T.C. WILLIAMS HIGH SCHOOL

ALEXANDRIA, VA

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STRUCTURAL OPTION

TECHNICAL REPORT #3

03 DECEMBER 2007

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EXECUTIVE SUMMARY

The purpose of this technical report is to research and analyze the existing lateral force resisting system used in the design of T.C. Williams High School. The primary codes used in this report are IBC 2006, and ASCE 7-05. The school was originally designed with the Virginia State Building Code, which at the time referenced IBC 2000, and ASCE 7-99. T.C. Williams is a 3 Story 461,000 SF high school in Alexandria, VA, designed to accommodate 2,500 students.

For structural analysis purposes TC Williams is broken down into 6 different sections through the use of control joints. For the purpose of the report only one of these buildings will be under a detailed analysis. The section of the building being analyzed was chosen because it is both the highest section of the building and accurately represents the other sections of the same height.

Lateral forces are resisted by ordinary steel concentrically braced frames. Four frames run in each the N-S, and E-W directions. Lateral forces are distributed to these frames through stiffness factors of the respective frames since the concrete floor acts as a rigid diaphragm. When loaded with lateral forces the frames act like a truss, and transfers the load to the columns which then transfers it to the footings in compression.

RAM Structural System was used to create a model which was used to aid in the design process. As previously expected, seismic forces controlled over wind due to the fact the building is rather short for its overall mass. The seismic forces obtained using RAM Structural System was really close to the ones calculated (usually within 5%). For instance the calculated base shear was 488 kips compared to the RAM results of 499 kips in the N-S direction, and 419 kips in the E-W direction.

A detailed drift analysis was then completed using RAM Structural Systems as well. The overall drift of the building was found to be at most 0.3 inches which was 4 ½ times less than the allowable drift of 1.3 inches. Along with a quick check of strength capacities, the frames were found to easily resist all the loads. It is safe to say the original design of concentrically braced frames easily resists all the lateral loads.

The overall overturning moments the building was found to need to resist were 15,480 ft-kips and 13,095 ft-kips in the N-S and E-W directions respectively. The foundations do not need to resist all of these loads in flexure as the braced frames act as a truss which transfers much of the load to the columns, which in turn transfers the load to the footings as a force in compression.

Structural System Overview

Roof System

Typical flat roof systems on T.C. Williams High School consists primarily of a Thermoplastic Polyolefin (TPO) Membrane system with rigid insulation on 1½" 22 gauge steel roof deck, supported by K-Series Steel Joists which are typically spaced 5' O.C. Typical sloped roofing systems are similar to the flat roofing systems except instead of the TPO Membrane system there is a standing seam metal roof.

Typical roofing systems over larger span areas such as the gymnasium and the auditorium consist of 3" 20 gauge steel roof deck, supported by DLH Steel Joists typically spaced 12' O.C.

Floor System

Typical floor systems consist of a steel composite deck and beam system with a 3" concrete slab on 1½" 18 gauge steel composite deck, supported by Steel Beams typically spaced 8' O.C. The concrete slab is made of Normal Weight Concrete (145 PCF) and has a minimum 28 day compressive strength (F'c) of 4000 PSI. Most typical Steel Beams are W18x35 spanning a maximum of 34' with steel studs spaced at 12" O.C. The range of steel beams varies greatly depending on specific room requirements; generally ranging anywhere from a W16x26 to a W21x44. Steel studs creating the composite action are ¾" in diameter and 3½" long.

Foundation

All main building foundations are constructed on subgrade soils improved by the installation of a 'Geopier Rammed Aggregate Pier Soil Reinforcement' system and are designed to bear on strata capable of sustaining a minimum bearing pressure of 6,000 PSF. The slab on grade consists of Normal Weight Concrete (145 PCF) and has a minimum 28 day compressive strength (F'c) of 3,500 PSI. Typical slabs are 4" thick and are reinforced with 6x6-W1.4xW1.4 WWF at mid depth. All spread and strip footings consist of Normal Weight Concrete (145 PCF) and have a minimum 28 day compressive strength (F'c) of 3,000 PSI.

LATERAL SYSTEM

T.C. Williams is separated into 6 different “buildings” through the use of ‘Fire Walls’. Both classroom towers are laterally supported with ordinary steel concentrically braced frames in both the N-S and E-W directions. The 3 story area connecting the 2 three story classroom towers is laterally supported with ordinary steel moment frames in both the N-S and E-W directions. Gymnasium and auditorium areas are supported by intermediate reinforced masonry shear walls, in all directions. The rest of the building, which includes the area between the gymnasium and auditorium sections, is laterally supported by ordinary reinforced masonry shear walls, in all directions.

COLUMNS

Steel columns are the primary gravity load resisting members of the building. They consist of Grade 50 ASTM A992 wide flange shapes, grade 46 ASTM A500 rectangular HSS shapes, and grade 42 ASTM A500 round HSS shapes. The wide flange shapes generally range from a W10x49 to a W10x68, and are the primary support for most of the building. The Round HSS shapes found connecting the two classroom wings and under the green roof, and generally range from HSS12.750x.375 to HSS16x.500.

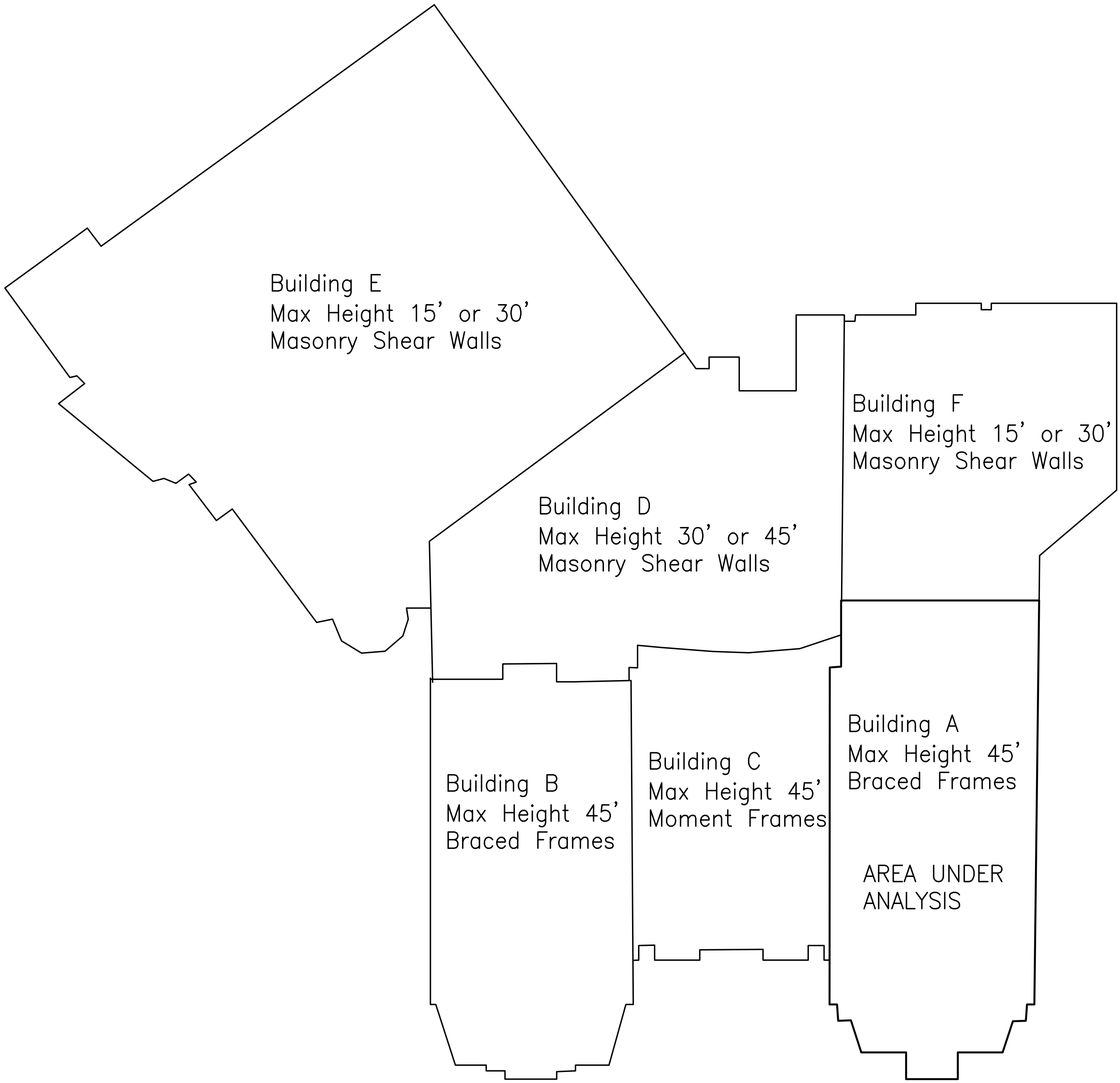

Building E
Max Height 15' or 30'
Masonry Shear Walls
Building F
Max Height 15' or 30'
Masonry Shear Walls
Building D
Max Height 30' or 45'
Masonry Shear Walls
Building B
Max Height 45'
Braced Frames
Building C
Max Height 45'
Moment Frames
Building A
Max Height 45'
Braced Frames
AREA UNDER
ANALYSIS

Figure 1

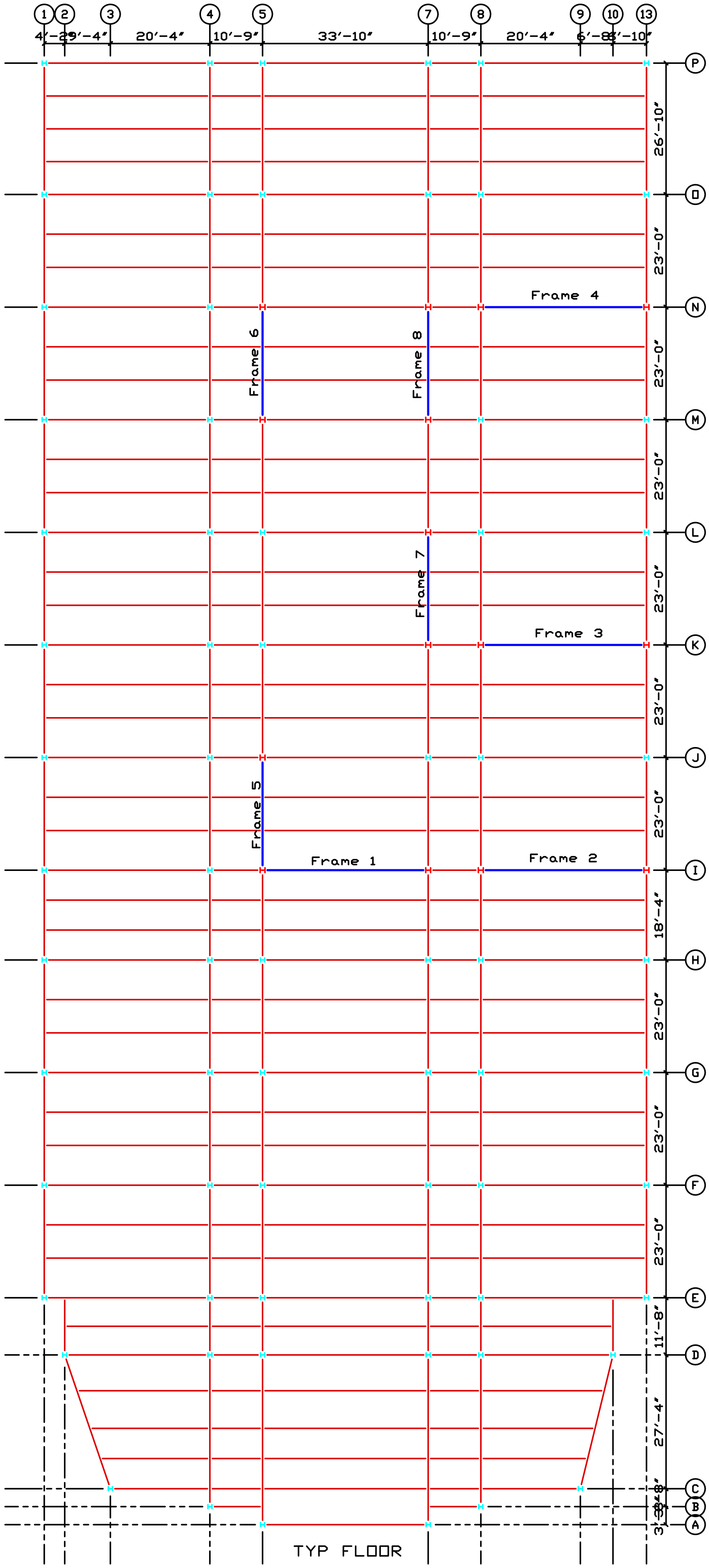

1
2
3
4
5
7
8
9
10
13
4'-2"
9'-4"
20'-4"
10'-9"
33'-10"
10'-9"
20'-4"
6'-8"
3'-10"
P
O
N
M
L
K
J
I
H
G
F
E
D
C
B
A
26'-10"
23'-0"
18'-4"
11'-8"
27'-4"
Frame 1
Frame 2
Frame 3
Frame 4
Frame 5
Frame 6
Frame 7
Frame 8
TYP FLOOR

Figure 1

CODES

ORIGINAL DESIGN CODES:

Virginia State Building Code (VUSBC), 2000 Edition

International Building Code (IBC), 2000 Edition

American Society of Civil Engineers (ASCE-7), 1999 Edition

Building Code Requirements for Structural Concrete (ACI 318-95)

Standard Specifications for Structural Concrete (ACI 301-96)

AISC Code of Standard Practice for Steel Buildings, 2000 Edition

AISC Specification for Structural Steel Buildings, Allowable Stress Design and Plastic Design, 1989 Edition

THESIS DESIGN CODES:

International Building Code (IBC), 2006 Edition

American Society of Civil Engineers (ASCE-7), 2005 Edition

AISC Steel Construction Manual, LRFD, 13^{th} Edition

THESIS DEFLECTION CRITERIA:

TOTAL = L / 240

LIVE = L / 360

CONSTRUCTION = L / 360

STRUCTURAL MEMBER SUPPORTING MASONRY WALLS = L / 600

LOADS

TYPICAL ROOF DEAD LOAD	THESIS DESIGN
TPO Membrane / S.S. metal Roof	3 psf
4"-6" Rigid Insulation	2.5 psf
$1^1/_2$" - 3" Galvanized Steel Deck	2 psf
K-Series Steel Joists	3.5 psf
Ceiling Finishes	5 psf
Mechanical / Electrical	6.5 psf
Sprinklers	2.5 psf
TOTAL	25 psf

TYPICAL FLOOR DEAD LOAD	THESIS DESIGN
3" NWC Slab (145 pcf)	38 psf
18 gauge $1^1/_2$" Composite Deck	3 psf
Steel Beams	5 psf
Ceiling Finishes	5 psf
Mechanical / Electrical	6.5 psf
Sprinklers	2.5 psf
TOTAL	60 psf

TYPICAL ROOF LIVE LOAD	THESIS DESIGN	CODE REFERENCE
Minimum Roof LL	20 psf	ASCE 7-05 Section 4.9.1
Ground Snow Load (Pg)	25 psf	IBC Figure 1608.2
Importance Category III	Is = 1.10	IBC Section 1604.5
Exposure Factor	Ce = 1.0	IBC Table 1608.3.1
Thermal Factor	Ct = 1.0	IBC Table 1608.3.2
Flat Roof Snow Load	19.25 psf + Drift	IBC Section 1608.3
Drift	Varies	ASCE 7-05 Section 7.7

FLOOR LIVE LOADS	THESIS DESIGN	ORIGINAL DESIGN	ASCE 7-05 MIN VALUE
Classroom	50 psf	50 psf	40 psf
First Floor Corridor	100 psf	100 psf	100 psf
Above First Floor Corridor	80 psf	80 psf	80 psf
Offices	50 psf	50 psf	50 psf
Light' Storage	125 psf	125 psf	125 psf
Mechanical	150 psf	150 psf	n/a
Green Roof	100 psf	100 psf	n/a
Library Stacks	150 psf	150 psf	150 psf

Seismic Analysis

Normally seismic forces wouldn't be much of a problem in Alexandria, VA, but due to extremely poor soil conditions, and small response modification values (R-Values) for the lateral resisting elements, seismic proved to be a much bigger factor than first thought. These R values differ greatly from what the engineer had originally intended. When this building was designed, there were much more lenient design codes for seismic, but since then the newer versions of the code such as ASCE 7-05 have greatly reduced these R-Values. For example in the 3 story classroom wings the building was originally designed with an R-Value of 5.0 for concentrically braced frames. Compared to the new code, the R-Value is 3.25 for concentrically braced frames.

Using the equivalent lateral force method, a base shear of 488 kips was obtained for building A. Included in the weight calculations of the building was 100% of the buildings dead load, along with 25% of storage rooms, and 100% of equipment operating weight if available. Also Included in the Dead load was interior CMU partitions, exterior walls, and the dead load weight of the floor system.

The base shear obtained using RAM Structural System is very similar to the value found using the equivalent frame method. RAM yielded a base shear of 499 kips in the N-S direction, and 419 kips in the E-W direction. The periods varied from 0.1224 seconds for mode 9 to 0.6889 seconds for mode 1.

SEISMIC ANALYSIS

SEISMIC ANALYSIS	THESIS DESIGN	CODE
Analysis Procedure	Equivalent Lateral Force Procedure	ASCE 7 Section 12.8
Importance Category	III	ASCE 7 Table 1-1
Importance Factor (I_E)	1.25	ASCE 7 Table 11.5-1
Seismic Category	II	ASCE 7 Section 11.6
Site Class	D	IBC Table 1613.5.2
Spectral Acceleration for Short Periods (Ss)	15.30%	IBC Figure 1615 (1)
Spectral Acceleration for 1 Second Periods (S1)	5.00%	IBC Figure 1615 (2)
Site Coefficient, Fa	1.6	ASCE 7 Table 11.4-1
Site Coefficient, Fv	2.4	ASCE 7 Table 11.4-2
S_{MS}	0.2448	ASCE 7 Section 11.4.3
S_{M1}	0.12	ASCE 7 Section 11.4.3
S_{DS}	0.1632	ASCE 7 Section 11.4.4
S_{D1}	0.08	ASCE 7 Section 11.4.4
Seismic Design Category	B	ASCE 7 Table 11.6-1,2
Structural System - Building 'A'	Ordinary Steel Concentrically Braced Frames	ASCE 7 Table 12.2-1
Structural System - Building 'B'	Ordinary Steel Concentrically Braced Frames	ASCE 7 Table 12.2-1
Structural System - Building 'C'	Ordinary Steel Moment Frames	ASCE 7 Table 12.2-1
Structural System - Building 'D'	Ordinary Reinforced Masonry Shear Walls	ASCE 7 Table 12.2-1
Structural System - Building 'E'	Intermediate Reinforced Masonry Shear Walls	ASCE 7 Table 12.2-1
Structural System - Building 'F'	Intermediate Reinforced Masonry Shear Walls	ASCE 7 Table 12.2-1
R Factor - Building 'A'	3.25	ASCE 7 Table 12.2-1
R Factor - Building 'B'	3.25	ASCE 7 Table 12.2-1
R Factor - Building 'C'	3.5	ASCE 7 Table 12.2-1
R Factor - Building 'D'	2.0	ASCE 7 Table 12.2-1
R Factor - Building 'E'	3.5	ASCE 7 Table 12.2-1
R Factor - Building 'F'	3.5	ASCE 7 Table 12.2-1
Deflection Modification Factor - Building 'A'	3.25	ASCE 7 Table 12.2-1
Deflection Modification Factor - Building 'B'	3.25	ASCE 7 Table 12.2-1
Deflection Modification Factor - Building 'C'	3.0	ASCE 7 Table 12.2-1
Deflection Modification Factor - Building 'D'	1.75	ASCE 7 Table 12.2-1
Deflection Modification Factor - Building 'E'	2.25	ASCE 7 Table 12.2-1
Deflection Modification Factor - Building 'F'	2.25	ASCE 7 Table 12.2-1

WIND ANALYSIS

After examining the seismic results of building A, one wouldn't expect wind to be a huge factor in the N-S direction. This would be due to the very long rectangular shape of the building being analyzed. A wind analysis was completed to analyze the wind in the E-W direction, and to see the difference between seismic and wind in the N-S direction.

Using Method 2 'The Analytical Procedure', for building A, a base shear of 88 kips was obtained in the N-S direction, which may be expected to the large rectangular shape of the short building. In the E-W direction a base shear of 244 kips was obtained. For building E, I obtained a base shear of 173 kips in the N-S direction, and 147 kips in the E-W direction.

The base shear obtained using RAM Structural system slightly differed from the hand calculations. The controlling base shear was found to be 167 kips in the E-W Direction and 59 kips in the N-S Direction. This may have differed due to the procedure taken to find the loads, but since seismic easily controls in both cases a further in depth analysis of assumptions of both wind designs is not needed.

WIND ANALYSIS

WIND ANALYSIS	THESIS DESIGN	CODE
Importance Category	III	ASCE 7 Table 1-1
Importance Factor, I_w	1.15	ASCE 7 Table 11.5-1
Basic Wind Speed, V	90mph	ASCE 7 Figure 6-1C
Directionality Factor, K_d	0.85*	ASCE 7 Table 6-4
Exposure Category	B	ASCE 7 Section 6.5.6.3
Topographic Factor, K_{zt}	1.0	ASCE 7 Figure 6-4
Gust Factor, G	0.85	ASCE 7 Section 6.5.8
Resonant Response Factor	1.0	ASCE 7 3.5.8.2
Mean Roof Height	45'	n/a
Enclosure Classification	Enclosed	ASCE 7 Section 6.5.9
Internal Pressure Coefficient, GC_{pi}	±0.18	ASCE Figure 6.5
Reduction Factor, R_i	1.0	ASCE 7 Section 6.5.11.1.1

*K_d is only permitted to be used in combination with load cases

External Pressure Coefficients, Cp	
Windward	0.8
E-W Leeward - Building 'A'	-0.5
N-S Leeward - Building 'A'	-0.2875
E-W Leeward - Building 'E'	-0.472
N-S Leeward - Building 'E'	-0.5
Side Wall	-0.7

z	k_z	q_z
0-15	0.57	13.59
30	0.7	16.69
45	0.785	18.72

PRESSURE				
N-S Building A				
WINDWARD		LEEWARD		TOTAL
h (ft)	P (psf)	h (ft)	P (psf)	-
0-15	12.6	0-15	-1.2	13.8
30	14.7	30	-1.2	15.9
45	16.1	45	-1.2	17.3
E-W Building A				
WINDWARD		LEEWARD		TOTAL
h (ft)	P (psf)	h (ft)	P (psf)	-
0-15	12.6	0-15	-4.6	17.2
30	14.7	30	-4.6	19.3
45	16.1	45	-4.6	20.7

PRESSURE				
N-S Building E				
WINDWARD		LEEWARD		TOTAL
h (ft)	P (psf)	h (ft)	P (psf)	-
0-15	12.6	0-15	-4.6	17.2
30	14.7	30	-4.6	19.3
E-W Building E				
WINDWARD		LEEWARD		TOTAL
h (ft)	P (psf)	h (ft)	P (psf)	-
0-15	12.6	0-15	-4.1	16.7
30	14.7	30	-4.1	18.8

LATTERAL FORCE DISTRIBUTION

In the part of the building being analyzed the primary lateral force resistance is achieved using ordinary steel concentrically braced frames. The frames resisting in the N-S direction are all nearly identical, and the frames resisting in the E-W direction are also all nearly identical. These frames differ in size as the frames running in the E-W direction are larger than the frames running in the N-S direction. However, even though the frames running E-W all contain the same sizes of shapes, there are some minor differences in geometry which could alter the stiffness. A RAM model was constructed to better analyze this system for both wind and seismic loads.

RAM Structural System recalculated all the seismic and wind loads using the 2003 IBC. The loading found using RAM differed slightly from the hand calculations used; however they were still similar and seismic still governed. In fact the seismic load which was by far the controlling case was nearly identical to the seismic load found in the hand calculations. The base shears calculated in the N-S and E-W Directions are 499 kips and 419 kips respectively. All the floors where assumed to act as rigid diaphragms so RAM distributed all the loads based on relative stiffness. This is very similar to the hand calculated base shear of 488 kips.

Through the hand calculations a lateral force distribution for the roof, 3rd floor, and 2nd floor equated to 143 kips, 229 kips and 116 kips respectively. Using ram to calculate the lateral force distributions equated to 149 kips, 235 kips, and 115 kips respectively. All of the loads were within a minimum of 5%, therefore the RAM model should be considered an accurate source.

TORSION

Due to the centralized distribution of braced frames in the part of the building being analyzed torsion probably won't be a major issue. However, Torsional effects may subject some frames to loads they are unable to handle, and torsion should always be a consideration when designing any lateral system as their effect can substantially affect the system. Torsion increases as the eccentricity between the center of mass and the geometrical center increases; through inspection this eccentricity should be fairly small for this section of the building.

When calculating torsion; story shear (H_S), eccentricity (e), relative stiffness (K_{SN}), and distance to the frame (C_N) all come into effect.

$$\text{Torsion} = (H_S * e * K_{SN} * C_N) / \Sigma(K_{SN} * C_N^2)$$

For final designs a more in depth torsional analysis should be completed to make sure torsion is not an issue.

DRIFT

Drift is a major controlling factor in when dealing with any lateral resisting system. The buildings deflection must be limited to l/400, where l is the buildings height in inches. Even if a building may function well with a higher deflection, they must be limited for serviceability and building inhabitant comfort.

A RAM analysis was preformed to accurately and quickly obtain the necessary information to see if drift would be a factor. For this building deflection would need to be limited to 1.35" (Δ_{MAX} = 45' * 12"/ft / 400). The results from RAM were greatly lower than the allowable, with maximum displacements of 0.26 inches and 0.30 inches in the E-W and N-S directions respectively. Both displacements were controlled by seismic, as wind wasn't much of a factor.

Level	Disp E-W (in)	Disp N-S (in)	Theta Z (rad)
Floor 2	0.082	0.095	0.00005
Floor 3	0.179	0.203	0.00011
Roof	0.255	0.305	0.00015

OVERTURNING MOMENT

Overturning moments have an effect on all lateral resisting systems. They may be calculated by summing the height above ground level multiplied by the story forces at each level. The story forces have been taken from ram and multiplied by the height to obtain the total overturning moment in both the E-W and N-S directions. The overturning moments are 13,095 ft kips and 15,480 ft kips respectively.

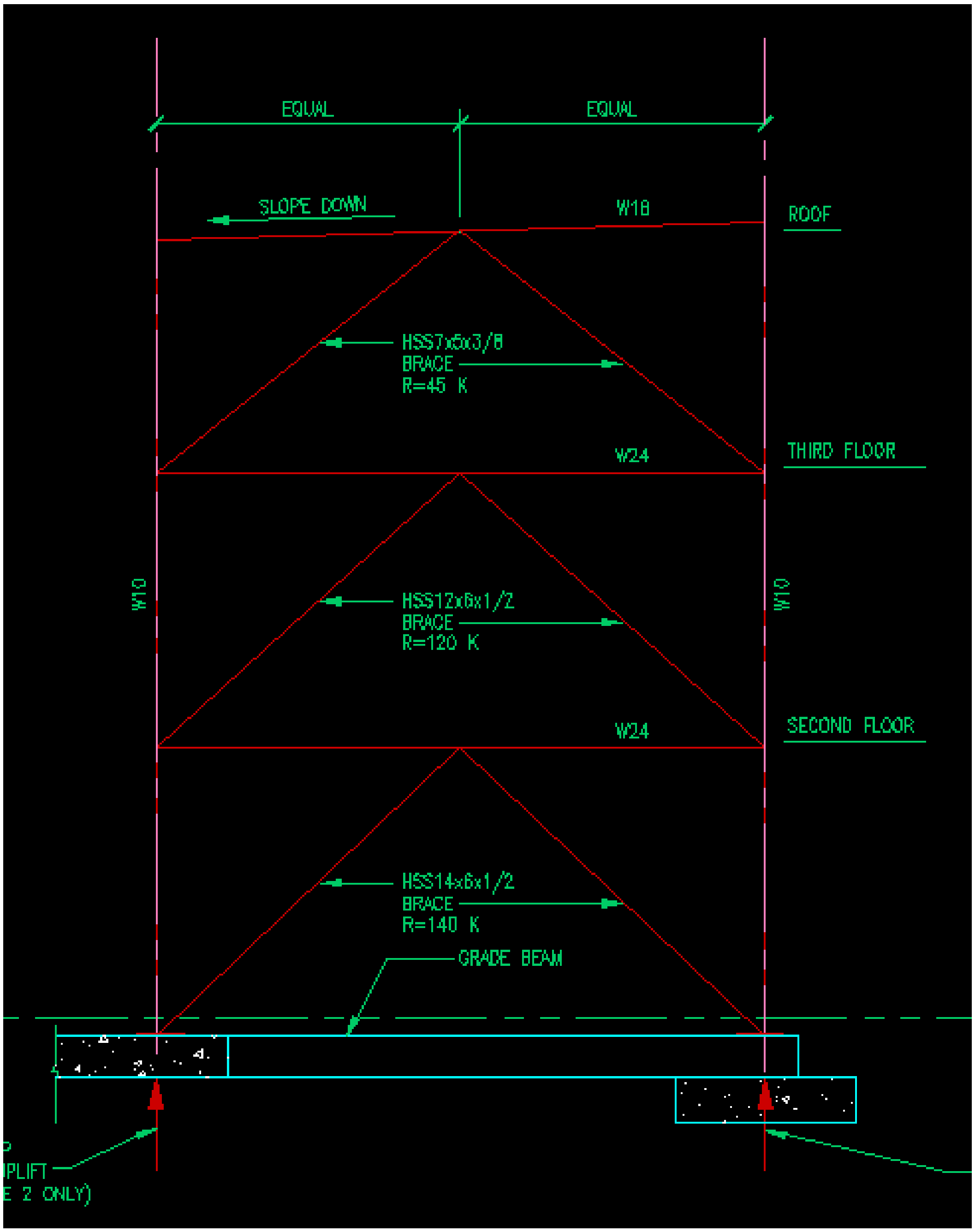
Normally the magnitude of the force would continue to increase the higher you go in the building, but due to the roof not having a slab, the seismic force is significantly less at that level.

The overturning moment is resisted by the braced frames which act like a truss. Loads are transferred from the braced frames to the columns, which then transfer the loads down to the footings as a compression force.

Overturning Moment		
E-W Direction		
Level	Height (ft)	Force (kips)
Floor 2	15	93
Floor 3	30	198
Roof	45	128
Moment	13,095 (ft kips)	
N-S Direction		
Level	Height (ft)	Force (kips)
Floor 2	15	115
Floor 3	30	235
Roof	45	149
Moment	15,480 (ft kips)	

STRENGTH CHECK

RAM Structural System was used to check the 8 concentrically braced frames for seismic strength capacity in the part of the building being analyzed. All 8 of the frames where found to meet the code requirements of 2002 LRFD, which is the most up to date LRFD code check. An omega safety factor of 2.0 was used in the calculations.



CONCLUSIONS

Conclusions about the lateral force resisting system in the TC Williams High School.

- The lateral force resisting system being analyzed is ordinary steel concentrically braced frames spanning 3 stories and 45 feet.
- Seismic base shears in both N-S and E-W directions (499 kips and 419 kips respectively), control over wind base shears (167 kips and 59 kips respectively). This is to be expected due to the very large volume building compared to its height.
- The forces are distributed to the braced frames through stiffness, due to the concrete slab acting as a rigid diaphragm. An example would be Frame # 2, in which the loads where 36 kips on the roof, 57 kips on the 3rd Floor, and 29 kips on the 2nd Floor.
- Torsion probably won't be a major concern due to the centralized distribution of braced frames. A more in depth analysis should be done regarding torsion for future analyses.
- The controlling drift caused by seismic forces was found to be 4 ½ times less than the allowable. Drift is easily controlled through the 4 frames in each direction.
- The overturning moments found in the N-S and E-W directions were 15,480 ft-kips and 13,095 ft-kips respectively. The frames will not have to totally resist all this load as they will act as a truss and much of the load will be transferred to the footings as compression forces, which are easily handled.
- A final seismic strength check was preformed. All of the members in all 8 of the frames met the 2002 LRFD code requirements.

APPENDICES

ADDITIONAL HAND CALCULATIONS

RAM STEEL CALCULATIONS

Seismic Design | TC Williams High School

Importance Cat. III ~ $I_E = 1.25$ Building Height = 50'
Seismic Cat. II ~ SUG = II
Site Class ~ D

Alexandria, VA 22302

$S_s = 15.3\%$ $F_a = 1.6$
$S_1 = 5.0\%$ $F_v = 2.4$

$S_{MS} = F_a S_s$
$= (1.6)(0.153) = 0.2448$

$S_{M1} = F_v S_1$
$= (2.4)(0.05) = 0.120$

$S_{DS} = \frac{2}{3} S_{MS}$
$= (\frac{2}{3})(0.2448) = 0.1632$

$S_{D1} = \frac{2}{3} S_{M1}$
$= \frac{2}{3}(0.120) = 0.080$

For $S_{DS} = 0.1632$ & SUG = II ⇒ SDC = A
For $S_{D1} = 0.80$ & SUG = II ⇒ SDC = B → controls

Seismic Design Catagorie : SDC = B

---

a) Load Bearing Masonry Walls w/ intermediate reinforced masonry shear walls

R = 3.5 - BUILDING 'E & F'

b) Building Frame System w/ ordinary steel concentrically braced frames

R = 3.25 - BUILDING 'A & B'

c) Building Frame System w/ ordinary reinforced masonry Shear walls

R = 2.0 - BUILDING 'D'

d) Moment Resisting Frame system w/ ordinary steel moment frames

R = 3.5 - BUILDING 'C'

SDC = B

$S_{DS} = 0.1632$ $S_{D1} = 0.080$

a) $R = 3.5$
b) $R = 3.25$
c) $R = 2.0$
d) $R = 3.5$

Determination of T

$S_{D1} = 0.080 \leq 0.1 \Rightarrow C_u = 1.7$

$T_a = C_T \cdot h_n^x$

$T_a = 0.02 (h_n)^{0.75}$

$T = C_u T_a = 1.7 (0.02 (h_n)^{0.75})$

$C_s = S_{DS} / (R/I) \{ \leq S_{D1} / (R/I) T, \geq 0.044\ S_{DS} I \}$

a) $C_s = 0.1632 / (\frac{3.5}{1.25}) = 0.058$

$h_n = 36'$

$T = 1.7(0.02(36)^{0.75}) = 0.50\ s$

$C_s \leq S_{D1} / ((R/I) \cdot T) = 0.08 / ((\frac{3.5}{1.25}) \cdot 0.50) = \underline{0.057}$ → controls

$C_s \geq 0.044\ S_{DS} I = 0.044 (0.1632)(1.25) = 0.009$

$\boxed{C_s = 0.057}$ - BUILDING E & F

b) $C_s = S_{DS} / (R/I) = 0.1632 / (\frac{3.25}{1.25}) = 0.063$

$h_n = 45'$

$T = 1.7 (0.02 (45)^{0.75}) = 0.59\ s$

$C_s \leq S_{D1} / (R/I) \cdot T = 0.08 / (3.25/1.25) \times 0.59 = \underline{0.052}$ → controls

$C_s \geq 0.044\ S_{DS} I = 0.009$

$\boxed{C_s = 0.052}$ - BUILDING A & B

c) $C_s = S_{DS}/(R/I) = 0.1632/(\frac{2}{1.25}) = 0.102$

$h_n = 45'$

$T = 1.7(0.02(45)^{0.75}) = 0.59\ s$

$C_s \leq S_{D1}/(\frac{R}{I}) \times T = 0.08/(\frac{2}{1.25}) \times 0.59 = \underline{0.085}$ → controls

$C_s \geq 0.009$

$\boxed{C_s = 0.085}$ - BUILDING 'D'

d) $C_s = 0.1632/(\frac{3.5}{1.25}) = 0.058$

$h_n = 45'$

$T = 0.59\ s$

$C_s \leq 0.08/(\frac{3.5}{1.25}) \times 0.59 = \underline{0.048}$ → controls

$C_s \geq 0.009$

$\boxed{C_s = 0.048}$ - BUILDING 'C'

BUILDING WEIGHT, W

BUILDING A

FLOOR 2

FLOOR DL = 60 psf (38,000 SF) = 2,280 K
WALL LOAD = 35 psf (10'8" × 1700') = 635 K
25% STORAGE = 125 psf (1340 SF)(0.25) = 42 K
Ext. WALLS = 100 psf (450' × 15') = 675 K
Int. FIRE WALLS = 54 psf (330' × 15') = 267 K
3,900 K

FLOOR 3

FLOOR DL = 2280 K
WALL LOAD = 635 K
25% STORAGE = 125 psf (620 SF)(0.25) = 19.4 K
Ext. WALLS = 675 K
INT FIREWALLS = 267 K
3880 K

ROOF

ROOF DL = 25 psf (38,000 SF) = 950 K
WALL LOAD = 35 psf (3'2" × 1700') = 188.5 K
EXT WALLS = 100 psf (7.5' × 450') = 337.5 K
INT WALLS = 54 psf (7.5' × 330') = 133.5 K
1,610 K

TOTAL WEIGHT = 9,390 K

$C_s = 0.052$

$V = C_s \times W$

$V = 488$ K

BUILDING WEIGHT, W

BUILDING E

FLOOR 2

FLOOR DL = 40,500 SF × 25 psf = 1,012.5 k
11,000 SF × 60 psf = 660 k

Mechanical = 2,400 SF × 150 psf = 360 k

WALL LOAD BELOW = 3'2" × 34' × 50 × 35 psf = 188 k

WALL LOAD ABOVE = 7'6" × 34' × 10 × 35 psf = 89 k

Ext. WALL BELOW = (282 + 287 + 325) × 7.5' × 100 psf = 670.5 k

Ext WALL ABOVE = 420 × 7.5' × 100 psf = 315 k

INTERIOR FIRE WALL = 325' × 15' × 54 psf = 263 k

3,560 k

FLOOR 3 (ROOF)

FLOOR DL = 11,000 × 25 psf = 275 k

WALL LOW BELOW = 3'2" × 34' × 10 × 35 psf = 37.7 k

Ext. WALL BELOW = 420 × 7.5' × 100 psf = 315 k

INTERIOR FIRE WALL = 325 × 7.5' × 54 psf = 131.6 k

760 k

TOTAL WEIGHT = 4320 k

$C_s = 0.057$

$V = C_s \times W$

$V = 246\ k$

Seismic Summary

Weight, W

Total DL

25% Storage LL (if available)

Partition Loads (if available)

Equipment Operating Weight (if available)

20% Flat Roof Snow Load *if* $P_f > 30$ psf

Base Shear (Building 'A')

V = Cs * W

Cs = 0.052

W = 9,390 kips

V = 0.052 * 9,390 k = 488 kips

Base Shear (Building 'E')

V = Cs * W

Cs = 0.057

W = 4,320 kips

V = 0.057 * 4,320 k = 246 kips

DESIGN BASE SHEAR FOR WIND

BUILDING A

V = AVG WIND OVER AREA OF WALL

$V_{A,N-S}$ = (13.8 psf * 15’ * 130’)+((15.9+13.8) / 2 psf * 15’ * 130’)+((17.3+15.9) / 2 psf * 15’ * 130’)

$V_{A,N-S}$ = 88 kips

$V_{A,E-W}$ = (17.2 psf * 15’ * 293’)+((17.2+19.3) / 2 psf * 15’ * 293’)+((19.3+20.7) / 2 psf * 15’ * 293’)

$V_{A,E-W}$ = 244 kips

$V_{E,N-S}$ = (17.2 psf * 15’ * 325’)+((19.3+17.2) / 2 psf * 15’ * 325’)

$V_{E,N-S}$ = 173 kips

$V_{E,E-W}$ = (16.7 psf * 15’ * 285’)+((18.8+16.7) / 2 psf * 15’ * 285’)

$V_{E,E-W}$ = 147 kips

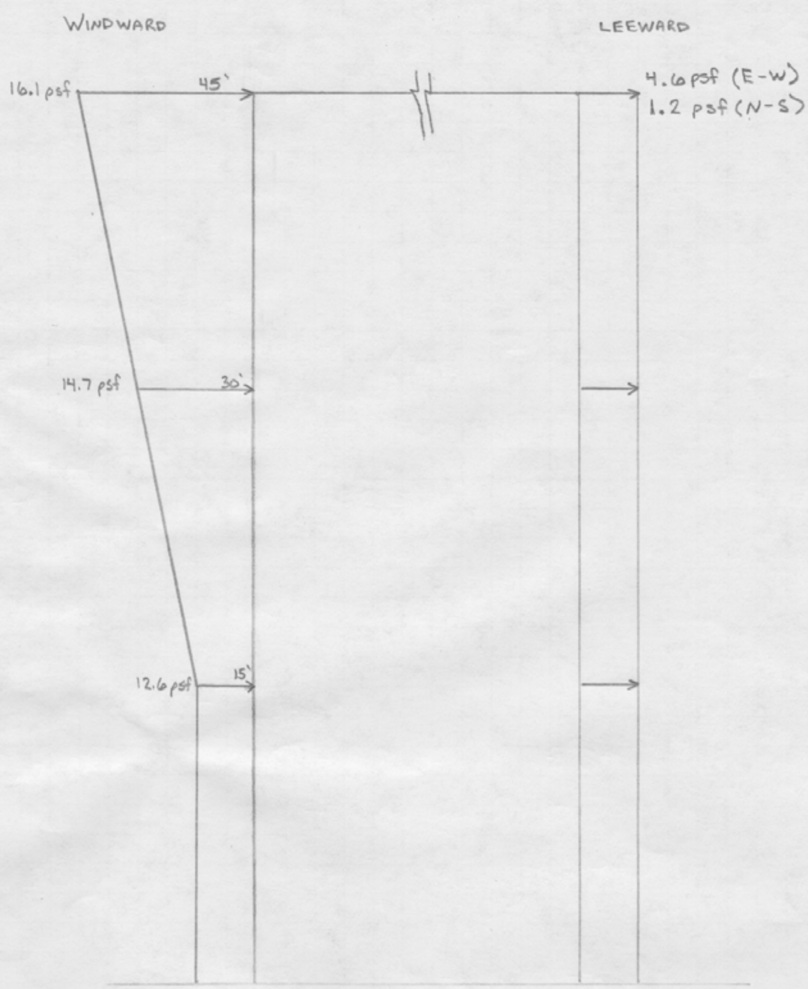
Wind Pressure, E-W

WINDWARD

$P = q_z G C_p - q_h(-GC_{pi})$

LEEWARD

$P = q_h G C_p - q_h(-GC_{pi})$



NOTE: DIST ON WINDWARD SIDE IS NOT LINEAR

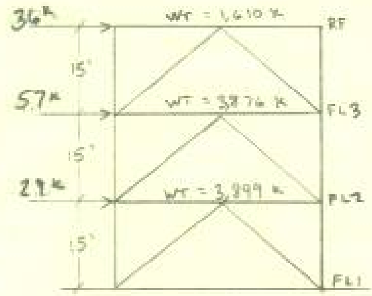
BASE SHEAR:

N-S	E-W
$V = 88^k$	$V = 244^k$

SPOT CHECK - BRACED FRAME

BRACE 1

BASE SHEAR, V = 488 K
RIGID DIAPHRAM
4 EQUAL STIFFNESS BRACED FRAMES
1/4 LOAD TO EACH FRAME



VERTICAL DIST OF SEISMIC FORCES

$F_x = C_{vx} \cdot V$

$C_{vx} = \frac{w_x h_x^k}{\sum_{i=1} w_i h_i^k}$; K=1 for $T \leq 0.5$ sec.

$C_{RF} = \frac{(1,610^k)(45')}{(1,610)(45') + (3,876)(30') + (3,899)(15')} = 0.293$

$C_{FL3} = \frac{(3,876^k)(30')}{(1,610)(45) + (3,876)(30) + (3,899)(15')} = 0.470$

$C_{FL2} = \frac{(3,899^k)(15')}{(1,610)(45) + (3,876)(30') + (3,899)(15')} = 0.237$

$F_{RF} = (0.293)(488^k)$
$F_{RF} = 143^k$

$F_{FL3} = (0.470)(488^k)$
$F_{FL3} = 229^k$

$F_{FL2} = (0.237)(488^k)$
$F_{FL2} = 116^k$

FORCES ON FRAME 1

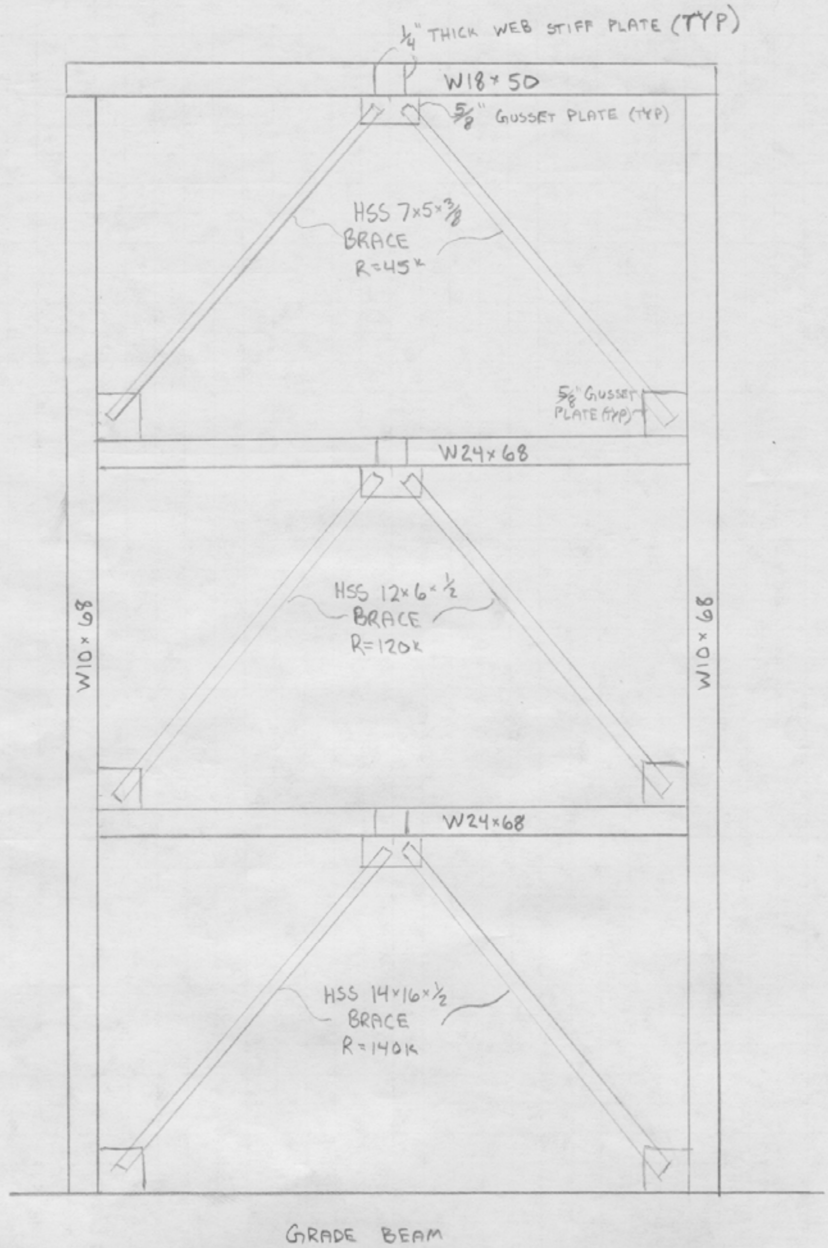
$F_{RF} = 143^k (1/4) = 36^k$

$F_{FL3} = 229^k (1/4) = 57^k$

$F_{FL2} = 116^k (1/4) = 29^k$

SPOT CHECK - BRACED FRAME

BRACE 1 DETAILS



SCALE: NOT TO SCALE

Loads and Applied Forces

LOAD CASE: Wind

Wind ASCE 7-02/IBC2003
Exposure: B
Basic Wind Speed (mph): 90.0 Importance Factor: 1.150
Apply Directionality Factor, Kd = 0.85
Use Topography Factor, Kzt: 1.00
Use Calculated Frequency for X-Dir.
Use Calculated Frequency for Y-Dir.
Gust Factor for Rigid Structures, G: Use Calculated G for X-Dir.
Gust Factor for Rigid Structures, G: Use Calculated G for Y-Dir.
Damping Ratio for Flexible Structures= 0.01
Mean Roof Height (ft): User Defined = 45.00
Ground Level: Base

WIND PRESSURES:

X-Direction: Natural Frequency = 1.452 Structure is Rigid
Y-Direction: Natural Frequency = 1.726 Structure is Rigid
CpWindward = 0.80 qLeeward (qh) = 15.94 psf
GCpn (Parapet): Windward = 1.80 Leeward = -1.10

Height	Kz	Kzt	qz	Gust Factor G		CpLeeward		Pressure (psf)	
ft			psf	X	Y	X	Y	X	Y
45.00	0.787	1.000	15.945	0.791	0.828	-0.500	-0.279	16.398	14.255
30.00	0.701	1.000	14.201	0.791	0.828	-0.500	-0.279	15.294	13.099
15.00	0.575	1.000	11.649	0.791	0.828	-0.500	-0.279	13.679	11.408
0.00	0.575	1.000	11.649	0.791	0.828	-0.500	-0.279	13.679	11.408

APPLIED DIAPHRAGM FORCES

Type: Wind_IBC03_1_X

Level	Diaph.#	Ht	Fx	Fy	X	Y
		ft	kips	kips	ft	ft
Roof	1	45.00	36.01	0.00	61.50	149.25
Level 3	1	30.00	68.33	0.00	61.50	149.25
Level 2	1	15.00	62.66	0.00	61.50	149.25

APPLIED STORY FORCES

Type: Wind_IBC03_1_X

Level	Ht	Fx	Fy
	ft	kips	kips
Roof	45.00	36.01	0.00
Level 3	30.00	68.33	0.00
Level 2	15.00	62.66	0.00
		167.00	0.00

APPLIED DIAPHRAGM FORCES

Type: Wind_IBC03_1_Y

Level	Diaph.#	Ht	Fx	Fy	X	Y

		ft	kips	kips	ft	ft
Roof	1	45.00	0.00	12.90	61.50	149.25
Level 3	1	30.00	0.00	24.20	61.50	149.25
Level 2	1	15.00	0.00	21.74	61.50	149.25

APPLIED STORY FORCES

Type: Wind_IBC03_1_Y

Level	Ht	Fx	Fy
	ft	kips	kips
Roof	45.00	0.00	12.90
Level 3	30.00	0.00	24.20
Level 2	15.00	0.00	21.74
		0.00	58.84

APPLIED DIAPHRAGM FORCES

Type: Wind_IBC03_2_X+E

Level	Diaph.#	Ht	Fx	Fy	X	Y
		ft	kips	kips	ft	ft
Roof	1	45.00	27.01	0.00	61.50	194.18
Level 3	1	30.00	51.24	0.00	61.50	194.18
Level 2	1	15.00	47.00	0.00	61.50	194.18

APPLIED STORY FORCES

Type: Wind_IBC03_2_X+E

Level	Ht	Fx	Fy
	ft	kips	kips
Roof	45.00	27.01	0.00
Level 3	30.00	51.24	0.00
Level 2	15.00	47.00	0.00
		125.25	0.00

APPLIED DIAPHRAGM FORCES

Type: Wind_IBC03_2_X-E

Level	Diaph.#	Ht	Fx	Fy	X	Y
		ft	kips	kips	ft	ft
Roof	1	45.00	27.01	0.00	61.50	104.33
Level 3	1	30.00	51.24	0.00	61.50	104.33
Level 2	1	15.00	47.00	0.00	61.50	104.33

APPLIED STORY FORCES

Type: Wind_IBC03_2_X-E

Level	Ht	Fx	Fy
	ft	kips	kips
Roof	45.00	27.01	0.00
Level 3	30.00	51.24	0.00

Level 2	15.00	47.00	0.00
		125.25	0.00

APPLIED DIAPHRAGM FORCES

Type: Wind_IBC03_2_Y+E

Level	Diaph.#	Ht	Fx	Fy	X	Y
		ft	kips	kips	ft	ft
Roof	1	45.00	0.00	9.67	80.10	149.25
Level 3	1	30.00	0.00	18.15	80.10	149.25
Level 2	1	15.00	0.00	16.31	80.10	149.25

APPLIED STORY FORCES

Type: Wind_IBC03_2_Y+E

Level	Ht	Fx	Fy
	ft	kips	kips
Roof	45.00	0.00	9.67
Level 3	30.00	0.00	18.15
Level 2	15.00	0.00	16.31
		0.00	44.13

APPLIED DIAPHRAGM FORCES

Type: Wind_IBC03_2_Y-E

Level	Diaph.#	Ht	Fx	Fy	X	Y
		ft	kips	kips	ft	ft
Roof	1	45.00	0.00	9.67	42.90	149.25
Level 3	1	30.00	0.00	18.15	42.90	149.25
Level 2	1	15.00	0.00	16.31	42.90	149.25

APPLIED STORY FORCES

Type: Wind_IBC03_2_Y-E

Level	Ht	Fx	Fy
	ft	kips	kips
Roof	45.00	0.00	9.67
Level 3	30.00	0.00	18.15
Level 2	15.00	0.00	16.31
		0.00	44.13

APPLIED DIAPHRAGM FORCES

Type: Wind_IBC03_3_X+Y

Level	Diaph.#	Ht	Fx	Fy	X	Y
		ft	kips	kips	ft	ft
Roof	1	45.00	27.01	9.67	61.50	149.25
Level 3	1	30.00	51.24	18.15	61.50	149.25

Level 2	1	15.00	47.00	16.31	61.50	149.25

APPLIED STORY FORCES

Type: Wind_IBC03_3_X+Y

Level	Ht	Fx	Fy
	ft	kips	kips
Roof	45.00	27.01	9.67
Level 3	30.00	51.24	18.15
Level 2	15.00	47.00	16.31
		125.25	44.13

APPLIED DIAPHRAGM FORCES

Type: Wind_IBC03_3_X-Y

Level	Diaph.#	Ht	Fx	Fy	X	Y
		ft	kips	kips	ft	ft
Roof	1	45.00	27.01	-9.67	61.50	149.25
Level 3	1	30.00	51.24	-18.15	61.50	149.25
Level 2	1	15.00	47.00	-16.31	61.50	149.25

APPLIED STORY FORCES

Type: Wind_IBC03_3_X-Y

Level	Ht	Fx	Fy
	ft	kips	kips
Roof	45.00	27.01	-9.67
Level 3	30.00	51.24	-18.15
Level 2	15.00	47.00	-16.31
		125.25	-44.13

APPLIED DIAPHRAGM FORCES

Type: Wind_IBC03_4_X+Y_CW

Level	Diaph.#	Ht	Fx	Fy	X	Y
		ft	kips	kips	ft	ft
Roof	1	45.00	20.25	7.26	42.90	194.18
Level 3	1	30.00	38.43	13.61	42.90	194.18
Level 2	1	15.00	35.25	12.23	42.90	194.18

APPLIED STORY FORCES

Type: Wind_IBC03_4_X+Y_CW

Level	Ht	Fx	Fy
	ft	kips	kips
Roof	45.00	20.25	7.26
Level 3	30.00	38.43	13.61
Level 2	15.00	35.25	12.23
		93.94	33.10

APPLIED DIAPHRAGM FORCES

Type: Wind_IBC03_4_X+Y_CCW

Level	Diaph.#	Ht ft	Fx kips	Fy kips	X ft	Y ft
Roof	1	45.00	20.25	7.26	80.10	104.33
Level 3	1	30.00	38.43	13.61	80.10	104.33
Level 2	1	15.00	35.25	12.23	80.10	104.33

APPLIED STORY FORCES

Type: Wind_IBC03_4_X+Y_CCW

Level	Ht ft	Fx kips	Fy kips
Roof	45.00	20.25	7.26
Level 3	30.00	38.43	13.61
Level 2	15.00	35.25	12.23
		93.94	33.10

APPLIED DIAPHRAGM FORCES

Type: Wind_IBC03_4_X-Y_CW

Level	Diaph.#	Ht ft	Fx kips	Fy kips	X ft	Y ft
Roof	1	45.00	20.25	-7.26	80.10	194.18
Level 3	1	30.00	38.43	-13.61	80.10	194.18
Level 2	1	15.00	35.25	-12.23	80.10	194.18

APPLIED STORY FORCES

Type: Wind_IBC03_4_X-Y_CW

Level	Ht ft	Fx kips	Fy kips
Roof	45.00	20.25	-7.26
Level 3	30.00	38.43	-13.61
Level 2	15.00	35.25	-12.23
		93.94	-33.10

APPLIED DIAPHRAGM FORCES

Type: Wind_IBC03_4_X-Y_CCW

Level	Diaph.#	Ht ft	Fx kips	Fy kips	X ft	Y ft
Roof	1	45.00	20.25	-7.26	42.90	104.33
Level 3	1	30.00	38.43	-13.61	42.90	104.33
Level 2	1	15.00	35.25	-12.23	42.90	104.33

APPLIED STORY FORCES

Type: Wind_IBC03_4_X-Y_CCW

Level	Ht	Fx	Fy

	ft	kips	kips
Roof	45.00	20.25	-7.26
Level 3	30.00	38.43	-13.61
Level 2	15.00	35.25	-12.23
		93.94	-33.10

LOAD CASE: Seismic

Seismic ASCE 7-02 / IBC 2003 Equivalent Lateral Force
Site Class: D Importance Factor: 1.25 Ss: 0.153 g S1: 0.050 g
Fa: 1.600 Fv: 2.400 SDs: 0.163 g SD1: 0.080 g
Seismic Design Category: B
Provisions for: Force
Ground Level: Base

Dir	Eccent	R	Ta Equation	Building Period-T
X	None	3.3	Std,Ct=0.030,x=0.75	Calculated
Y	None	3.3	Std,Ct=0.030,x=0.75	Calculated

Dir	Ta	Cu	T	T-used	Eq95521-1	Eq95521-2	Eq95521-3	k
X	0.521	1.700	0.689	0.689	0.063	0.045	0.0090	1.094
Y	0.521	1.700	0.579	0.579	0.063	0.053	0.0090	1.040

Total Building Weight (kips) = 9390.00

APPLIED DIAPHRAGM FORCES

Type: EQ_IBC03_X_NoE_F

Level	Diaph.#	Ht	Fx	Fy	X	Y
		ft	kips	kips	ft	ft
Roof	1	45.00	128.09	0.00	62.95	154.78
Level 3	1	30.00	198.06	0.00	61.52	153.99
Level 2	1	15.00	93.23	0.00	61.56	154.02

APPLIED STORY FORCES

Type: EQ_IBC03_X_NoE_F

Level	Ht	Fx	Fy
	ft	kips	kips
Roof	45.00	128.09	0.00
Level 3	30.00	198.06	0.00
Level 2	15.00	93.23	0.00
		419.37	0.00

APPLIED DIAPHRAGM FORCES

Type: EQ_IBC03_Y_NoE_F

Level	Diaph.#	Ht	Fx	Fy	X	Y
		ft	kips	kips	ft	ft
Roof	1	45.00	0.00	148.66	62.95	154.78
Level 3	1	30.00	0.00	235.02	61.52	153.99
Level 2	1	15.00	0.00	114.90	61.56	154.02

APPLIED STORY FORCES

Type: EQ_IBC03_Y_NoE_F

Level	Ht	Fx	Fy

	ft	kips	kips
Roof	45.00	0.00	148.66
Level 3	30.00	0.00	235.02
Level 2	15.00	0.00	114.90
		0.00	498.58

Building Story Shears

RAM Frame v11.0
Building 1
DataBase: BUILDI~1

12/03/07 12:25:59

CRITERIA:

Rigid End Zones: Ignore Effects
Member Force Output: At Face of Joint
P-Delta: Yes Scale Factor: 1.00
Ground Level: Base
Wall Mesh Criteria :
Wall Element Type : Shell Element with No Out-of-Plane Stiffness
Max. Allowed Distance between Nodes (ft) : 8.00

Load Case: E1 Seismic EQ_IBC03_X_NoE_F

Level	**Diaph. #**	**Shear-X**	**Shear-Y**
		kips	**kips**
Roof	1	31.08	0.13
Roof	None	97.70	-0.04
Level 3	1	95.33	0.10
Level 3	None	233.78	0.09
Level 2	1	140.53	0.25
Level 2	None	283.10	-0.24

Summary - Total Story Shears

Level	**Shear-X**	**Change-X**	**Shear-Y**	**Change-Y**
	kips	**kips**	**kips**	**kips**
Roof	128.78	128.78	0.09	0.09
Level 3	329.11	200.33	0.19	0.11
Level 2	423.63	94.52	0.01	-0.19

Load Case: E2 Seismic EQ_IBC03_Y_NoE_F

Level	**Diaph. #**	**Shear-X**	**Shear-Y**
		kips	**kips**
Roof	1	-3.31	0.79
Roof	None	3.36	148.77
Level 3	1	-7.01	-0.40
Level 3	None	7.16	387.37
Level 2	1	-9.27	3.69
Level 2	None	9.48	499.85

Summary - Total Story Shears

Level	**Shear-X**	**Change-X**	**Shear-Y**	**Change-Y**
	kips	**kips**	**kips**	**kips**
Roof	0.05	0.05	149.57	149.57
Level 3	0.16	0.11	386.96	237.40
Level 2	0.21	0.05	503.54	116.57

Frame Story Shears

RAM Frame v11.0
Building 1
DataBase: BUILDI~1 12/03/07 12:25:59

CRITERIA:

Rigid End Zones: Ignore Effects
Member Force Output: At Face of Joint
P-Delta: Yes Scale Factor: 1.00
Ground Level: Base
Wall Mesh Criteria :
Wall Element Type : Shell Element with No Out-of-Plane Stiffness
Max. Allowed Distance between Nodes (ft) : 8.00

Frame #1

Load Case: E1 Seismic EQ_IBC03_X_NoE_F

Level	Shear-X kips	Change-X kips	Shear-Y kips	Change-Y kips
Roof	31.52	31.52	0.00	0.00
Level 3	95.48	63.96	0.00	0.00
Level 2	135.06	39.58	0.01	0.01

Load Case: E2 Seismic EQ_IBC03_Y_NoE_F

Level	Shear-X kips	Change-X kips	Shear-Y kips	Change-Y kips
Roof	-3.30	-3.30	0.00	0.00
Level 3	-6.98	-3.68	-0.04	-0.04
Level 2	-9.45	-2.47	0.25	0.30

Frame #2

Load Case: E1 Seismic EQ_IBC03_X_NoE_F

Level	Shear-X kips	Change-X kips	Shear-Y kips	Change-Y kips
Roof	48.86	48.86	-0.01	-0.01
Level 3	116.11	67.25	0.00	0.01
Level 2	143.06	26.95	0.11	0.11

Load Case: E2 Seismic EQ_IBC03_Y_NoE_F

Level	Shear-X kips	Change-X kips	Shear-Y kips	Change-Y kips
Roof	4.12	4.12	0.01	0.01
Level 3	7.08	2.97	-0.09	-0.10
Level 2	7.93	0.85	0.51	0.60

Frame #3

Frame Story Shears

Load Case: E1 Seismic EQ_IBC03_X_NoE_F

Level	Shear-X kips	Change-X kips	Shear-Y kips	Change-Y kips
Roof	34.84	34.84	-0.01	-0.01
Level 3	83.36	48.52	0.00	0.01
Level 2	102.05	18.70	0.11	0.11

Load Case: E2 Seismic EQ_IBC03_Y_NoE_F

Level	Shear-X kips	Change-X kips	Shear-Y kips	Change-Y kips
Roof	1.55	1.55	0.01	0.01
Level 3	3.05	1.51	-0.09	-0.10
Level 2	3.87	0.81	0.51	0.60

Frame #4

Load Case: E1 Seismic EQ_IBC03_X_NoE_F

Level	Shear-X kips	Change-X kips	Shear-Y kips	Change-Y kips
Roof	13.80	13.80	-0.01	-0.01
Level 3	34.23	20.43	0.00	0.01
Level 2	40.54	6.31	0.11	0.11

Load Case: E2 Seismic EQ_IBC03_Y_NoE_F

Level	Shear-X kips	Change-X kips	Shear-Y kips	Change-Y kips
Roof	-2.31	-2.31	0.01	0.01
Level 3	-2.99	-0.68	-0.09	-0.10
Level 2	-2.22	0.77	0.51	0.60

Frame #5

Load Case: E1 Seismic EQ_IBC03_X_NoE_F

Level	Shear-X kips	Change-X kips	Shear-Y kips	Change-Y kips
Roof	-0.09	-0.09	-14.12	-14.12
Level 3	-0.04	0.05	-25.26	-11.14
Level 2	1.20	1.24	-13.10	12.15

Load Case: E2 Seismic EQ_IBC03_Y_NoE_F

Level	Shear-X kips	Change-X kips	Shear-Y kips	Change-Y kips
Roof	0.00	0.00	37.98	37.98

Level 3	-0.01	-0.01	97.81	59.83
Level 2	0.06	0.07	124.17	26.36

Frame #6

Load Case: E1 Seismic EQ_IBC03_X_NoE_F

Level	Shear-X kips	Change-X kips	Shear-Y kips	Change-Y kips
Roof	-0.04	-0.04	0.49	0.49
Level 3	0.00	0.04	-5.52	-6.00
Level 2	0.45	0.45	-13.10	-7.58

Load Case: E2 Seismic EQ_IBC03_Y_NoE_F

Level	Shear-X kips	Change-X kips	Shear-Y kips	Change-Y kips
Roof	0.00	0.00	36.19	36.19
Level 3	0.00	0.00	94.77	58.59
Level 2	0.00	0.00	124.17	29.40

Frame #7

Load Case: E1 Seismic EQ_IBC03_X_NoE_F

Level	Shear-X kips	Change-X kips	Shear-Y kips	Change-Y kips
Roof	-0.07	-0.07	6.82	6.82
Level 3	-0.02	0.04	15.47	8.65
Level 2	0.82	0.85	12.94	-2.53

Load Case: E2 Seismic EQ_IBC03_Y_NoE_F

Level	Shear-X kips	Change-X kips	Shear-Y kips	Change-Y kips
Roof	0.00	0.00	37.43	37.43
Level 3	0.00	0.00	97.31	59.88
Level 2	0.03	0.03	126.75	29.44

Frame #8

Load Case: E1 Seismic EQ_IBC03_X_NoE_F

Level	Shear-X kips	Change-X kips	Shear-Y kips	Change-Y kips
Roof	-0.04	-0.04	6.92	6.92
Level 3	0.00	0.04	15.49	8.57
Level 2	0.45	0.45	12.93	-2.56

Frame Story Shears

Load Case: E2 Seismic EQ_IBC03_Y_NoE_F

Level	Shear-X kips	Change-X kips	Shear-Y kips	Change-Y kips
Roof	0.00	0.00	37.95	37.95
Level 3	0.00	0.00	97.38	59.43
Level 2	0.00	0.00	126.67	29.29

Story Displacements

RAM Frame v11.0
Building 1
DataBase: BUILDI~1
Building Code: IBC

12/03/07 12:21:23

CRITERIA:

Rigid End Zones:		Ignore Effects	
Member Force Output:		At Face of Joint	
P-Delta:	Yes	Scale Factor:	1.00
Ground Level:	Base		

Wall Mesh Criteria :

Wall Element Type : Shell Element with No Out-of-Plane Stiffness

Max. Allowed Distance between Nodes (ft) : 8.00

LOAD CASE DEFINITIONS:

D	DeadLoad	RAMUSER
Lp	PosLiveLoad	RAMUSER
W1	Wind	Wind_IBC03_1_X
W2	Wind	Wind_IBC03_1_Y
W3	Wind	Wind_IBC03_2_X+E
W4	Wind	Wind_IBC03_2_X-E
W5	Wind	Wind_IBC03_2_Y+E
W6	Wind	Wind_IBC03_2_Y-E
W7	Wind	Wind_IBC03_3_X+Y
W8	Wind	Wind_IBC03_3_X-Y
W9	Wind	Wind_IBC03_4_X+Y_CW
W10	Wind	Wind_IBC03_4_X+Y_CCW
W11	Wind	Wind_IBC03_4_X-Y_CW
W12	Wind	Wind_IBC03_4_X-Y_CCW
E1	Seismic	EQ_IBC03_X_NoE_F
E2	Seismic	EQ_IBC03_Y_NoE_F

Level: Roof, Diaph: 1

Center of Mass (ft): (62.95, 154.78)

LdC	Disp X in	Disp Y in	Theta Z rad
D	-0.00294	0.00223	0.00000
Lp	-0.00282	0.00156	0.00000
W1	0.08889	0.00653	0.00006
W2	0.00117	0.03060	0.00000
W3	0.04624	0.00130	-0.00003
W4	0.08710	0.00850	0.00013
W5	0.00388	0.02348	0.00001
W6	-0.00213	0.02242	-0.00001
W7	0.06754	0.02785	0.00005
W8	0.06579	-0.01805	0.00005
W9	0.03308	0.01779	-0.00003
W10	0.06823	0.02399	0.00011
W11	0.03177	-0.01664	-0.00003
W12	0.06692	-0.01044	0.00010
E1	0.25504	0.01748	0.00015

E2	0.01418	0.30463	0.00002

Level: Level 3, Diaph: 1

Center of Mass (ft): (61.52, 153.99)

LdC	Disp X in	Disp Y in	Theta Z rad
D	-0.00091	0.00119	0.00000
Lp	-0.00103	0.00080	0.00000
W1	0.06568	0.00226	0.00005
W2	0.00078	0.02154	0.00000
W3	0.03398	0.00079	-0.00003
W4	0.06454	0.00260	0.00009
W5	0.00282	0.01629	0.00001
W6	-0.00166	0.01602	-0.00001
W7	0.04984	0.01785	0.00004
W8	0.04868	-0.01446	0.00003
W9	0.02424	0.01261	-0.00003
W10	0.05052	0.01417	0.00008
W11	0.02337	-0.01162	-0.00003
W12	0.04965	-0.01006	0.00008
E1	0.17907	0.00601	0.00011
E2	0.00919	0.20282	0.00001

Level: Level 2, Diaph: 1

Center of Mass (ft): (61.56, 154.02)

LdC	Disp X in	Disp Y in	Theta Z rad
D	0.00017	0.00001	0.00000
Lp	0.00013	0.00001	0.00000
W1	0.03314	-0.00001	0.00002
W2	0.00034	0.01120	0.00000
W3	0.01728	0.00002	-0.00001
W4	0.03243	-0.00004	0.00005
W5	0.00136	0.00839	0.00000
W6	-0.00085	0.00840	-0.00000
W7	0.02511	0.00839	0.00002
W8	0.02460	-0.00841	0.00002
W9	0.01232	0.00632	-0.00001
W10	0.02534	0.00627	0.00004
W11	0.01194	-0.00628	-0.00001
W12	0.02496	-0.00633	0.00004
E1	0.08169	-0.00001	0.00005
E2	0.00401	0.09499	0.00000

Periods and Modes

RAM Frame v11.0
Building 1
DataBase: BUILDI~1 12/03/07 12:25:59

CRITERIA:

Rigid End Zones:		Ignore Effects	
P-Delta:	Yes	Scale Factor:	1.00
Diaphragm:	Rigid		
Ground Level:	Base		

Wall Mesh Criteria :
Max. Allowed Distance between Nodes (ft) : 8.00

Load Case: Seismic EQ_IBC03_X_NoE_F

FREQUENCIES AND PERIODS:

Mode	Period sec	Frequency Hz	Frequency rad/sec
1	0.6889	1.4515	9.1201
2	0.5795	1.7256	10.8426
3	0.4637	2.1565	13.5499
4	0.2616	3.8233	24.0224
5	0.2537	3.9411	24.7625
6	0.2134	4.6870	29.4495
7	0.1672	5.9795	37.5705
8	0.1602	6.2419	39.2193
9	0.1224	8.1697	51.3318

MODAL PARTICIPATION FACTORS:

Mode	X-Dir	Y-Dir	Rotation
1	38.6989	7.2080	191.0968
2	-4.9767	53.7529	-31.4770
3	-37.3594	1.0527	198.3305
4	17.5885	8.3425	43.5096
5	6.2235	-19.7607	13.7219
6	-6.8451	0.1454	67.5715
7	0.6557	9.8403	0.0436
8	-13.2756	0.0967	37.4281
9	-3.1097	0.0084	10.8252

MODAL DIRECTION FACTORS:

Mode	X-Dir	Y-Dir	Rotation
1	49.60	2.10	48.30
2	0.79	97.93	1.28
3	49.70	0.03	50.27
4	49.17	14.84	35.98
5	8.40	85.11	6.49
6	52.53	0.02	47.44
7	0.06	99.90	0.04
8	64.23	0.04	35.73
9	25.51	0.02	74.47

MODAL EFFECTIVE MASS FACTORS:

Mode	X-Dir	Y-Dir	Rotation

Periods and Modes

	%Mass	%SumM	%Mass	%SumM	%Mass	%SumM
1	42.80	42.80	1.48	1.48	42.96	42.96
2	0.71	43.50	82.57	84.05	1.17	44.12
3	39.88	83.39	0.03	84.08	46.27	90.39
4	8.84	92.23	1.99	86.07	2.23	92.62
5	1.11	93.34	11.16	97.23	0.22	92.84
6	1.34	94.67	0.00	97.23	5.37	98.21
7	0.01	94.69	2.77	100.00	0.00	98.21
8	5.04	99.72	0.00	100.00	1.65	99.86
9	0.28	100.00	0.00	100.00	0.14	100.00

MODE SHAPES:

Story	Diaph. #	Dir	Mode 1	Mode 2	Mode 3	Mode 4	Mode 5
3	1	X	0.21211	-0.02479	-0.23917	-0.19974	-0.08687
		Y	0.05446	0.31751	0.00615	-0.12880	0.30409
		R	0.00030	-0.00004	0.00025	-0.00038	-0.00015
2	1	X	0.15889	-0.02081	-0.14758	0.05795	0.01725
		Y	0.02772	0.21347	0.00326	0.04711	-0.09776
		R	0.00024	-0.00004	0.00025	-0.00008	-0.00004
1	1	X	0.07388	-0.01015	-0.06289	0.17002	0.07008
		Y	0.00945	0.10035	0.00292	0.07518	-0.19142
		R	0.00012	-0.00002	0.00013	0.00020	0.00008

Story	Diaph. #	Dir	Mode 6	Mode 7	Mode 8	Mode 9
3	1	X	0.26660	-0.00315	-0.01439	-0.13586
		Y	-0.00602	0.16437	0.00678	-0.00514
		R	0.00011	0.00001	-0.00066	0.00100
2	1	X	-0.15008	-0.00046	0.11922	0.10833
		Y	0.00291	-0.20354	-0.00397	0.00268
		R	-0.00013	-0.00001	0.00000	-0.00016
1	1	X	-0.01726	0.00717	-0.22228	-0.07736
		Y	0.00079	0.21589	0.00195	-0.00047
		R	0.00025	0.00000	0.00014	0.00008