# TECHNICAL ASSIGNMENT 1

## STRUCTURAL CONCEPTS/STRUCTURAL EXISTING CONDITIONS REPORT


# GATEWAY COMMONS
# ITHACA, NEW YORK

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STRUCTURAL OPTION
December 21, 2007
AE 481W
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# Executive Summary

The Gateway Commons building in Ithaca, New York is a mixed-use development building being used for retail and residential apartments. It has a basement floor below grade and six floors above grade at a height of 62 feet. CMU walls supporting precast concrete hollow core planks make up the building structure. The building façade uses a combination of brick, an Exterior Insulation Finish System (EIFS), and metal panels.

The purpose of this report is to research the structural system of the Gateway Commons building in Ithaca, NY. It includes descriptions of the foundation, walls, floor system, roof system and lateral system. An overview of the building dead loads, live loads, and code requirements are provided. An analysis of the lateral loading on the building due to wind and seismic forces is provided. At the 4$^{th}$ floor the lateral load is distributed onto the shear walls so that a design check of one of the shear walls could be conducted. At the end of the report an appendix includes calculations that were performed to conduct the lateral system analysis. Lateral loads are distributed onto the shear walls by the method of rigidity. Hand calculations proved that the shear wall being checked is able to resist the lateral loading.

It can be concluded that seismic is the controlling lateral force being resisted by the shear walls. It creates a base shear of 208 kips compared to 95.1 kips due to the wind forces, and a overturning moment of 9500 ft-k compared to 3383 ft-k due to the wind forces. It was also found that there were differences between the original design and the analysis that was conducted for this report. The seismic base shear value obtained by the design engineer was 295 k compared to the 208 k in the report. Differences could be due to the use of different codes, values, and procedures. For this report wind and seismic calculations were determined by using ASCE 7-05 and the 2002 Building Code of New York State was used in the original design. There is also the possibility that the original design used different values for wall weights than were used in this report.

# Introduction

Gateway Commons located in Ithaca, New York is a mixed use project containing retail and residential spaces. It has a basement floor below grade and six floors above grade at a height of 62 feet. The basement has a floor to floor height of 11'-4" and the floors above grade have height of 10' except for the first floor which has a height of 12'. The total building area is 43,000 square feet. The ground floor is retail spaces and the others contain residential apartments. Construction for this project was completed in April of 2007. A typical floor plan of the building is shown in Figure 1.

The building has a basement space between grid lines A and D. The floor for this space is a 5" thick slab on grade. Between grid lines D and E there is a compacted structural fill instead of basement space. The slab on grade that lies on that compacted structural fill is the first floor's floor system between grid lines D and E. Between grid lines A and D hollow core planks are supported by concrete foundation walls that transfer the loads from above onto strip footings.

Located above the concrete foundations walls are CMU walls. Some of the walls are part of the gravity framing system and only support the gravity loads bearing on them. Other walls are part of the lateral system and are designed to resist lateral forces from wind and seismic.

The walls that are part of the lateral system are considered intermediate reinforced masonry shear walls. These walls span in both the N-S and E-W directions. These shear walls are classified as wall types MW2 and MW3. These shear walls are highlighted in green on the plan in Figure 1.

The walls that are part of the gravity framing system are considered wall type MW1. These are all of the other walls on the plan that are not highlighted in green. These walls support the precast concrete hollow core floor planks that act as the flooring system. The roof is constructed out of the same hollow core planks and is also supported by CMU walls as well as two different steel shapes that support the roof planks at their 2'-8" overhang. The building sections in Figures 3 and 4 should also help describe the structure of the Gateway Commons building.

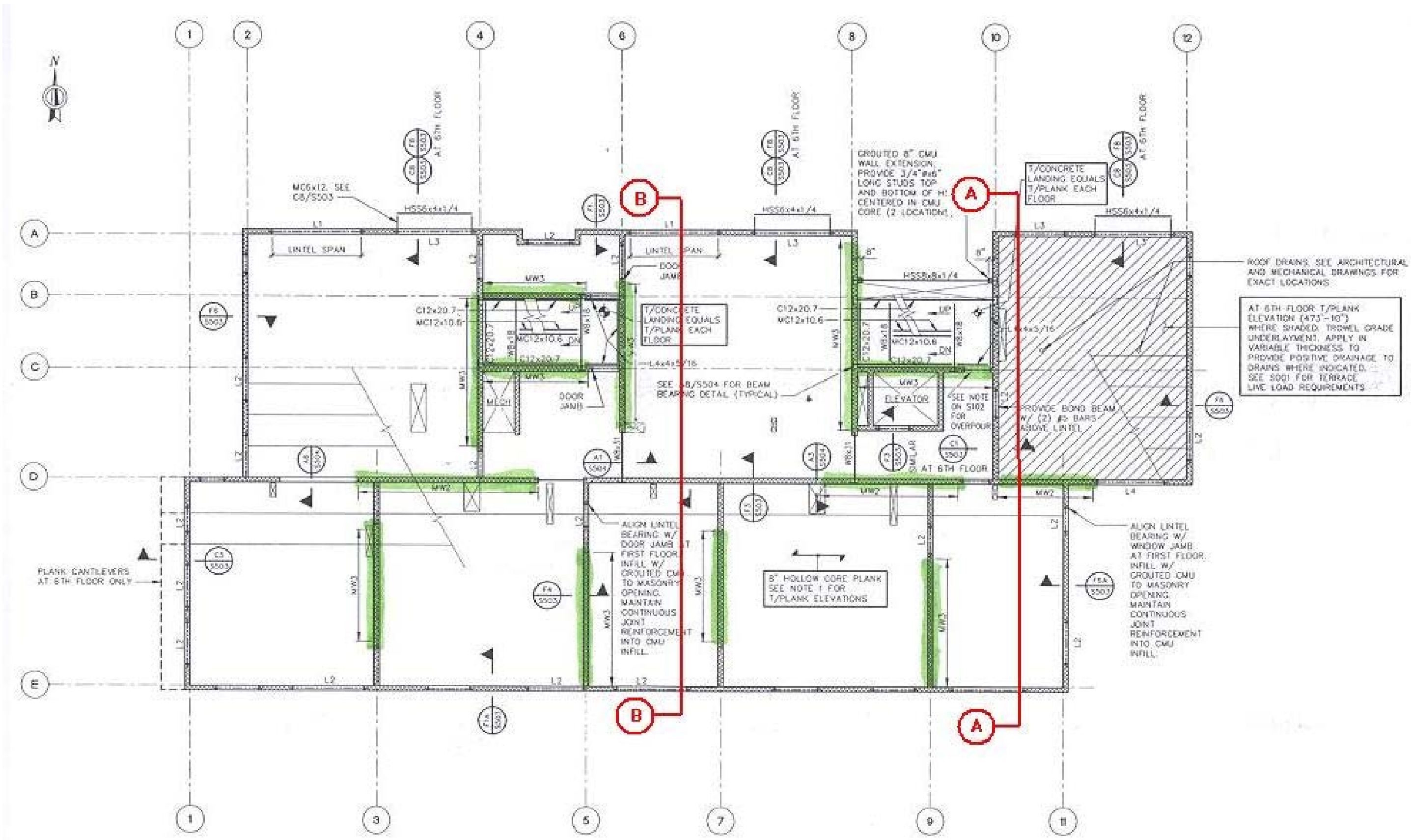



**Figure 1** – Typical Framing Plan

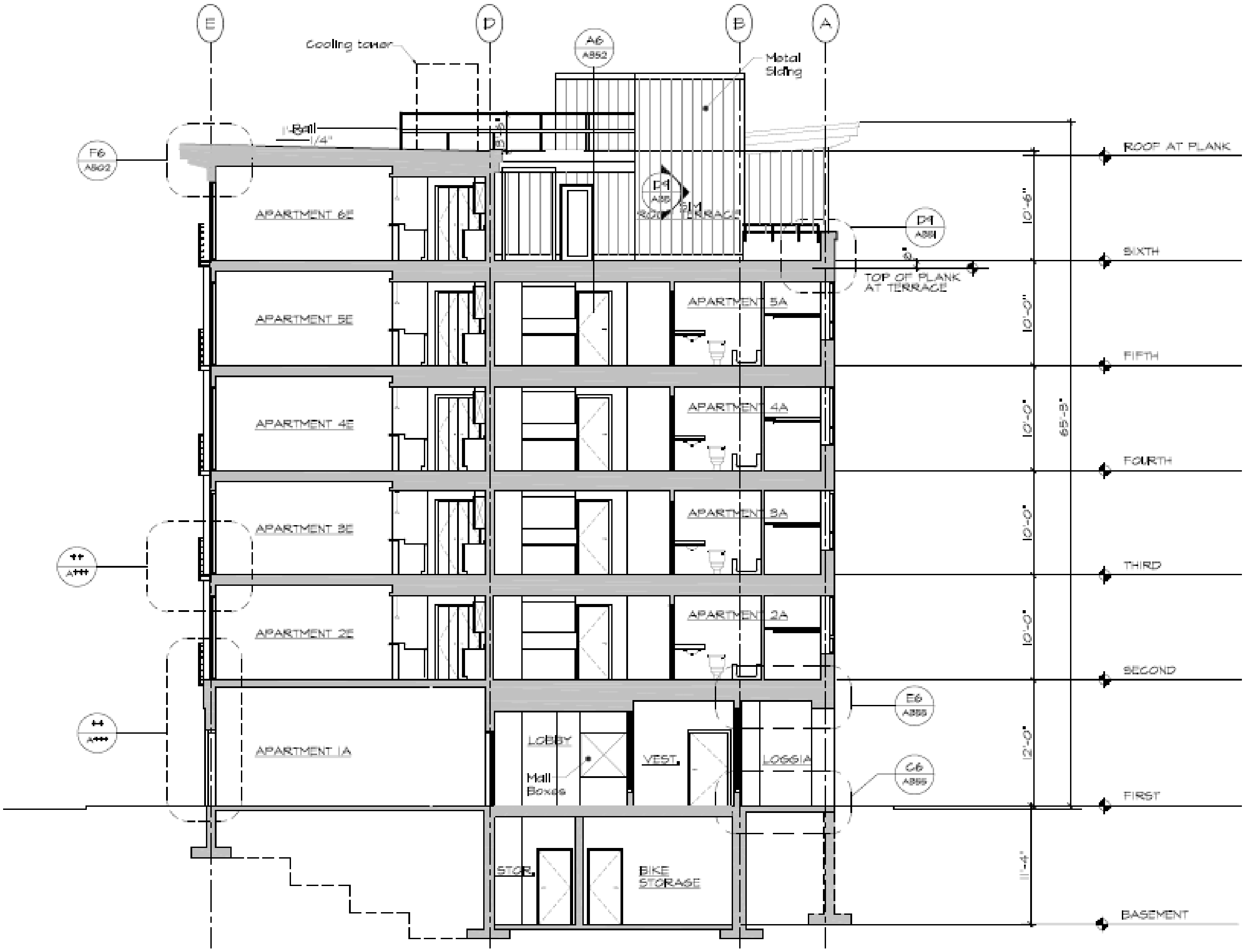



**Figure 2** – Section A

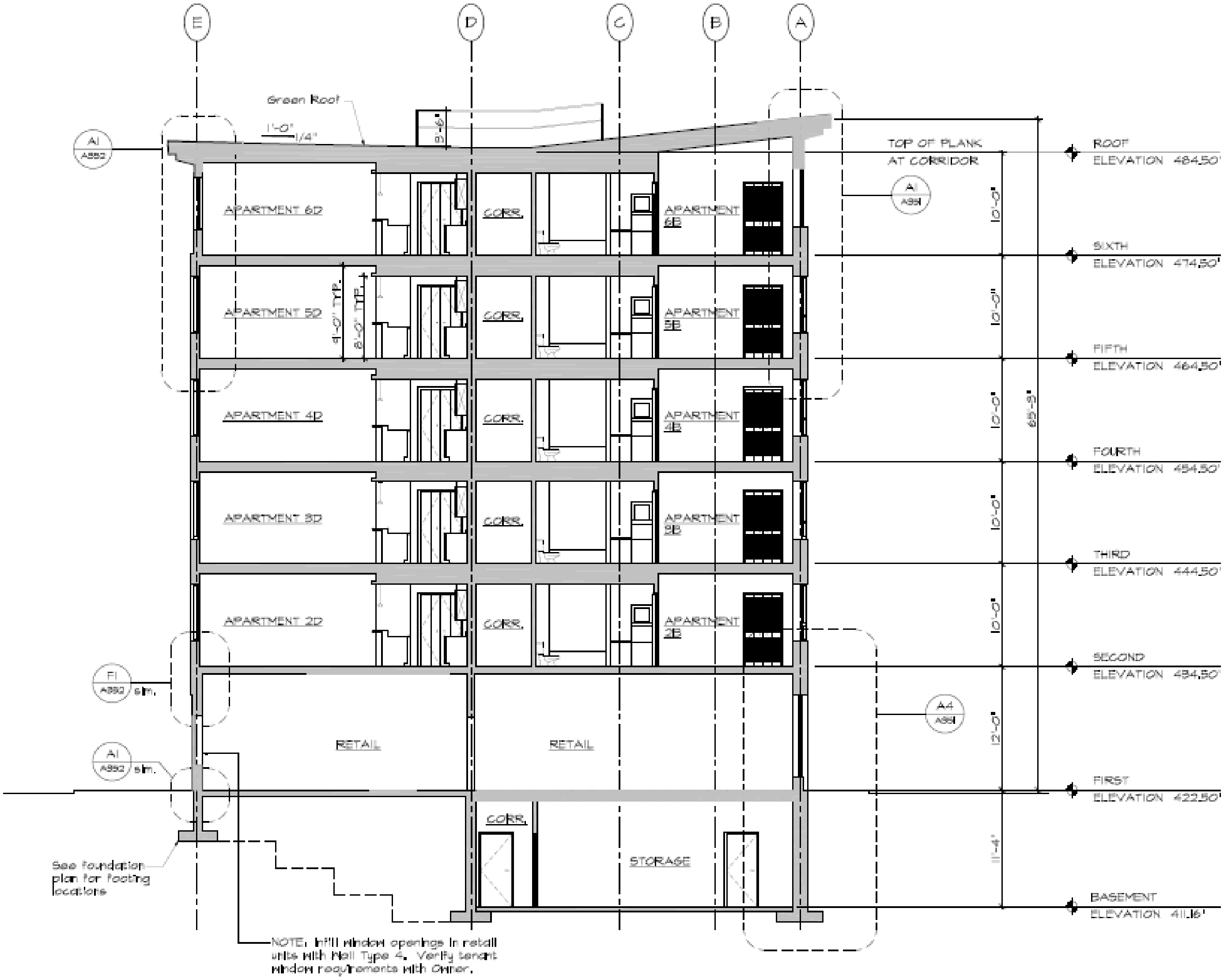



**Figure3** – Section B

# Structural System

## *Foundation*

Between grid lines A and D, the basement floor slab-on-grade and loads from the concrete foundations walls are transferred onto strip footings with a 28-day strength of f'c = 3,000 psi. These strip footings sit on undisturbed indigenous soils composed of sand and gravel with an allowable bearing capacity of 5,000 psf . The slab-on-grade is 5" thick and reinforced with #4 bars at 16" on center spanning in both directions. The slab-on-grade has a concrete strength of f'c = 3,500 psi. The foundations walls will have a concrete strength of f'c = 3,000 psi or 4,000 psi depending on the type of wall. Between grid lines D and E the footings sit on a compacted structural fill that has an allowable bearing capacity of 5,000 psf. The slab on grade in this section is supported by the compacted structural fill and the foundation walls on grid lines D and E. It has the same thickness and reinforcing as the other slab on grade. The slab on grade in this section is 11'-4" higher than slab on grade between grid lines A and D.

There are also five concrete piers that are supported by spot footings on the north east corner of the building. The reason for these piers is to create the loggia. At the second floor a concrete beam spans across the piers to pick up the gravity loads and distribute them onto the piers.

## *Masonry Walls*

The walls that are not considered part of the lateral system are wall type MW1. Unlike the concrete foundations walls these walls are constructed out of 8" thick concrete masonry units (CMU). These walls act as the gravity framing system and support the precast concrete hollow core floor planks that act as the flooring system. Between the first and second floors the walls are grouted solid. Between the second and third floors the walls are grouted at 2' on center. For the rest of the floors, wall type MW1 has vertical reinforcing of #5 at 4' on center. The walls are horizontally reinforced at 16" on center. A wall schedule describing this reinforcing can be found in Figure 8. The exterior walls on the north and part of the east and west sides have a brick façade that is supported by shelf angles at each floor. The exterior walls on the south and other part of the east and west sides carry an Exterior Insulation Finish System (EIFS) façade.

## *Floor System*

The primary flooring system for the elevated floors of the building is precast concrete hollow core planks. The planks span in the east/west direction. On the first floor the planks have a thickness of 10", but on floors two through six the plank thickness is 8". The planks on the first floor have a 2" thick concrete topping. All planks have a maximum width of 4' and are allowed to have a minimum width of 1'-6". Planks located at interior bearing partitions must be connected with a 6' long #3 bar or 5/16" diameter strand grouted into the keyway, as shown in Figure 5. Planks are often connected to exterior CMU walls with #4 dowels that are bent into the keyways, as shown in Figure 6. On the first floor, half of the floor is planks while the other half is a 5" thick slab on grade. The slab on grade described in the foundations section is the floor system for the basement.

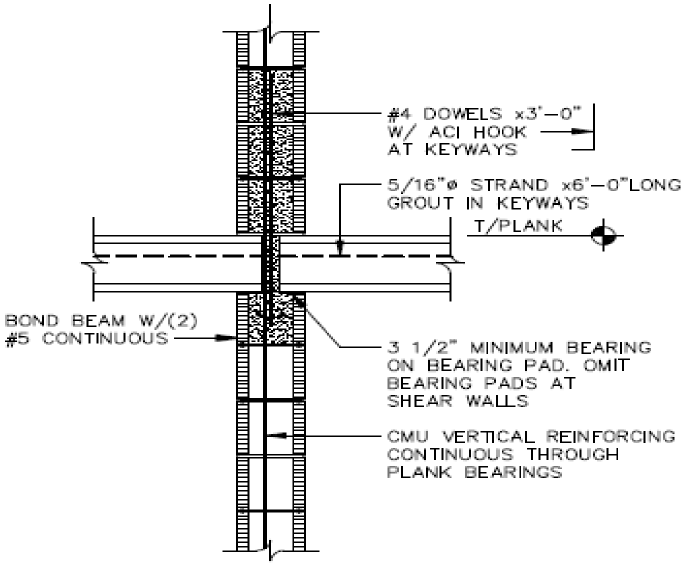



**Figure 5** – Floor Planks at Interior Walls

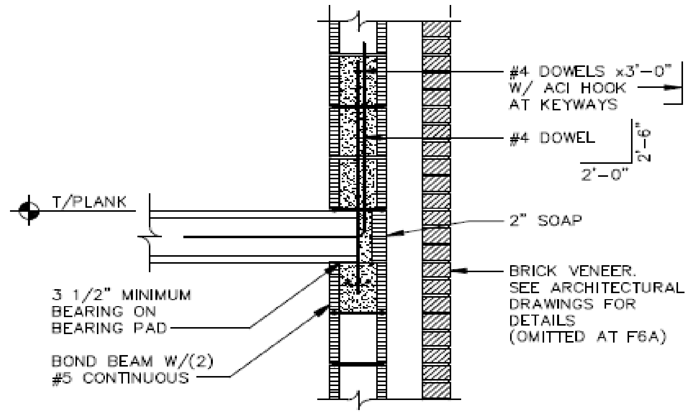



**Figure 6** – Floor Planks at Exterior Walls

## *Roof*

The roof structure uses the same 8" thick, precast, hollow core, concrete planks as used on the floors. At gridline D the roof begins to slope up toward the building's south end at ¼"/foot. Between gridline D and C the roof begins to slope up toward the building's north end at slightly larger slope. The building section in Figure 7 shows how the roof is sloped. The roof planks have a 2'-8" roof overhang. Two different steel shapes are used to support the planks at the overhang, a WT6x43.5 and an L6x6x1/2. There is also a roof terrace on the sixth floor that uses the same planks system as used by the typical floor system. There is no roof overhang on the sixth floor roof terrace.

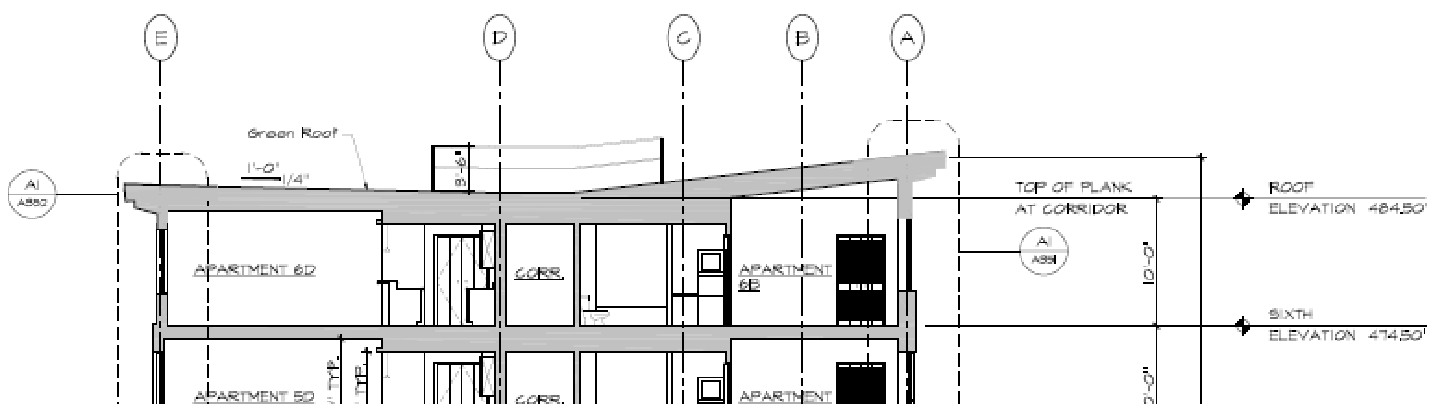



**Figure 7** – Building Section for Roof

## *Lateral System*

The structure is laterally supported by intermediate reinforced masonry shear walls in the N-S and E-W directions. Like the load bearing walls for the gravity framing system the shear walls are also 8" thick CMU walls. However, the shear walls are designed to resist the lateral loads due to seismic and wind forces. These lateral forces are distributed onto the shear walls through the rigid floor system of hollow core planks. There are two different shear wall types, MW2 and MW3. The shear walls are highlighted in green on the floor plan in Figure 1. The wall schedule in Figure 8 describes the reinforcing for both shear wall types.

WALL ~~LINTEL~~ SCHEDULE

| MARK | VERTICAL REINFORCING | HORIZONTAL REINFORCING | REMARKS |
|---|---|---|---|
| MW1 | #5 AT 4'-0"OC | STANDARD JOINT REINFORCING AT 16"OC | GROUT WALL SOLID 1ST-2ND FLOORS<br>GROUT WALL AT 2'-0"OC 2ND-3RD FLOORS |
| MW2 | #5 AT 4'-0"OC (TYPICAL)<br>(6)#5 EACH END (1ST-2ND)<br>(4)#5 EACH END (2ND-4TH)<br>(2)#5 EACH END (4TH-ROOF) | STANDARD JOINT REINFORCING 1ST-2ND AND 6TH-ROOF, HEAVY DUTY JOINT REINFORCING AT 8"OC 2ND-6TH | GROUT WALL SOLID 1ST-2ND FLOORS |
| MW3 | #5 AT 4'-0"OC (TYPICAL)<br>(2)#5 EACH END | STANDARD JOINT REINFORCING 1ST-2ND AND 6TH-ROOF, HEAVY DUTY JOINT REINFORCING AT 8"OC 2ND-6TH | GROUT WALL SOLID 1ST-2ND FLOOR |

NOTES:
1. UNLESS NOTED OTHERWISE ON PLAN, ALL WALLS ARE TYPE MW1.
2. MINIMUM REINFORCING REQUIREMENTS SHOWN ON A3/S506 APPLY TO ALL WALLS.
3. SEE F6/S506 FOR PLACEMENT OF VERTICAL BARS AT ENDS OF WALLS.

**Figure 8** – Wall Schedule

# Loads

This gravity load information was obtained from the general notes page of the building plans. These loads were used by the engineer to design the gravity load bearing walls. This information will also determine the total dead load on the building which in turn will be used to determine the amount of seismic loading on the building.

## *Live Loads*

First Floor…………………………………....100 psf
Second – Sixth Floor……………………...40 psf
Sixth Floor Terrace………………………..100 psf

## *Dead Loads*

First Floor…………………………………....100 psf
Second – Sixth Floor……………………...70 psf
CMU Walls………………………………. 55 psf
Brick Façade………………………………40 psf
Green Roof or Roof Top Pavers…………..95 psf
Other Roof Areas…………………………75 psf
Mechanical Equipment……………………5 psf
Partition walls……………………………..10 psf

## *Snow Loads*

Ground Snow load (Pg)………………......45 psf
Flat Roof Snow Load (Pf)……….……….....32 psf

# Codes and References

The codes that were referenced to design the Gateway Commons building and the material properties of its structural components are listed below.

## *Applicable Codes and Standards*

- 2002 Building Code of New York State (BCNYS)
- ASTM Standards
- NCMA Tek Notes
- ACI Standards
- ASCE 7-98

| Cast in Place Concrete | |
|---|---|
| **Member** | **28 Day Compressive Strength (f'c)** |
| Columns and Beams | 4,000 psi |
| Interior Slabs on Grade | 3,500 psi |
| Footings, Foundations Walls, Piers, Misc. | 3,000 psi |
| Retaining Walls, Basement Walls, Exterior Slabs | 4,000 psi |

| Structural and Miscellaneous Steel | | |
|---|---|---|
| **Material** | **ASTM Standard** | **Fy (ksi)** |
| Rolled Steel W Shapes | A 992 | 50 |
| Rolled Steel C and MC Shapes | A 36 | 36 |
| Rolled Steel Plates, Bars, and Angles | A 36 | 36 |
| Hollow Structural Sections (HSS) | A 500, Grade B or C | 46 or 50 |
| Pipe | A 53, Type E or S, Grade B | 35 |
| Reinforcing Bars | A 615, Grade 60 | 60 |

# Lateral Loads

Lateral loads acting on the building are the result of wind and seismic forces. Wind and seismic loads were originally calculated using the 2002 Building Code of New York State. For this report loads were calculated using methods from ASCE 7 – 05. Wind loads were calculated for the north-south and east-west directions. The following is a summary of the lateral load findings. See Appendix A for a complete set of wind and seismic calculations.

## *Wind*

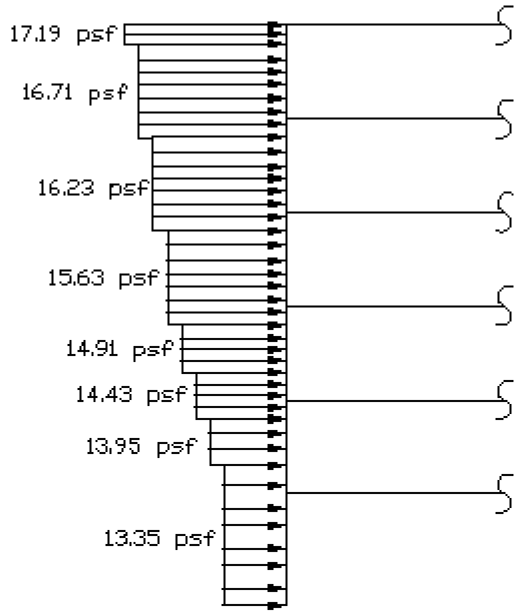
Wind loads were calculated for the north-south and east-west directions. Since the load in the north-south direction is the larger of the two a loading diagram is only provided for that direction. Some of the factors used to determine the wind loads and a chart summarizing the calculations for the wind loads acting in the north-south direction are listed below. Also listed below are diagrams of the loads at each floor due to wind forces. For detailed wind calculations see Appendix A.

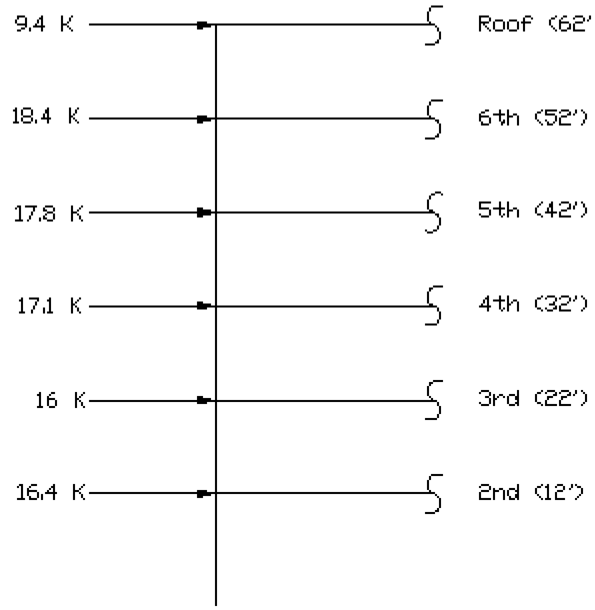
Basic Wind Speed: 90 mph
Importance Factor: 1
Exposure Category: B
GCpi = $\pm 0.18$
G = 0.85

Long side of building (N-S direction)

| Z (ft) | Kz | qz | $P_{sidewall}$ (psf) | $P_{leeward}$ (psf) | $P_{windward}$ (psf) | $P_{total}$ (psf) |
|---|---|---|---|---|---|---|
| 0-15 | 0.57 | 10.04659 | -5.97772224 | -6.52 | 6.83168256 | 13.3516826 |
| 20 | 0.62 | 10.92787 | -6.50208384 | -6.52 | 7.43095296 | 13.950953 |
| 25 | 0.66 | 11.6329 | -6.92157312 | -6.52 | 7.91036928 | 14.4303693 |
| 30 | 0.7 | 12.33792 | -7.3410624 | -6.52 | 8.3897856 | 14.9097856 |
| 40 | 0.76 | 13.39546 | -7.97029632 | -6.52 | 9.10891008 | 15.6289101 |
| 50 | 0.81 | 14.27674 | -8.49465792 | -6.52 | 9.70818048 | 16.2281805 |
| 60 | 0.85 | 14.98176 | -8.9141472 | -6.52 | 10.1875968 | 16.7075968 |
| 70 | 0.89 | 15.68678 | -9.33363648 | -6.52 | 10.66701312 | 17.1870131 |

Base Shear: 95.1 k
Overturning Moment: 3383 ft-k



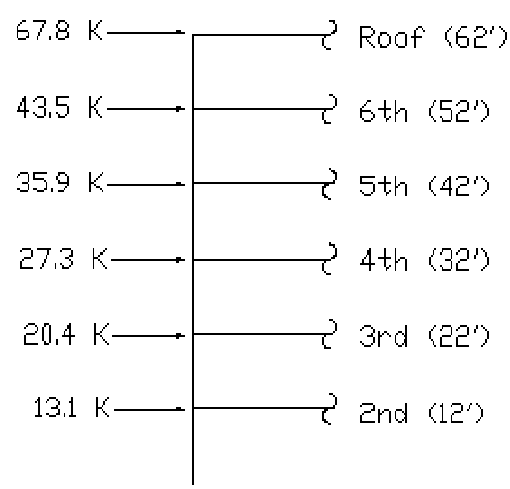




## *Seismic*

The weight of the building is based on the framing and other dead loads on the building. Some of the other factors used to determine the seismic loads and a chart displaying a summary of seismic load calculations are shown below. The seismic forces at each story prove to be larger than those created by the wind; therefore seismic is the controlling lateral load in both directions. A diagram showing the seismic lateral loading at each story is also shown below. For detailed seismic calculations see Appendix A.

Importance Factor: 1
Occupancy Category: II
Site Class: D
Seismic Design Category: B
Response Modification Factor: 3.5

| Level | Height (ft) | Wx(hx)^k | Cvx | Fx |
|---|---|---|---|---|
| 2 | 12 | 15012 | 0.062912 | 13.08575 |
| 3 | 22 | 23408 | 0.098098 | 20.40443 |
| 4 | 32 | 31360 | 0.131423 | 27.33608 |
| 5 | 42 | 41160 | 0.172493 | 35.8786 |
| 6 | 52 | 49868 | 0.208987 | 43.46924 |
| Roof | 62 | 77810 | 0.326086 | 67.8259 |
| | | | | |
| | ∑Wx(hx)^k = | 238618 | | |




Base Shear: 208 k
Overturning Moment: 9500 ft-k

## *Shear Walls*

The seismic load acting on the 4th floor is distributed onto the shear walls as based on the stiffness of the walls. The stiffness of the walls is determined from the reciprocal of this deflection equation that is shown below. There are also loads on walls due to torsion because the lateral load acts at the center of mass of the floor which is 7.4 feet away from the center of rigidity. The net forces acting on the walls in the north-south direction are shown in Figure 8. Rigidity and torsion calculations are displayed in Appendix B.

$$\Delta = \frac{Vh^3}{12(Em)(I)} + \frac{1.2(V)(h)}{(Ev)A}$$

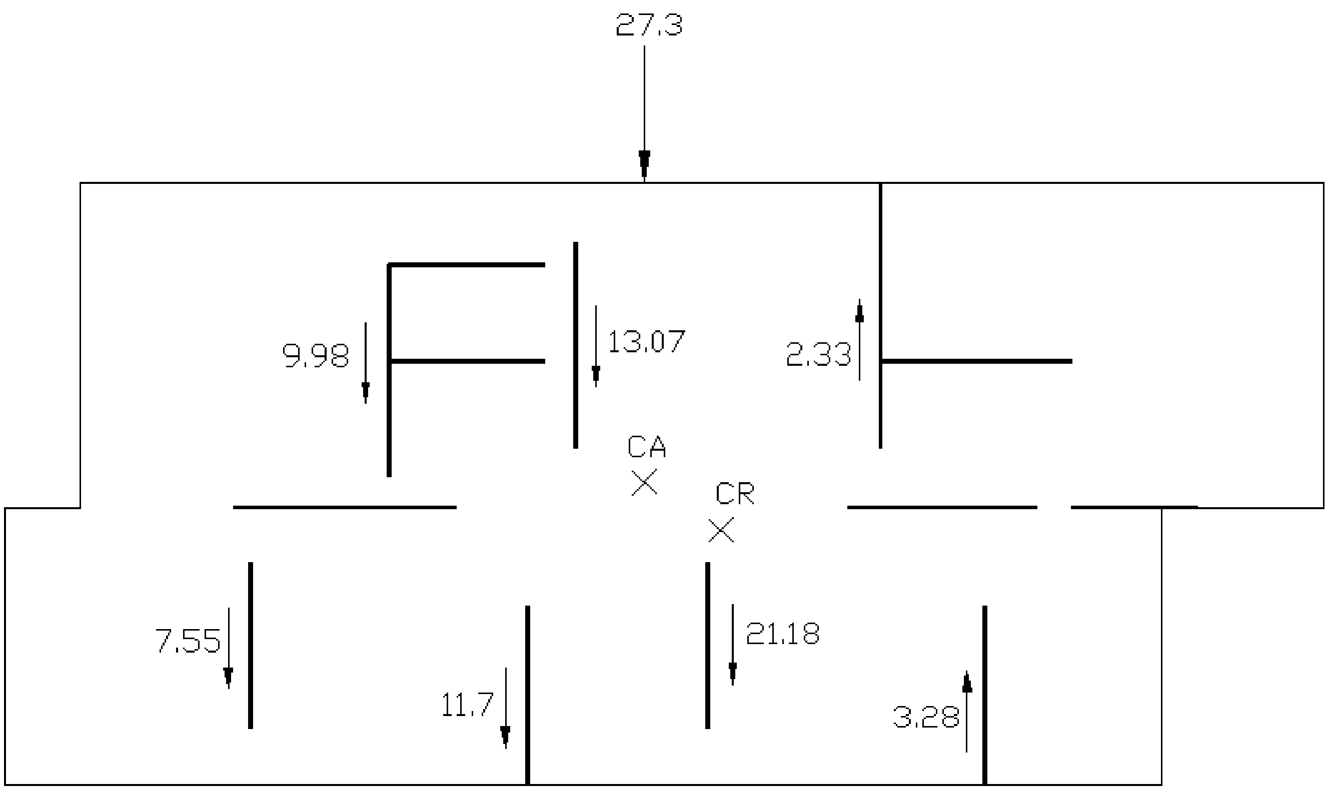



**Figure 7** – Distribution of Forces onto N-S Shear Walls

# Shear Wall Design Check

The shear wall check will be performed on the 4th floor. The wall will be checked against the lateral load due to seismic loading that has been distributed due to the method of rigidity. The wall being checked is the one with the 13.1 kip shear loading as seen in figure 7. This wall is 8 inches thick and 20 feet long. Calculations show that the wall is able to resist the entire shear loading. The reinforcement in the wall was checked against what was required. The vertical reinforcement of (4)#6 at each end along with #5 at 4’ o.c. and the horizontal reinforcement at 8” o.c. are both acceptable. These calculations can be found in Appendix B.

# Conclusions

Lateral loads that were calculated based on methods from ASCE 7-05 show that seismic was the controlling lateral force acting on the building. The original engineer also determined that seismic controlled. The seismic base shear value obtained by the design engineer was 295 k while the value obtained in this report was 208 k. The difference in values may be due to the fact that methods from ASCE were used to determine the lateral loads for this report and that the design engineer used methods from BCNYS to determine the lateral loads originally. Also, the building was originally designed with the dead load of CMU to be 55 psf for all of the walls in the building. This report used Tec Note 14-13A to determine the fully grouted first floor walls to have a dead load of 84 psf and the rest of the walls to be 55 psf. These and other unseen factors may have caused the difference in findings.

# Appendix A: Lateral Loads Calculations

# Wind

DESMAN ASSOCIATES
8614 Westwood Center Drive Suite 300
VIENNA, VIRGINIA 22182
(703) 448-1190
FAX (703) 893-4067

JOB: Wind
SHEET NO.: 1 OF:
CALCULATED BY: GN DATE:
CHECKED BY: DATE:
SCALE:

| | ASCE 7-05 |
|---|---|
| $V = 90$ mph | Figure 6-1 |
| $K_d = 0.85$ | Table 6-4 |
| $I = 1$ | Table 6-1 |
| $K_{zt} = 1$ | Figure 6-4 |
| $G = 0.85$ | $T_a < 1$ ∴ Rigid 6.5.8.1 |
| $GC_{pi} = \pm 0.18$ | Fig. 6.5 |
| $K_h = 63'$ ∴ $0.87$ | Table 6.3 |

Exposure B, Case 2
enclosed Building

| Surface | Cp |
|---|---|
| Windward | 0.8 |
| Sidewall | -0.7 |
| Leeward (N-S) | -0.5 |
| Leeward (E-W) | -0.32 |

ASCE 7-05 Figure 6-6

(N-S) $L/B = \frac{58}{111} = 0.52$

(E-W) $L/B = \frac{111}{58} = 1.9$

$q_z = 0.00256\, K_z K_{zt} K_d V^2 I$ (lb/ft²)    ASCE 7-05 6.5.10, equ. (6-15)

$q_z = 0.00256(K_z)(1)(0.85)(90)^2(1)$

$q_z = 17.6256\,(K_z)$ [lb/ft²]

$q_h = 0.00256(0.87)(1)(0.85)(90)^2(1)$

$= 15.33$

0 PRODUCT 207

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JOB Wind
SHEET NO. 2 OF
CALCULATED BY GN DATE
CHECKED BY DATE
SCALE

ASCE 7-05
6.5.12.2.1 equ. (6-17)

Side $q_z(0.85)(-0.7) \pm 15.33(0.18) = -q_z(0.595)$

Lee(N-S) $q_h(0.85)(-0.5) \pm 15.33(0.18) = (-15.33)(0.425) = -6.52$

Lee(E-W) $q_h(0.85)(-0.32) \pm 15.33(0.18) = (-15.33)(0.272) = -4.17$

Wind $q_z(0.85)(0.8) \pm 15.33(0.18) = q_z(0.68)$

$P = q_z G C_p - q_h G C_{pi}$ – side & Windward

$P = q_h G C_p - q_h G C_{pi}$ – Leeward

D PRODUCT 207

# Wind loading for the N-S direction

| Z (ft) | Kz | qz | Psidewall (psf) | Pleeward (psf) | Pwindward (psf) | Ptotal (psf) |
|---|---|---|---|---|---|---|
| 0-15 | 0.57 | 10.04659 | -5.97772224 | -6.52 | 6.83168256 | 13.3516826 |
| 20 | 0.62 | 10.92787 | -6.50208384 | -6.52 | 7.43095296 | 13.950953 |
| 25 | 0.66 | 11.6329 | -6.92157312 | -6.52 | 7.91036928 | 14.4303693 |
| 30 | 0.7 | 12.33792 | -7.3410624 | -6.52 | 8.3897856 | 14.9097856 |
| 40 | 0.76 | 13.39546 | -7.97029632 | -6.52 | 9.10891008 | 15.6289101 |
| 50 | 0.81 | 14.27674 | -8.49465792 | -6.52 | 9.70818048 | 16.2281805 |
| 60 | 0.85 | 14.98176 | -8.9141472 | -6.52 | 10.1875968 | 16.7075968 |
| 70 | 0.89 | 15.68678 | -9.33363648 | -6.52 | 10.66701312 | 17.1870131 |

# Wind loading for the N-S direction

| Z (ft) | Kz | qz | Psidewall (psf) | Pleeward (psf) | Pwindward (psf) | Ptotal (psf) |
|---|---|---|---|---|---|---|
| 0-15 | 0.57 | 10.04659 | -5.97772224 | -4.17 | 6.83168256 | 11.0016826 |
| 20 | 0.62 | 10.92787 | -6.50208384 | -4.17 | 7.43095296 | 11.600953 |
| 25 | 0.66 | 11.6329 | -6.92157312 | -4.17 | 7.91036928 | 12.0803693 |
| 30 | 0.7 | 12.33792 | -7.3410624 | -4.17 | 8.3897856 | 12.5597856 |
| 40 | 0.76 | 13.39546 | -7.97029632 | -4.17 | 9.10891008 | 13.2789101 |
| 50 | 0.81 | 14.27674 | -8.49465792 | -4.17 | 9.70818048 | 13.8781805 |
| 60 | 0.85 | 14.98176 | -8.9141472 | -4.17 | 10.1875968 | 14.3575968 |
| 70 | 0.89 | 15.68678 | -9.33363648 | -4.17 | 10.66701312 | 14.8370131 |

# Seismic

Weights per floor:

2nd Floor = 1251 k
3rd Floor = 1064 k
4th Floor = 980 k
5th Floor = 980 k
6th Floor = 959 k
Roof = 1255 k

$S_{MS} = F_a \cdot S_s = 1.6(0.159) = 0.25$

$S_{M1} = F_v \cdot S_1 = 2.4(0.055) = 0.13$

$S_1 = 0.055,\ F_v = 2.4$

$S_s = 0.159,\ F_a = 1.6$

Site Class D

$S_{DS} = 2/3\ S_{MS} = 2/3\ (0.25) = 0.167$

$S_{D1} = 2/3\ S_{M1} = 2/3\ (0.13) = 0.087$

$R = 3.5$

$I = 1$

Occupancy Catagory II

SDC = B

$T_a = C_t h_n^x$

$T_a = 0.02(65.25')^{0.75}$

$T_a = 0.459$

$C_u T_a = 1.7(0.459) = 0.78$

$C_s \geq \begin{cases} S_{DS}/(R/I) & 0.167/3.5 = 0.048 \\ S_{D1}/[T(R/I)] & 0.087/0.78(3.5) = 0.032 \\ \dfrac{S_{D1}(T_L)}{T^2(R/I)} & \dfrac{0.087(6)}{(0.78)^2(8)} = 0.107 \end{cases}$

$V = 0.032(6489)\text{k}$

**$V = 208\text{ k}$**

**$C_s = 0.032$**

# Appendix B:
# Shear Wall Calculations

# Renter of rigidity in the X direction analyzed at the 4th floor

$V_{4th\ floor}$ = 27.3k

| X dimension | | | |
|---|---|---|---|
| Wall | K | x | Kx |
| 1 | 1747.3 | 32.75 | 57224.08 |
| 2 | 1747 | 90.3 | 157754.1 |
| 3 | 1754.4 | 108.5 | 190352.4 |
| 4 | 1759.6 | 44.5 | 78302.2 |
| 5 | 1759.6 | 44.5 | 78302.2 |
| 6 | 1738.8 | 93.5 | 162577.8 |
| sum | 10506.7 | | 724512.8 |

X = ∑Kx/∑K = 724512.8/10506.7 = 69’

# Renter of rigidity in the Y direction analyzed at the 4th floor

| Y dimension | | | |
|---|---|---|---|
| Wall | K | y | Kx |
| 1 | 2340.8 | 13.33 | 31202.86 |
| 2 | 2362.4 | 8.55 | 20198.52 |
| 3 | 2340.8 | 13.33 | 31202.86 |
| 4 | 2362.4 | 8.55 | 20198.52 |
| 5 | 2349.6 | 39.87 | 93678.55 |
| 6 | 2359 | 42.29 | 99762.11 |
| 7 | 2375.3 | 45.24 | 107458.6 |
| sum | 16490.3 | | 403702 |

Y = ∑Ky/∑K = 403702/16490.3 = 24.5’

**Center of Rigidity = (69’,24.5’)**

# Center of mass for the 4th floor

| X dimension | | |
|---|---|---|
| Area | X | Ax |
| 2412.4 | 45.8 | 110487.9 |
| 465.6 | 93.5 | 43533.6 |
| 762.3 | 114.9 | 87588.27 |
| 2969.4 | 55.7 | 165395.6 |
| 6609.7 | | 407005.4 |

| Y dimension | | |
|---|---|---|
| Area | Y | Ay |
| 2412.4 | 42.4 | 102285.8 |
| 465.6 | 39.4 | 18344.64 |
| 762.3 | 42.4 | 32321.52 |
| 2969.4 | 13.3 | 39493.02 |
| 6609.7 | | 192444.9 |

X = ∑Ax/∑A = 407005.4/6609.7
= 61.6'

Y = ∑Ay/∑A = 192444.9/6609.7
= 29.1'

**Center of Mass = (61.6',29.1')**

# Loads on shear walls due to torsion

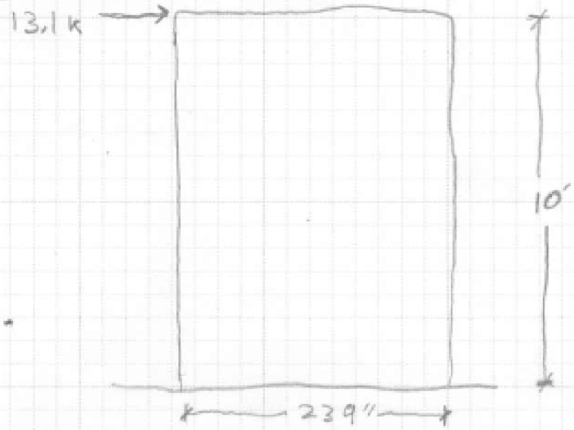
Vt = V(e)(di)(Ki)/J

J = ∑Ki(di^2)
e = 7.4'
V = 27.3 kips

| Wall | di | K | J | Vt |
|---|---|---|---|---|
| 1 | 46.7 | 2340.8 | 5105027 | 4.3259 |
| 2 | 24.55 | 2362.4 | 1423824 | 8.2289 |
| 3 | 11.25 | 2340.8 | 296258 | 17.9573 |
| 4 | 29.94 | 2362.4 | 2117664 | 6.7475 |
| 5 | 35.5 | 2349.6 | 2961083 | 5.6907 |
| 6 | 22.64 | 2359 | 1209152 | 8.9231 |
| 7 | 25.74 | 2375.3 | 1573749 | 7.8485 |

# Design Check: Shear Walls

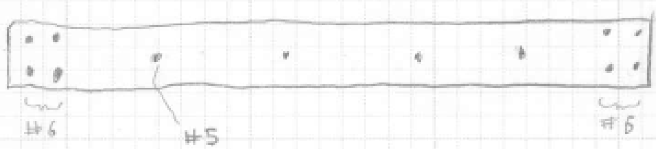
Spot Check: Shear Wall




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

8" CMU
$b = 7.625"$

$V = 13.1$ kips




$d$

Assume $c = 7"$ for location of N.A.

$a = 0.85(7) = 5.95$ in

$X = 0.5(a) = 0.5(5.95) = 2.98$

$T = A_s F_y$
$= [4(0.31) + 4(.44)]\,60 = 180$ k

$C = A_s f_s + 0.85 f'_m b a$
$= 4(.44)60 + 0.85(2)(7.625)(5.95)$
$= 105.6 + 77.1$
$= 182.7$

$T - C = 182.7 - 180 = 2.7$ k
close enough ∴ use $c = 7$

$d = 239 - 2.98 = 236"$

$f_v = \frac{13.1 \text{ kips}}{7.625(236)} = 7.3$ psi

$M/Vd = \frac{0.5(10' \cdot 12)\,13.1}{13.1\text{k}\,(236)} = 0.25 < 1$

use $F_v = \frac{1}{2}(4 - M/Vd)\sqrt{f'_m}$ but not to exceed $120 - 45(M/Vd)$

$F_v = \frac{1}{2}(4 - 0.25)\sqrt{2000} = 83.9$

$120 - 45(0.25) = 108.75$

$83.9 < 108.8$ ✓ ok

$7.3 < 83.9$
$f_v < F_v$
✓ ok

reinforcement check

horizontal reinf.

Spacing $< \begin{cases} d/2 = 118 \\ 48in \text{ controls} \end{cases}$

Spacing @ 8" o.c. < 48"

✓ok

Vertical reinf.

$A_v = \frac{V_s}{F_y d} = \frac{13.1k(4' \cdot 12)}{60(236)} = 0.044$

$1/3 A_v = \frac{1}{3}(0.044) = 0.015 < 0.31$

✓ok