468.4	2.734
Q	60798882	1162.6	-44.8	1351639	2007.04	1.22E+11	8.2E+13	1.60E+15	167468.4	7.407
R	7336026	1369	-334	1874161	111556	8.18E+11	1.4E+13	1.60E+15	167468.4	1.052
S	20308017	541	-60.4	292681	3648.16	7.41E+10	5.9E+12	1.60E+15	167468.4	1.151
T	29471731	605.8	297.2	366993.6	88327.84	2.60E+12	1.1E+13	1.60E+15	167468.4	1.871
U	9809969	917.8	387.2	842356.8	149923.8	1.47E+12	8.3E+12	1.60E+15	167468.4	0.943
V	22945766	605.8	440	366993.6	193600	4.44E+12	8.4E+12	1.60E+15	167468.4	1.457
W	34615561	605.8	704	366993.6	495616	1.72E+13	1.3E+13	1.60E+15	167468.4	2.197
X	9809969	501.4	962	251402	925444	9.08E+12	2.5E+12	1.60E+15	167468.4	0.515
Y	5045944	371.8	2477.6	138235.2	6138502	3.10E+13	7.0E+11	1.60E+15	167468.4	0.197
Z	21628485	579.4	1446.8	335704.4	2093230	4.53E+13	7.3E+12	1.60E+15	167468.4	1.313
XX	9809969	501.4	1377.2	251402	1896680	1.86E+13	2.5E+12	1.60E+15	167468.4	0.515
ZZ	37163532	610.6	1635.2	372832.4	2673879	9.94E+13	1.4E+13	1.60E+15	167468.4	2.378
YY	22945766	272.2	1762.4	74092.84	3106054	7.13E+13	1.7E+12	1.60E+15	167468.4	0.654
WW	22945766	272.2	1635.2	74092.84	2673879	6.14E+13	1.7E+12	1.60E+15	167468.4	0.654
	1.26E+09					**4.05E+14**	**1.2E+15**			**-55.241**

Torsional Shear in East/West At Level 7										
Wall Name	Rx (k/in)	Xi (in)	Yi (in)	(Xi)^2	(Yi)^2	Ri*(Yi)^2	Ri*(Xi)^2	J	Vey	Vti
1	24259346	-2292.2	-298	5254181	88804	2.15E+12	1.27E+14	1.60E+15	149641.2	-0.677
2	9809969	-2309	123.2	5331481	15178.24	1.49E+11	5.23E+13	1.60E+15	149641.2	0.113
3	43472748	-2141	-76	4583881	5776	2.51E+11	1.99E+14	1.60E+15	149641.2	-0.309
4	8555851	-2069	35.6	4280761	1267.36	1.08E+10	3.66E+13	1.60E+15	149641.2	0.029
5	13696532	-1809.8	-252.4	3275376	63705.76	8.73E+11	4.49E+13	1.60E+15	149641.2	-0.324
6	16336541	-1657.4	-252.4	2746975	63705.76	1.04E+12	4.49E+13	1.60E+15	149641.2	-0.386
7	8555851	-1196.6	32	1431852	1024	8.76E+09	1.23E+13	1.60E+15	149641.2	0.026
8	24259346	-1091	-287.2	1190281	82483.84	2.00E+12	2.89E+13	1.60E+15	149641.2	-0.652
9	12386756	-974.6	-118	949845.2	13924	1.72E+11	1.18E+13	1.60E+15	149641.2	-0.137
10	24259346	-966.2	195.2	933542.4	38103.04	9.24E+11	2.26E+13	1.60E+15	149641.2	0.443
11	22945766	427	-301.6	182329	90962.56	2.09E+12	4.18E+12	1.60E+15	149641.2	-0.648
12	5045944	980.2	-217.6	960792	47349.76	2.39E+11	4.85E+12	1.60E+15	149641.2	-0.103
13	17660804	1328.2	-196	1764115	38416	6.78E+11	3.12E+13	1.60E+15	149641.2	-0.324
14	25568887	1459	-76	2128681	5776	1.48E+11	5.44E+13	1.60E+15	149641.2	-0.182
15	17660804	980.2	170	960792	28900	5.10E+11	1.70E+13	1.60E+15	149641.2	0.281
16	24259346	807.4	195.2	651894.8	38103.04	9.24E+11	1.58E+13	1.60E+15	149641.2	0.443
17	44725345	676.6	195.2	457787.6	38103.04	1.70E+12	2.05E+13	1.60E+15	149641.2	0.817
18	44725345	400.6	326	160480.4	106276	4.75E+12	7.18E+12	1.60E+15	149641.2	1.365
19	93468858	333.4	653.6	111155.6	427193	3.99E+13	1.04E+13	1.60E+15	149641.2	5.720
20	68120244	163	653.6	26569	427193	2.91E+13	1.81E+12	1.60E+15	149641.2	4.169
21	7336026	613	582.8	375769	339655.8	2.49E+12	2.76E+12	1.60E+15	149641.2	0.400
22	28175143	818.2	1078.4	669451.2	1162947	3.28E+13	1.89E+13	1.60E+15	149641.2	2.845
23	43472748	664.6	1078.4	441693.2	1162947	5.06E+13	1.92E+13	1.60E+15	149641.2	4.389
24	35891429	598.6	1115.6	358322	1244563	4.47E+13	1.29E+13	1.60E+15	149641.2	3.749
25	30763981	412.6	1115.6	170238.8	1244563	3.83E+13	5.24E+12	1.60E+15	149641.2	3.213
26	8555851	818.2	1538	669451.2	2365444	2.02E+13	5.73E+12	1.60E+15	149641.2	1.232
27	24259346	400.6	1636.4	160480.4	2677805	6.50E+13	3.89E+12	1.60E+15	149641.2	3.717
28	4004580	129.4	1692.8	16744.36	2865572	1.15E+13	6.71E+10	1.60E+15	149641.2	0.635
29	12386756	224.2	-118	50265.64	13924	1.72E+11	6.23E+11	1.60E+15	149641.2	-0.137
	7.45E+08					**3.53E+14**	**8.17E+14**			**29.708**

Torsional Shear in North/South At Roof										
Wall Name	Rx (k/in)	Xi (in)	Yi (in)	(Xi)^2	(Yi)^2	Ri*(Yi)^2	Ri*(Xi)^2	J	Vex	Vti
A	9809969	-2237	302	5004169	91204	8.95E+11	4.9E+13	1.60E+15	160016.4	-2.197
AA	9809969	-2237	-46	5004169	2116	2.08E+10	4.9E+13	1.60E+15	160016.4	-2.197
B	6161607	-2213	-154	4897369	23716	1.46E+11	3.0E+13	1.60E+15	160016.4	-1.365
BB	6161607	-2213	-454	4897369	206116	1.27E+12	3.0E+13	1.60E+15	160016.4	-1.365
C	53422966	-1565	338	2449225	114244	6.10E+12	1.3E+14	1.60E+15	160016.4	-8.371
D	72977204	-1565	194	2449225	37636	2.75E+12	1.8E+14	1.60E+15	160016.4	-11.435
E	80233852	-1577	110	2486929	12100	9.71E+11	2.0E+14	1.60E+15	160016.4	-12.668
F	72977204	-1577	110	2486929	12100	8.83E+11	1.8E+14	1.60E+15	160016.4	-11.522
G	49709367	-1421	-130	2019241	16900	8.40E+11	1.0E+14	1.60E+15	160016.4	-7.072
H	20308017	-1373	-298	1885129	88804	1.80E+12	3.8E+13	1.60E+15	160016.4	-2.792
I	50949378	-401	182	160801	33124	1.69E+12	8.2E+12	1.60E+15	160016.4	-2.046
J	82646186	-329	38	108241	1444	1.19E+11	8.9E+12	1.60E+15	160016.4	-2.722
K	1.09E+08	-323	-22	104329	484	5.28E+10	1.1E+13	1.60E+15	160016.4	-3.526
L	1.02E+08	-323	-226	104329	51076	5.20E+12	1.1E+13	1.60E+15	160016.4	-3.294
M	94668503	-323	-295.6	104329	87379.36	8.27E+12	9.9E+12	1.60E+15	160016.4	-3.061
N	72977204	-323	-295.6	104329	87379.36	6.38E+12	7.6E+12	1.60E+15	160016.4	-2.360
O	17660804	727	-306.4	528529	93880.96	1.66E+12	9.3E+12	1.60E+15	160016.4	1.285
P	35891429	727	-306.4	528529	93880.96	3.37E+12	1.9E+13	1.60E+15	160016.4	2.612
Q	60798882	1162.6	-44.8	1351639	2007.04	1.22E+11	8.2E+13	1.60E+15	160016.4	7.077
R	7336026	1369	-334	1874161	111556	8.18E+11	1.4E+13	1.60E+15	160016.4	1.006
S	20308017	541	-60.4	292681	3648.16	7.41E+10	5.9E+12	1.60E+15	160016.4	1.100
T	29471731	605.8	297.2	366993.6	88327.84	2.60E+12	1.1E+13	1.60E+15	160016.4	1.788
U	9809969	917.8	387.2	842356.8	149923.8	1.47E+12	8.3E+12	1.60E+15	160016.4	0.901
V	22945766	605.8	440	366993.6	193600	4.44E+12	8.4E+12	1.60E+15	160016.4	1.392
W	34615561	605.8	704	366993.6	495616	1.72E+13	1.3E+13	1.60E+15	160016.4	2.100
X	9809969	501.4	962	251402	925444	9.08E+12	2.5E+12	1.60E+15	160016.4	0.492
Y	5045944	371.8	2477.6	138235.2	6138502	3.10E+13	7.0E+11	1.60E+15	160016.4	0.188
Z	21628485	579.4	1446.8	335704.4	2093230	4.53E+13	7.3E+12	1.60E+15	160016.4	1.255
XX	9809969	501.4	1377.2	251402	1896680	1.86E+13	2.5E+12	1.60E+15	160016.4	0.492
ZZ	37163532	610.6	1635.2	372832.4	2673879	9.94E+13	1.4E+13	1.60E+15	160016.4	2.272
YY	22945766	272.2	1762.4	74092.84	3106054	7.13E+13	1.7E+12	1.60E+15	160016.4	0.625
WW	22945766	272.2	1635.2	74092.84	2673879	6.14E+13	1.7E+12	1.60E+15	160016.4	0.625
	1.26E+09					**4.05E+14**	**1.2E+15**			**-52.783**

Torsional Shear in East/West At Roof										
Wall Name	Rx (k/in)	Xi (in)	Yi (in)	(Xi)^2	(Yi)^2	Ri*(Yi)^2	Ri*(Xi)^2	J	Vey	Vti
1	24259346	-2292.2	-298	5254181	88804	2.15E+12	1.27E+14	1.60E+15	142983.6	-0.647
2	9809969	-2309	123.2	5331481	15178.24	1.49E+11	5.23E+13	1.60E+15	142983.6	0.108
3	43472748	-2141	-76	4583881	5776	2.51E+11	1.99E+14	1.60E+15	142983.6	-0.296
4	8555851	-2069	35.6	4280761	1267.36	1.08E+10	3.66E+13	1.60E+15	142983.6	0.027
5	13696532	-1809.8	-252.4	3275376	63705.76	8.73E+11	4.49E+13	1.60E+15	142983.6	-0.309
6	16336541	-1657.4	-252.4	2746975	63705.76	1.04E+12	4.49E+13	1.60E+15	142983.6	-0.369
7	8555851	-1196.6	32	1431852	1024	8.76E+09	1.23E+13	1.60E+15	142983.6	0.024
8	24259346	-1091	-287.2	1190281	82483.84	2.00E+12	2.89E+13	1.60E+15	142983.6	-0.623
9	12386756	-974.6	-118	949845.2	13924	1.72E+11	1.18E+13	1.60E+15	142983.6	-0.131
10	24259346	-966.2	195.2	933542.4	38103.04	9.24E+11	2.26E+13	1.60E+15	142983.6	0.424
11	22945766	427	-301.6	182329	90962.56	2.09E+12	4.18E+12	1.60E+15	142983.6	-0.619
12	5045944	980.2	-217.6	960792	47349.76	2.39E+11	4.85E+12	1.60E+15	142983.6	-0.098
13	17660804	1328.2	-196	1764115	38416	6.78E+11	3.12E+13	1.60E+15	142983.6	-0.310
14	25568887	1459	-76	2128681	5776	1.48E+11	5.44E+13	1.60E+15	142983.6	-0.174
15	17660804	980.2	170	960792	28900	5.10E+11	1.70E+13	1.60E+15	142983.6	0.269
16	24259346	807.4	195.2	651894.8	38103.04	9.24E+11	1.58E+13	1.60E+15	142983.6	0.424
17	44725345	676.6	195.2	457787.6	38103.04	1.70E+12	2.05E+13	1.60E+15	142983.6	0.781
18	44725345	400.6	326	160480.4	106276	4.75E+12	7.18E+12	1.60E+15	142983.6	1.304
19	93468858	333.4	653.6	111155.6	427193	3.99E+13	1.04E+13	1.60E+15	142983.6	5.465
20	68120244	163	653.6	26569	427193	2.91E+13	1.81E+12	1.60E+15	142983.6	3.983
21	7336026	613	582.8	375769	339655.8	2.49E+12	2.76E+12	1.60E+15	142983.6	0.382
22	28175143	818.2	1078.4	669451.2	1162947	3.28E+13	1.89E+13	1.60E+15	142983.6	2.718
23	43472748	664.6	1078.4	441693.2	1162947	5.06E+13	1.92E+13	1.60E+15	142983.6	4.194
24	35891429	598.6	1115.6	358322	1244563	4.47E+13	1.29E+13	1.60E+15	142983.6	3.582
25	30763981	412.6	1115.6	170238.8	1244563	3.83E+13	5.24E+12	1.60E+15	142983.6	3.070
26	8555851	818.2	1538	669451.2	2365444	2.02E+13	5.73E+12	1.60E+15	142983.6	1.177
27	24259346	400.6	1636.4	160480.4	2677805	6.50E+13	3.89E+12	1.60E+15	142983.6	3.552
28	4004580	129.4	1692.8	16744.36	2865572	1.15E+13	6.71E+10	1.60E+15	142983.6	0.606
29	12386756	224.2	-118	50265.64	13924	1.72E+11	6.23E+11	1.60E+15	142983.6	-0.131
	7.45E+08					**3.53E+14**	**8.17E+14**			**28.386**

Total Shear in Each Wall at All Levels in Longitudinal Direction (Kips)								
Wall No.	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Roof
A	12.9	12.93	12.45	11.48	10.03	8.09	5.68	2.78
AA	12.9	12.93	12.45	11.48	10.03	8.09	5.68	2.78
B	8.1	8.12	7.82	7.21	6.30	5.08	3.56	1.74
BB	8.1	8.12	7.82	7.21	6.30	5.08	3.56	1.74
C	70.4	70.40	67.78	62.53	54.61	44.07	30.91	15.11
D	96.2	96.17	92.59	85.42	74.60	60.20	42.22	20.65
E	105.7	105.74	101.80	93.91	82.02	66.19	46.42	22.70
F	96.2	96.17	92.59	85.42	74.60	60.20	42.22	20.65
G	65.5	65.51	63.07	58.18	50.82	41.01	28.76	14.06
H	26.8	26.76	25.77	23.77	20.76	16.75	11.75	5.75
I	67.1	67.14	64.64	59.63	52.08	42.03	29.47	14.41
J	108.9	108.92	104.86	96.73	84.49	68.18	47.81	23.38
K	143.7	143.69	138.33	127.62	111.46	89.94	63.07	30.85
L	134.2	134.23	129.23	119.22	104.13	84.03	58.92	28.82
M	124.8	124.76	120.11	110.81	96.78	78.10	54.77	26.78
N	96.2	96.17	92.59	85.42	74.60	60.20	42.22	20.65
O	29.3	29.27	28.18	25.99	22.70	18.32	12.85	6.28
P	59.5	59.48	57.26	52.82	46.14	37.23	26.11	12.77
Q	113.1	113.12	108.90	100.46	87.75	70.81	49.66	24.28
R	14.4	14.36	13.82	12.75	11.14	8.99	6.30	3.08
S	31.9	31.89	30.70	28.32	24.74	19.96	14.00	6.85
T	47.2	47.18	45.42	41.90	36.59	29.53	20.71	10.13
U	17.1	17.13	16.49	15.21	13.29	10.72	7.52	3.68
V	36.7	36.73	35.36	32.62	28.49	22.99	16.12	7.88
W	55.4	55.41	53.34	49.21	42.98	34.68	24.32	11.89
X	15.2	15.22	14.66	13.52	11.81	9.53	6.68	3.27
Y	7.5	7.53	7.25	6.68	5.84	4.71	3.30	1.62
Z	34.4	34.35	33.07	30.51	26.65	21.50	15.08	7.37
XX	15.2	15.22	14.66	13.52	11.81	9.53	6.68	3.27
ZZ	59.6	59.57	57.35	52.90	46.21	37.29	26.15	12.79
YY	33.2	33.16	31.92	29.45	25.72	20.75	14.55	7.12
WW	33.2	33.16	31.92	29.45	25.72	20.75	14.55	7.12

Total Overturning Moment in Each Wall at All Levels in Longitudinal Direction (Kips)							
Wall No.	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Level 5**	**Level 6**	**Level 7**
A	634.3	505.00	380.54	265.72	165.43	84.50	27.75
AA	634.3	505.00	380.54	265.72	165.43	84.50	27.75
B	398.4	317.19	239.02	166.90	103.91	53.08	17.43
BB	398.4	317.19	239.02	166.90	103.91	53.08	17.43
C	3454.2	2750.13	2072.34	1447.04	900.91	460.19	151.14
D	4718.5	3756.76	2830.87	1976.69	1230.66	628.63	206.46
E	5187.7	4130.32	3112.36	2173.25	1353.04	691.14	226.99
F	4718.5	3756.76	2830.87	1976.69	1230.66	628.63	206.46
G	3214.1	2558.96	1928.28	1346.45	838.28	428.20	140.63
H	1313.1	1045.43	787.77	550.07	342.47	174.94	57.45
I	3294.2	2622.80	1976.38	1380.04	859.19	438.88	144.14
J	5343.7	4254.50	3205.94	2238.59	1393.72	711.92	233.81
K	7049.5	5612.66	4229.36	2953.21	1838.63	939.19	308.45
L	6585.7	5243.41	3951.12	2758.93	1717.67	877.40	288.16
M	6121.0	4873.39	3672.30	2564.23	1596.46	815.48	267.83
N	4718.5	3756.76	2830.87	1976.69	1230.66	628.63	206.46
O	1435.9	1143.24	861.47	601.54	374.51	191.30	62.82
P	2918.2	2323.36	1750.74	1222.49	761.10	388.76	127.66
Q	5549.8	4418.56	3329.52	2324.92	1447.45	739.33	242.78
R	704.3	560.75	422.54	295.05	183.69	93.83	30.81
S	1564.7	1245.73	938.71	655.47	408.08	208.45	68.45
T	2314.4	1842.67	1388.52	969.56	603.63	308.33	101.25
U	840.5	669.16	504.23	352.09	219.21	111.97	36.77
V	1801.9	1434.65	1081.06	754.87	469.97	240.06	78.83
W	2718.4	2164.28	1630.86	1138.78	708.99	362.15	118.93
X	746.9	594.68	448.11	312.90	194.81	99.51	32.68
Y	369.2	293.96	221.51	154.67	96.30	49.19	16.15
Z	1685.4	1341.88	1011.15	706.06	439.58	224.53	73.74
XX	746.9	594.68	448.11	312.90	194.81	99.51	32.68
ZZ	2922.6	2326.84	1753.36	1224.32	762.24	389.35	127.86
YY	1626.6	1295.09	975.90	681.44	424.25	216.71	71.17
WW	1626.6	1295.09	975.90	681.44	424.25	216.71	71.17

Total Shear in Each Wall at All Levels in Transverse Direction (Kips)								
Wall No.	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Level 5**	**Level 6**	**Level 7**	**Roof**
1	54.18	54.18	52.16	48.12	42.03	33.92	23.78	11.63
2	21.91	21.91	21.09	19.46	17.00	13.71	9.62	4.70
3	97.09	97.09	93.47	86.23	75.31	60.78	42.62	20.84
4	19.11	19.11	18.40	16.97	14.82	11.96	8.39	4.10
5	30.59	30.59	29.45	27.17	23.73	19.15	13.43	6.57
6	36.49	36.49	35.13	32.40	28.30	22.84	16.02	7.83
7	19.11	19.11	18.40	16.97	14.82	11.96	8.39	4.10
8	54.18	54.18	52.16	48.12	42.03	33.92	23.78	11.63
9	27.66	27.66	26.63	24.57	21.46	17.32	12.14	5.94
10	56.18	56.18	54.06	49.87	43.56	35.15	24.65	12.05
11	48.32	48.32	46.56	42.95	37.51	30.27	21.23	10.38
12	10.81	10.81	10.41	9.60	8.39	6.77	4.75	2.32
13	37.98	37.98	36.58	33.75	29.48	23.79	16.68	8.16
14	56.28	56.28	54.20	50.00	43.67	35.24	24.71	12.08
15	40.71	40.71	39.18	36.14	31.57	25.47	17.86	8.74
16	56.18	56.18	54.06	49.87	43.56	35.15	24.65	12.05
17	103.58	103.58	99.67	91.95	80.31	64.81	45.45	22.22
18	106.05	106.05	102.02	94.12	82.20	66.33	46.52	22.75
19	234.58	234.58	225.50	208.03	181.69	146.62	102.82	50.28
20	170.96	170.96	164.34	151.61	132.42	106.86	74.93	36.64
21	18.19	18.19	17.49	16.13	14.09	11.37	7.97	3.90
22	75.77	75.77	72.78	67.14	58.64	47.32	33.19	16.23
23	116.91	116.91	112.30	103.59	90.48	73.02	51.20	25.04
24	97.09	97.09	93.25	86.02	75.13	60.63	42.52	20.79
25	83.22	83.22	79.93	73.73	64.40	51.97	36.44	17.82
26	24.67	24.67	23.68	21.84	19.08	15.40	10.80	5.28
27	70.97	70.97	68.10	62.82	54.87	44.28	31.05	15.18
28	11.81	11.81	11.33	10.45	9.13	7.37	5.17	2.53
29	27.05	27.05	26.05	24.03	20.99	16.94	11.88	5.81

Total Shear in Each Wall at All Levels in Transverse Direction (Kips)								
Wall No.	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Level 5**	**Level 6**	**Level 7**	**Roof**
1	54.18	54.18	52.16	48.12	42.03	33.92	23.78	11.63
2	21.91	21.91	21.09	19.46	17.00	13.71	9.62	4.70
3	97.09	97.09	93.47	86.23	75.31	60.78	42.62	20.84
4	19.11	19.11	18.40	16.97	14.82	11.96	8.39	4.10
5	30.59	30.59	29.45	27.17	23.73	19.15	13.43	6.57
6	36.49	36.49	35.13	32.40	28.30	22.84	16.02	7.83
7	19.11	19.11	18.40	16.97	14.82	11.96	8.39	4.10
8	54.18	54.18	52.16	48.12	42.03	33.92	23.78	11.63
9	27.66	27.66	26.63	24.57	21.46	17.32	12.14	5.94
10	56.18	56.18	54.06	49.87	43.56	35.15	24.65	12.05
11	48.32	48.32	46.56	42.95	37.51	30.27	21.23	10.38
12	10.81	10.81	10.41	9.60	8.39	6.77	4.75	2.32
13	37.98	37.98	36.58	33.75	29.48	23.79	16.68	8.16
14	56.28	56.28	54.20	50.00	43.67	35.24	24.71	12.08
15	40.71	40.71	39.18	36.14	31.57	25.47	17.86	8.74
16	56.18	56.18	54.06	49.87	43.56	35.15	24.65	12.05
17	103.58	103.58	99.67	91.95	80.31	64.81	45.45	22.22
18	106.05	106.05	102.02	94.12	82.20	66.33	46.52	22.75
19	234.58	234.58	225.50	208.03	181.69	146.62	102.82	50.28
20	170.96	170.96	164.34	151.61	132.42	106.86	74.93	36.64
21	18.19	18.19	17.49	16.13	14.09	11.37	7.97	3.90
22	75.77	75.77	72.78	67.14	58.64	47.32	33.19	16.23
23	116.91	116.91	112.30	103.59	90.48	73.02	51.20	25.04
24	97.09	97.09	93.25	86.02	75.13	60.63	42.52	20.79
25	83.22	83.22	79.93	73.73	64.40	51.97	36.44	17.82
26	24.67	24.67	23.68	21.84	19.08	15.40	10.80	5.28
27	70.97	70.97	68.10	62.82	54.87	44.28	31.05	15.18
28	11.81	11.81	11.33	10.45	9.13	7.37	5.17	2.53
29	27.05	27.05	26.05	24.03	20.99	16.94	11.88	5.81

Torsional Shear in North/South At Level 6										
Wall Name	Rx (k/in)	Xi (in)	Yi (in)	(Xi)^2	(Yi)^2	Ri*(Yi)^2	Ri*(Xi)^2	J	Vex	Vti
A	9809969	-2237	302	5004169	91204	8.95E+11	4.9E+13	1.60E+15	139556.4	-1.916
AA	9809969	-2237	-46	5004169	2116	2.08E+10	4.9E+13	1.60E+15	139556.4	-1.916
B	6161607	-2213	-154	4897369	23716	1.46E+11	3.0E+13	1.60E+15	139556.4	-1.191
BB	6161607	-2213	-454	4897369	206116	1.27E+12	3.0E+13	1.60E+15	139556.4	-1.191
C	53422966	-1565	338	2449225	114244	6.10E+12	1.3E+14	1.60E+15	139556.4	-7.300
D	72977204	-1565	194	2449225	37636	2.75E+12	1.8E+14	1.60E+15	139556.4	-9.973
E	80233852	-1577	110	2486929	12100	9.71E+11	2.0E+14	1.60E+15	139556.4	-11.048
F	72977204	-1577	110	2486929	12100	8.83E+11	1.8E+14	1.60E+15	139556.4	-10.049
G	49709367	-1421	-130	2019241	16900	8.40E+11	1.0E+14	1.60E+15	139556.4	-6.168
H	20308017	-1373	-298	1885129	88804	1.80E+12	3.8E+13	1.60E+15	139556.4	-2.435
I	50949378	-401	182	160801	33124	1.69E+12	8.2E+12	1.60E+15	139556.4	-1.784
J	82646186	-329	38	108241	1444	1.19E+11	8.9E+12	1.60E+15	139556.4	-2.374
K	1.09E+08	-323	-22	104329	484	5.28E+10	1.1E+13	1.60E+15	139556.4	-3.075
L	1.02E+08	-323	-226	104329	51076	5.20E+12	1.1E+13	1.60E+15	139556.4	-2.873
M	94668503	-323	-295.6	104329	87379.36	8.27E+12	9.9E+12	1.60E+15	139556.4	-2.670
N	72977204	-323	-295.6	104329	87379.36	6.38E+12	7.6E+12	1.60E+15	139556.4	-2.058
O	17660804	727	-306.4	528529	93880.96	1.66E+12	9.3E+12	1.60E+15	139556.4	1.121
P	35891429	727	-306.4	528529	93880.96	3.37E+12	1.9E+13	1.60E+15	139556.4	2.278
Q	60798882	1162.6	-44.8	1351639	2007.04	1.22E+11	8.2E+13	1.60E+15	139556.4	6.172
R	7336026	1369	-334	1874161	111556	8.18E+11	1.4E+13	1.60E+15	139556.4	0.877
S	20308017	541	-60.4	292681	3648.16	7.41E+10	5.9E+12	1.60E+15	139556.4	0.959
T	29471731	605.8	297.2	366993.6	88327.84	2.60E+12	1.1E+13	1.60E+15	139556.4	1.559
U	9809969	917.8	387.2	842356.8	149923.8	1.47E+12	8.3E+12	1.60E+15	139556.4	0.786
V	22945766	605.8	440	366993.6	193600	4.44E+12	8.4E+12	1.60E+15	139556.4	1.214
W	34615561	605.8	704	366993.6	495616	1.72E+13	1.3E+13	1.60E+15	139556.4	1.831
X	9809969	501.4	962	251402	925444	9.08E+12	2.5E+12	1.60E+15	139556.4	0.429
Y	5045944	371.8	2477.6	138235.2	6138502	3.10E+13	7.0E+11	1.60E+15	139556.4	0.164
Z	21628485	579.4	1446.8	335704.4	2093230	4.53E+13	7.3E+12	1.60E+15	139556.4	1.094
XX	9809969	501.4	1377.2	251402	1896680	1.86E+13	2.5E+12	1.60E+15	139556.4	0.429
ZZ	37163532	610.6	1635.2	372832.4	2673879	9.94E+13	1.4E+13	1.60E+15	139556.4	1.981
YY	22945766	272.2	1762.4	74092.84	3106054	7.13E+13	1.7E+12	1.60E+15	139556.4	0.545
WW	22945766	272.2	1635.2	74092.84	2673879	6.14E+13	1.7E+12	1.60E+15	139556.4	0.545
	1.26E+09					**4.05E+14**	**1.2E+15**			**-46.034**

APPENDIX D: MOMENT AXIAL-INTERACTION DIAGRAM (ASD)

Partially grouted 8” CMU reinforced with (1) # 9 @ 16” O.C.

F_s= 24,000 psi f'_m = 6000 psi E_s = 29000 ksi E_m = 900(6000) = 5400 psi

Fb = (1/3)f'_m = (1/3)(6000) = 2000 psi

<u>Pure Compression:</u>

P_a = 0.25(f'_m)(A_n) + 0.65(A_{st})(F_s) = 0.25(6000)(7.63*16 – 1) = 181,620 lbs/16”

P_a = 136,556 lbs/ft

$$r = \sqrt{\frac{I}{A}} = \sqrt{\frac{378.6}{62}} = 2.47 \qquad \frac{h}{r} = \frac{(12)(10)}{2.47} = 48.6 < 99 \therefore ok$$

Slenderness ratio = $\left[1 - \left(\frac{h/r}{140}\right)^2\right] = \left[1 - \left(\frac{48.6}{140}\right)^2\right] = 0.88$

P_a = (0.88)(181,620) = 136,556 lbs/ft

<u>Pure Flexure:</u>

d= h/2 = 7.63/2 = 3.81”

jd = d-(kd/3) ≈ (7/8)d = (7/8)(3.81) = 3.33

M = A_sF_sJd = (1.0)(24000)(3.33) = 79,920 lb-in/16”

M = 60,090 lb-in/ft

<u>Balanced Point:</u>

n = E_s/E_m = 29000/5400 = 5.37

$$k = \frac{n}{\left(\frac{Fs}{Fb}\right) + n} = \frac{5.37}{\left(\frac{24000}{2000}\right) + 5.37} = 0.309$$

T = A_sF_S = (1.0)(24000) = 24000 lbs/16”

C = (1/2)(F_b)(K_b)(d)(b) = (1/2)(2000)(0.309)(3.81)(16) = 18,837 lbs/16”

P = C – T = 18937 - 24000 = -5063 lbs/16” = - 3807 lbs/ft

P = 0.88(-3807) = - 3,350 lbs/ft

M_b = T (d – h/2) + C (h/2 – K_bd/3) = 0 + 18937((7.63/2) – (0.309*3.81)/3) =
M_b = 64,719 lb-in/16” = 48,660 lb-in/ft

Additional Points

For K < K_b say K = 0.2

ε_s = Fs/Es = 24000/29000000 = 0.000828

ε_m = ε_s (kd/(d-Kd)) = 0.000828((0.2*3.81)/(3.81- 0.2(3.81)) = 0.000207

f_b = ε_m(E_m) = 0.000207(5400000) =1117.8 psi

C = (1/2)(f_b)(k)(d)(b) = (1/2)(1117.8)(0.2)(3.81)(16) = 6814 lbs/16”

T = A_sF_s = (1.0)(24000) = 24000 lbs/16”

P = C – T = 6814 – 24000 = - 17186 lbs/16” = -12922 lbs/ft

P =(0.88)(-12922) = -11371 lbs/ft

M_b = T (d – h/2) + C (h/2 – Kbd/3) = 0 + 6814((7.63/2) – (0.2*3.81)/3) =
M_b = 24,231 lb-in/16” = 18,218 lb-in/ft

For K > K_b say K = 0.5

ε_m = F_b/E_m = 2000/5400000 = 0.00037

ε_s = ε_m((d – kd)/kd) = 0.00037((3.81 – 0.5*3.81)/(0.5*3.81) = 0.00037

fs = ε_s(E_s) = 0.00037(29000000) = 10730 psi

C = (1/2)(f_b)(k)(d)(b) =(1/2)(2000)(0.5*3.81*16) = 30480 lbs/16”

T = A_sf_s = (1.0)(10730) = 10730 lbs/16”

P = C – T = 30480 – 10730 = 19750 lbs/16” = 14,850 lbs/ft

P = 0.88(14850) = 13068 lbs/ft

M_b = T (d – h/2) + C (h/2 – Kd/3) = 0 + 30480((7.63/2) – (0.5*3.81)/3) =

M_b = 96774 lbs/16” = 72762 lbs/ft

Say K = 0.6

$\varepsilon_m = F_b/E_m = 2000/5400000 = 0.00037$

$\varepsilon_s = \varepsilon_m((d - kd)/kd) = 0.00037((3.81 - (0.6*3.81))/(0.6*3.81) = 0.002467$

$f_s = \varepsilon_s(E_s) = 0.002467(29000000) = 7153$ psi

$C = (1/2)(f_b)(k)(d)(b) = (1/2)(2000)(0.6*3.81*16) = 36{,}576$ lbs/16”

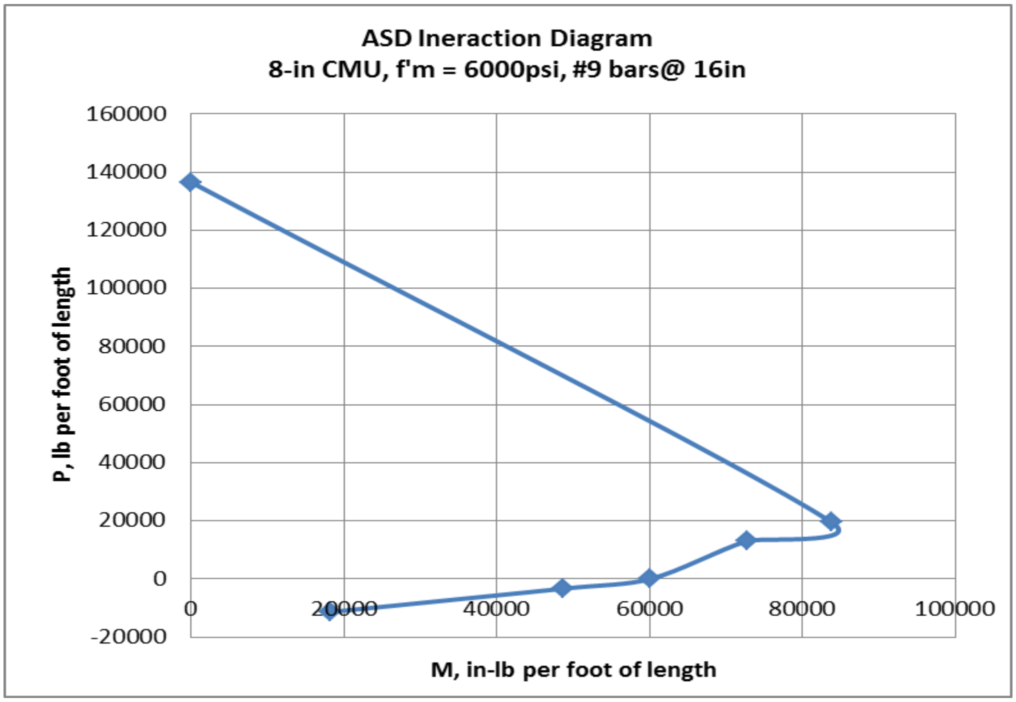
$T = A_s f_s = (1.0)(7153) = 7153$ lbs/16”

$P = C - T = 36576 - 7153 = 29423$ lbs/16” = 22123 lbs/ft

$P = 0.88(22123) = 19{,}468$ lbs/ft

$M_b = T\,(d - h/2) + C\,(h/2 - Kd/3) = 0 + 36576((7.63/2) - (0.6*3.81)/3) =$

$M_b = 111{,}484$ lbs/16” = 83,822 lbs/ft



APPENDIX E: WALL ADEQUACY CHECK UNDER EARTHQUAKE

Controlling Load Combination:

1. $D + F$
2. $D + H + F + L + T$
3. $D + H + F + (L_r \text{ or } S \text{ or } R)$
4. $D + H + F + 0.75(L + T) + 0.75(L_r \text{ or } S \text{ or } R)$
5. $D + H + F + (W \text{ or } 0.7E)$
6. $D + H + F + 0.75(W \text{ or } 0.7E) + 0.75L + 0.75(L_r \text{ or } S \text{ or } R)$
7. $0.6D + W + H$
8. $0.6D + 0.7E + H$

Floor	DL (kips)	LL (Kips)
7	1.9	2
6	3.8	4
5	5.7	6
4	7.6	8
3	9.5	10
2	11.4	12
1	13.3	14

Earthquake load = 47.51(1000)/(210) = 226 psf

Eccentricity (e) = (t/2) – (plate/3) = (8/2)-(4/3) = 2.67”

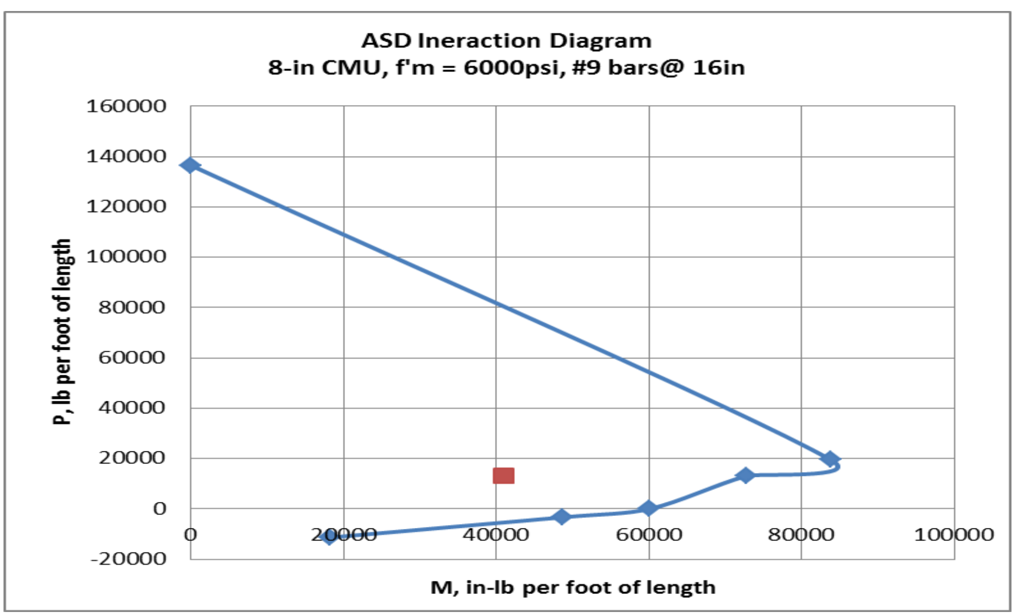
Mearthq @ level 1 =(0.7) $Wl^2/8$ =0.7(226) (10^2)(12)/8 = 23.73 Kips-in

MDead @ level 1 = (13.3) (2.67/2) = 17.8 Kips-in

Mmax @ level 1 = 23.73 + 17.8 = 41 Kips-in

$P_{max} = P_{dead}$ = 13.3 kips

Plot Point (P,M) = (13,300 lbs; 41,000 lbs-in) → OK



APPENDIX F: COST/SCHEDULE

Existing System

LineNumber	Quantity	Unit	Description	Crew	Daily Output	Labor Hours	Days to Complete	Mat. O&P	Labor O&P	Equip. O&P	Total O&P	Ext. Mat. O&P	Ext. Labor O&P	Ext. Equip. O&P	Ext. Total O&P	Labor Type
51223750360	2080.43	L.F.	W8x24 Columns	E2	550	0.102	3.78	$ 32.19	$ 8.60	$ 3.40	$ 44.19	$ 66,969.04	$ 17,891.70	$ 7,073.46	$ 91,934.20	STD
51223755300	3575.73	L.F.	W24x68 Beams	E5	1110	0.072	3.22	$ 90.85	$ 6.25	$ 1.82	$ 98.92	$ 324,855.07	$ 22,348.31	$ 6,507.83	$ 353,711.21	STD
52119100540	487.599	L.F.	Open Web Bar joists	E7	2000	0.04	0.24	$7.25	$3.24	$1.17	$11.67	$ 3,535.09	$ 1,579.82	$ 570.49	$ 5,690.28	STD
50521901500	264	L.F.	Field Welding - 1/4" thick	E14	50	0.16	5.28	$0.66	$14.00	$3.36	$18.02	$ 174.24	$ 3,696.00	$ 887.04	$ 4,757.28	STD
50523250300	44	Ea	High Strength Bolts - 3/4" dis. A325	1 Sswk	105	0.076	0.42	$1.60	$6.35	$ -	$7.95	$ 70.40	$ 279.40	$ -	$ 349.80	STD
33053405001	24380	S.F.	4" thick Structural concrete	C14G	2873	0.019	8.49	$ 1.10	$ 0.85	$ 0.01	$ 1.96	$ 26,818.00	$ 20,723.00	$ 243.80	$ 47,784.80	STD
32205500500	243.8	C.S.F.	Welded wire fabric, sheets, 4 x 4	2 Rodm	31	0.516	7.86	$ 21.71	$ 27.74	$ -	$ 49.45	$ 5,292.90	$ 6,763.01	$ -	$ 12,055.91	STD
31113351500	24380	S.F.	C.I.P. concrete forms	C2	495	0.097	49.25	$ 1.02	$ 3.96	$ -	$ 4.98	$ 24,867.60	$ 96,544.80	$ -	$ 121,412.40	STD
							78.55									
Total												$ 452,582.34	$ 169,826.04	$ 15,282.62	$ 637,695.88	

New System

LineNumber	Quantity	Unit	Description	Crew	Daily Output	Labor Hours	Days to Complete	Mat. O&P	Labor O&P	Equip. O&P	Total O&P	Ext. Mat. O&P	Ext. Labor O&P	Ext. Equip. O&P	Ext. Total O&P	Labor Type
034113500100	24380	S.F.	8" Hollowcore, untoped	C11	3200	0.023	7.62	$ 7.48	$ 2.02	$ 0.72	$ 10.22	$ 182,362.40	$ 49,247.60	$ 17,553.60	$ 249,163.60	STD
033105350416	150.5	C.Y.	2" topping	C14B	260	0.8	0.58	$ 86.25	$ -	$ -	$ 86.25	$ 12,980.63	$ -	$ -	$ 12,980.63	STD
032110600150	39.05	Ton	2 #8's Rebar at 16" o.c.	4 Rodm	2.7	11.852	14.46	$1,037.38	$ 637.05	$ -	$1,674.43	$ 40,509.69	$ 24,876.80	$ -	$ 65,386.49	STD
042210280600	19504	S.F.	8" High Strength Hollow Concrete Bl	D8	360	0.111	54.18	$ 3.89	$ 6.30	$ -	$ 10.19	$ 75,870.56	$ 122,875.20	$ -	$ 198,745.76	STD
							76.84									
Total												$ 311,723.28	$ 196,999.60	$ 17,553.60	$ 526,276.48	

APPENDIX H : REFERENCES

American Society of Civil Engineers, Minimum Design Loads for Buildings and Other Structures (ASCE 7-05)

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