HIGH RISE CONDO
SOHO, NEW YORK, NY

TECHNICAL ASSIGNMENT 3

November 21, 2006

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EXECUTIVE SUMMARY AND INTRODUCTION

The Soho high rise condominium project consists of 13 above grade stories and two below grade stories. The building encompasses roughly 175,000 SF stretching from 28 feet below grade to 175 feet above grade. The first floor houses highly marketable retail spaces while the remaining 12 stories are condominium units. A sub-cellar level is set aside for resident parking and the cellar level contains a pool lounge, exercise facility, resident storage spaces and mechanical rooms. There are also roof terraces and Jacuzzi pools located at the 6th Floor step back. The floor system of the Soho high rise is typically a 10-1/2" two-way normal weight concrete flat plate with bays range in size from 13 feet by 21 feet to 25 feet by 25 feet. Typical concrete columns of 20 x 14 and 12x 19 carry the gravity loads down to the 4' thick mat foundation where they are transferred to the ground.

In the third technical report the existing lateral system was investigated. The shear walls of the Soho High Rise were found to be adequate to resist both the imposed wind and seismic loads. The total deflections resulting from seismic and wind loading were all well under the generally accepted standard of H/400 and most were in the H/800 to H/1000 range. A more detailed analysis will be carried out using ETABS in the upcoming reports. This analysis has not accounted for the redistribution of forces between shear walls that will occur as their relative stiffnesses change throughout the building, particularly at the tower transfer level. The interaction of the shear walls via link beams was also neglected in this analysis for simplification purposes. This may result in the shear walls acting as more of contiguous section throughout the building rather than individual shapes as has been assumed for this report.

ASCE 7-05 was used to determine all wind and seismic loads. For wind loads Method 2 (analytical procedure) of ASCE 7-05 section 6 was used. Seismic design loads were established using the equivalent lateral force procedure set forth in ASCE 7-05.

LATERAL SYSTEM

Concrete shear walls make up the buildings lateral load resisting system. The two elevator cores have been used as the main components of these elements and are connected up to the seventh floor where they become independent sections. Mechanical and architectural penetrations have been allowed in several areas, but require specially detailed link beams to transfer the shear forces. Typical shear wall reinforcement is #4 @ 12" o.c. each way, but increases in some areas to accommodate for axial load and increased shear forces that must be resisted. All shear walls are cast in place with a 28 day compressive strength of 5000 psi. Typical shear wall thickness is 12", although there are some 8" thick wall sections. The interconnecting of the shear walls at a centralized location allows perpendicular sections to be used as "flanges" increasing moment of inertia and therefore rigidity as well as overall capacity. Typical shear wall configurations for both the tower and base can be seen below in Figure 1 and Figure 2.

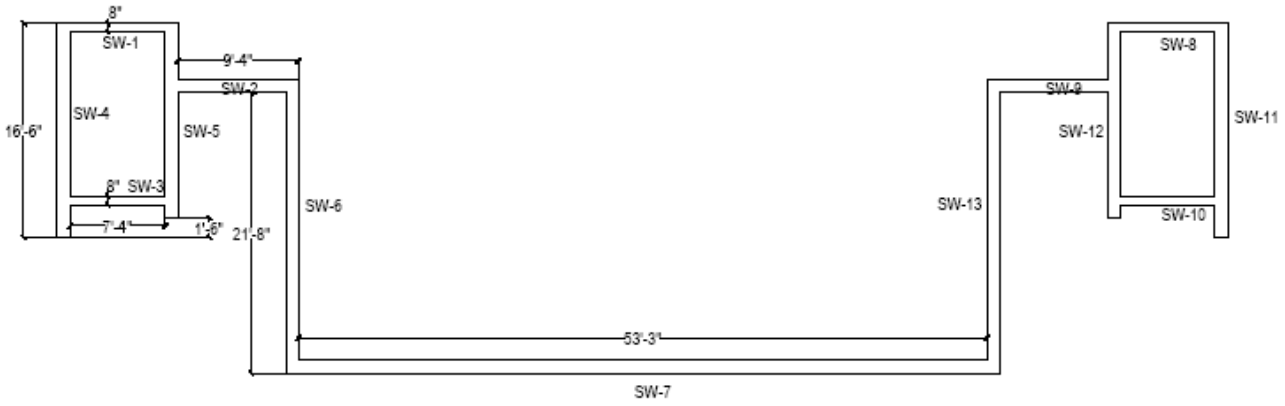


Figure 1
Typical Shear Wall Layout at Building Core
(Sub-cellar to 6th Floor)

Figure 2
Typical Shear Wall Layout at Building Core
(6th Floor to Roof)

CODE AND DESIGN REQUIREMENTS

Codes and References

1. "The Building Code of the City of New York".

2. "The New York City Seismic Code: Local Law 17/95".

3. "Building Code Requirements for Structural Concrete (ACI 318-02)", American Concrete Institute.

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

Lateral Deflection Criteria

Wind allowable drift (total building):	H/500
Wind inter-story drift:	H/400
Seismic allowable drift:	H/400

GRAVITY AND LATERAL LOADS

The gravity and lateral loads were determined in accordance with ASCE 7-05. General assumptions for dead loads were made based on unit weights from ASCE 7-05 and interpretation of structural details and components. Gravity loads are as follows:

Dead Loads (for seismic)

Construction Dead Loads:

Concrete	150 PCF

Superimposed Dead Loads:

¼" Glass and Framing	20 PSF
Partitions	20 PSF
Finishes and Misc.	5 PSF
MEP	10 PSF
Roofing	20 PSF
Terrace (pavers, planters, etc.)	150 PSF

Lateral Loads

A summary of both wind and seismic load analyses are in the following section. Please refer to Appendices A and B for a more detailed description of wind and seismic procedures.

Wind

Wind loads were analyzed using section 6 of ASCE 7-05. Appendix A contains a detailed analysis of wind loads using the equations and factors set forth in ASCE. These factors are dependent on building location and characteristics as well as experimental data. For ease of analysis the high rise was modeled as two rectangular boxes, one on top of the other. The tributary width for the tower in the N-S is roughly half of the base. This was taken into account in determining the resultant forces, but its effect on other variables has been considered negligible. Through a generalized analysis of the buildings fundamental period set forth in ASCE 7-05 the high rise condo was found to behave as a rigid structure. (*See the seismic analysis located in appendix B for the building period calculation*) Because the building is more than twice as large in the E-W direction the total wind load resulting from wind in the N-S direction is much larger. The wind loading was found to control in the N-S direction. Also note that because story heights are not constant the wind distribution is not a perfect curve (i.e. at the first floor the story height is 19 feet while the typical building story height is between 12 and 13 feet).

Level	Load (k)		Shear (k)		Moment (ft-k)	
	N/S	E/W	N/S	E/W	N/S	E/W
Roof	41	7	0	0	6,793	1,127
12	76	13	41	7	11,974	1,978
11	71	12	117	19	10,282	1,698
10	69	11	188	31	9,229	1,517
9	69	11	257	42	8,397	1,381
8	67	11	326	54	7,358	1,202
7	65	11	394	65	6,365	1,033
6	64	10	459	75	5,481	886
5	81	26	524	86	5,913	1,903
4	79	25	604	112	4,594	1,460
3	64	20	684	137	2,668	842
2	61	19	747	157	1,783	558
1	69	21	809	176	1,097	333
Totals	877	197	877	197	81,934	15,918

Seismic

Seismic loads were found using the applicable sections of ASCE 7-05. All factors and accelerations were found using the tables and equations contained in ASCE and can be found in Appendix B. All dead loads used are based on ASCE 7-05 and are listed in the gravity loads section of this report. Because the high rise condo is narrow in the N-S direction relative to the E-W direction the seismic design was found to control over wind in the E-W direction.

					Load	Shear	Moment
	w_x	h_x	$w_x h_x^k$	C_{vx}	F_x	V_x	M_x
Level	(kips)	(ft.)			(kips)	(kips)	(ft-kips)
Roof	785	184.67	1,774,746	0.108	57		10,591
13	980	172.67	2,005,890	0.122	65	57	11,193
12	975	160.67	1,793,858	0.109	58	115	9,314
11	975	148.67	1,599,172	0.097	52	180	7,683
10	975	136.67	1,411,890	0.086	46	232	6,236
9	975	124.67	1,232,345	0.075	40	277	4,965
8	975	112.67	1,060,916	0.064	34	317	3,863
7	975	100.67	898,042	0.055	29	352	2,922
6	3,890	76.67	2,394,392	0.145	77	381	5,933
5	2,480	58	1,010,009	0.061	33	458	1,893
4	2,480	45	693,755	0.042	22	491	1,009
3	2,480	32	418,865	0.025	14	513	433
2	2,355	19	183,885	0.011	6	527	113
Totals	21,300		16,477,765	1.000	533	533	66,148

Load Combinations

1) 1.4(D + F)
2) 1.2(D + F + T) +1.6(L + H) + 0.5(L_r or S or R)
3) 1.2D + 1.6(L_r or S or R) + (L or 0.8W)
4) **1.2D + 1.6W + L + 0.5(L_r or S or R)**
5) **1.2D + 1.0E + L + 0.2S**
6) 0.9D + 1.6W + 1.6H
7) 0.9D + 1.0E + 1.6H

When establishing critical loads for a given member all the above load combinations should be considered. For gravity members load combination 2 typically control and simplifies to 1.2D + 1.6 L. For design of lateral elements load combinations 4 and 5 should be used depending on whether wind or seismic controls the building's design in that direction. Load combinations 6 and 7 should be used when designing for uplift in columns or for the tension check on shear wall boundary elements.

LOAD DISTRIBUTION

The wind and seismic loads for the shear walls in the high rise condo were distributed to each element based on the rigidity of that element with respect to the entire rigidity of the building in that direction. The high rise was broken into a base section and tower section due to the drastic change in wall geometry at the tower transfer level. To establish the rigidity of each element the moment of inertia was calculated for the shape, limiting the effective flange widths to 6 times the web thickness. These calculations can be seen in Appendix D. Upon establishing the moment of inertia of each shape, the rigidity of the element was found using the inverse of the deflection equation for a cantilevered wall under uniform load.

$$\Delta_{shear} = \frac{6}{5} \times \frac{1}{2} \times \frac{VH}{AwG} \qquad \Delta_{flexural} = \frac{(wH)H^3}{8EI}$$

These two equations were then combined and simplified to establish an equation for total rigidity (the total derivation can be seen in Appendix D):

$$\frac{1}{Rigidity} = \Delta_{total} = \frac{1.44H}{Aw} + \frac{H^3}{8I}$$

Torsional effects were also considered for each wall section based on the equation below. Eccentricities for wind loads were based on the distance from the center of rigidity to the center of the building while those for seismic loads were based on the distance between the center of rigidity and the center of mass. As per ASCE 7-05 an incidental offset of 5% of the building dimension was also added to the seismic to account for error in establishing center of mass. Eccentricities ranged from 2'-15' for wind loads and 6'-15' for seismic loads or between 5% and 20%. Because all of the shear walls are located in the rear portion of the building the eccentricities in the y-direction are higher than those in the x-direction. As can be seen in the appendix, torsional effects were relatively small compared to the direct shear on any one wall element for most cases; however in some cases an increased story shear of up to 6 kips was seen. The total loads on each wall element can be seen in Appendix F.

$$\text{Torsional Distribution Ratio} = \frac{RC_n}{\sum RC_n^2}$$

R= Element Rigidity
C_n=Elements Perpendicular distance from the center of Rigidity

DEFLECTIONS

To establish the total building deflection the building was broken into the tower and the base and each was calculated separately. This was done to account for the shear wall configuration changes at the tower transfer level. To account for the relative deflection between the base and tower the virtual work method was used to establish the rotation at the top of the base level (*see Appendix G for full calculation).* This deflection accounted for between 15% and 20% of the total deflection of the building in most cases. Total building deflection was found to be 1 ¼" for wind in the N-S direction and 1 ½" for seismic in the N-S direction. For wind and seismic in the E-W direction deflections were typically ½" and 2 ½", respectively. These deflections fell well within the accepted standard of H/400 and were actually in the H/800 to H/1000 range. Shear Wall Two was found to have roughly twice the deflection of the other two walls in the E-W direction. This is still within the acceptable range of H/400; however the high discrepancy between the deflections is highly unlikely. A more detailed analysis using a computer modeling program such as ETABS may result in a more accurate deflection calculation.

SPOT CHECKS

Shear

Shear Walls Three and Four were checked for shear capacity and found to be adequate to resist the shear forces imposed on them. Shear Wall Three is oriented in the E-W direction and is governed by Seismic, while Shear Wall Four is oriented in the N-S direction and is governed by wind loading. The tensile capacity of the concrete in both shear walls was found adequate to resist the tension forces resulting from the moment generated by the lateral loads. See Appendix F for the spot checks of the shear walls.

Overturning

Overturning of the Soho high rise will not control the design of foundations by inspection. Because the foundation system of the high rise is a 4'-0" thick mat foundation the shear mass of the system will resolve any uplift forces.

CONCLUSIONS

The shear walls of the Soho High Rise were found to be adequate to resist both the imposed wind and seismic loads. The total deflections resulting from seismic and wind loading were all well under the generally accepted standard of H/400 and most were in the H/800 to H/1000 range. A more detailed analysis will be carried out using ETABS in the upcoming reports. This analysis has not accounted for the redistribution of forces between shear walls that will occur as their relative stiffnesses change throughout the building, particularly at the tower transfer level. The interaction of the shear walls via link beams was also neglected in this analysis for simplification purposes. This may result in the shear walls acting as more of contiguous section throughout the building rather than individual shapes as has been assumed for this report.

APPENDIX

Exposure Class	B
Importance Factor I	1
Topographic Factor K_{zt}	1
Wind Directionality Factor K_d	0.85
Basic Wind Speed V (mph)	100
N-S Length of Bldg.	80
E-W Length of Bldg.	200
Ct factor in the N-S Direction	0.02
Ct factor in the E-W Direction	0.02

x= 0.75

No. of Stories	13
Typ. Story Height (ft)	12
Builidng Height (ft)	174
L/B in N-S Direction	0.40
L/B in E-W Direction	2.50
h/L in N-S Direction	2.18
h/L in E-W Direction	0.87

	$C_{p,windward}$	$C_{p,leeward}$	$C_{p,side\ wall}$	Gust Factor
N-S Direciton:	0.80	-0.50	-0.70	0.91
E-W Direciton:	0.80	-0.28	-0.70	0.91

GUST FACTOR		
	N-S	E-W
L	80.00	200.00
B	200.00	80.00
n_1	1.04	1.04
TYPE	RIGID	RIGID
z_{min}	30.00	30.00
c	0.30	0.30
I_z	0.25	0.25
h	174.00	174.00
L_z	469.76	469.76
l	320.00	320.00
z	104.40	104.40
epsilon hat	0.33	0.33
Q	0.97	0.98
g_Q	3.40	3.40
g_v	3.40	3.40
G	0.91	0.91

Trib Width(ft)	Level	hx	Kz	qz	Pressures						Load (k)		Shear (k)		Moment (ft-k)	
					NS windward	NS leeward	NS side wall	EW windward	EW leeward	EW side wall	N/S	E/W	N/S	E/W	N/S	E/W
6.835	Roof	164.855	1.17	25.46	18.55	-11.59	-15.68	18.61	-6.40	-15.73	41	7	0	0	6,793	1,127
12.84	12	158.02	1.13	24.59	17.91	-11.59	-15.68	17.97	-6.40	-15.73	76	13	41	7	11,974	1,978
12	11	145.18	1.13	24.59	17.91	-11.59	-15.68	17.97	-6.40	-15.73	71	12	117	19	10,282	1,698
12	10	133.18	1.09	23.72	17.28	-11.59	-15.68	17.34	-6.40	-15.73	69	11	188	31	9,229	1,517
12	9	121.18	1.09	23.72	17.28	-11.59	-15.68	17.34	-6.40	-15.73	69	11	257	42	8,397	1,381
12	8	109.18	1.04	22.63	16.49	-11.59	-15.68	16.54	-6.40	-15.73	67	11	326	54	7,358	1,202
12	7	97.18	0.99	21.54	15.70	-11.59	-15.68	15.75	-6.40	-15.73	65	11	394	65	6,365	1,033
12	6	85.18	0.96	20.89	15.22	-11.59	-15.68	15.27	-6.40	-15.73	64	10	459	75	5,481	886
15.34	5	73.18	0.93	20.24	14.74	-11.59	-15.68	14.79	-6.40	-15.73	81	26	524	86	5,913	1,903
15.84	4	57.84	0.85	18.50	13.48	-11.59	-15.68	13.52	-6.40	-15.73	79	25	604	112	4,594	1,460
13	3	42	0.81	17.63	12.84	-11.59	-15.68	12.88	-6.40	-15.73	64	20	684	137	2,668	842
13	2	29	0.76	16.54	12.05	-11.59	-15.68	12.09	-6.40	-15.73	61	19	747	157	1,783	558
16	1	16	0.62	13.49	9.83	-11.59	-15.68	9.86	-6.40	-15.73	69	21	809	176	1,097	333
Totals											877	197	877	197	81,934	15,918

SEISMIC LOADS

OCCUPANCY CATEGORY → II → I = 1.0

SITE CLASS = D → STIFF CLAYS → N = 35 BLOWS/FT (FROM GEOTECH REPORT)

$S_s = 42.84$ USGS WEB SITE
$S_1 = 9.44$

$S_{MS} = F_a S_s = (1.46)(.4284) = 0.624$

$S_{M1} = F_v S_1 = (2.4)(0.0944) = 0.227$

$S_{DS} = \frac{2}{3} S_{MS} = \frac{2}{3}(0.624) = .416 \rightarrow C$

$S_{D1} = \frac{2}{3} S_{M1} = \frac{2}{3}(0.227) = .151 \rightarrow C$

$T_s = \frac{S_{D1}}{S_{DS}} = \frac{.151}{.416} = 0.363$ $T_0 = 0.2 T_s = 0.2(.363) = .073$

$T_L = 6$ Fig 22-15 ASCE 7-05

ORDINARY REINFORCED CONCRETE SHEAR WALLS
R = 4
Cd = 4

$T_a = C_t h_n^x = (174)^{.75} .02 = 0.96$ $C_u T_a = 1.6(0.96) = 1.54$

$C_s = \frac{S_{DS}}{R/I} = \frac{.416}{4/1} = .104$

NOT EXCEEDING

$C_s = \frac{S_{D1}}{T(R/I)} = \frac{.151}{1.54(4/1)} = 0.025$

K = 1.48 (12.8.3)

$C_s \geq 0.01$

$V = C_s W_T = 0.025(21,300) = 532.5^K$

FLOOR AREAS

FLOOR	AREA (SF)	TERRACE AREA
2	13300	—
3-5	14000	—
6	5500	8500 SF
7-12	5500	—
13	4700	500 SF
ROOF	4700	—

WEIGHTS

FLOOR	
2	$W_2 = (13,300)(20+5+10+132+10) = 2355^K$
3-5	$W_{3-5} = 14000(177) = 2480$
6	$W_6 = 5500(220) + 8500(315) = 3890$
7-12	$W_{7-12} = 5500(177) = 975$
13	$W_{13} = 4700(177) + 500(147+150) = 980$
R	$W_R = 4700(10+132+20+5) = 785$
	$21,300^K$

SEISMIC DESIGN

2/2

TYP FLOOR LOAD

PARTITIONS	20 PSF
FIN. & MISC.	5 PSF
MEP	10 PSF
10½" SLAB	132 PSF
COLUMNS	10 PSF
	177 PSF

TYP. TERRACE LOAD

TERRACE	150 PSF
FIN & MISC.	5 PSF
MEP	10 PSF
10½" SLAB	132 PSF

6TH FLOOR

PARTITIONS	20 PSF
FIN. & MISC.	5 PSF
MEP	10 PSF
12" SLAB	150 PSF
BEAMS & SLAB ADD.	25 PSF
COLUMNS	10 PSF
	220 PSF

6TH FLOOR TERRACE

TERRACE	150 PSF
12" SLAB	150 PSF
MEP	10 PSF
FIN & MISC.	5 PSF
	315 PSF

ROOF

MEP	10 PSF
ROOF	20 PSF
SLAB	132 PSF
MISC.	5 PSF
	167 PSF

Floors Ground-6th

Element	Area	Height	Unit Weight	Weight	Distance from zero Reference		Wx	Wy
					x	y		
	SF	FT	K/CF	Kips	FT	FT	Ft-k	Ft-k
Floor	14000	0.875	0.15	1837.5	100	35	183750	64312.5
SW-1	6.16	12	0.15	11.088	61.66	69.66	683.6861	772.3901
SW-2	3.66	12	0.15	6.588	73.75	65	485.865	428.22
SW-3	6.16	12	0.15	11.088	61.66	56.25	683.6861	623.7
SW-4	16.5	12	0.15	29.7	57.5	63	1707.75	1871.1
SW-5	15	12	0.15	27	65.75	62.5	1775.25	1687.5
SW-6	22.66	12	0.15	40.788	75.25	54.25	3069.297	2212.749
SW-7	9.33	12	0.15	16.794	102.33	43.5	1718.53	730.539
SW-8	6.16	12	0.15	11.088	143	69.66	1585.584	772.3901
SW-9	3.66	12	0.15	6.588	134	65	882.792	428.22
SW-10	6.16	12	0.15	11.088	143	56.33	1585.584	624.587
SW-11	16.5	12	0.15	29.7	147	61.75	4365.9	1833.975
SW-12	15	12	0.15	27	138.75	62.5	3746.25	1687.5
SW-13	22.66	12	0.15	40.788	129.33	54.33	5275.112	2216.012
SUM				2106.798			211315.3	80201.38
xbar	100.3016							
ybar	38.0679							

Floors 6th-Roof

Element	Area	Height	Unit Weight	Weight	Distance from zero Reference		Wx	Wy
					x	y		
	SF	FT	K/CF	Kips	FT	FT	Ft-k	Ft-k
Floor	5010	0.875	0.15	657.5625	100.5	55	66095.03	36165.94
SW-1	6.16	12	0.15	11.088	61.66	69.66	683.6861	772.3901
SW-2	3.66	12	0.15	6.588	73.75	65	485.865	428.22
SW-3	9.33	12	0.15	16.794	61.66	56	1035.518	940.464
SW-4	16.5	12	0.15	29.7	57.5	63	1707.75	1871.1
SW-5	11	12	0.15	19.8	65.75	61	1301.85	1207.8
SW-6	10	12	0.15	18	75.25	60.66	1354.5	1091.88
SW-8	6.16	12	0.15	11.088	143	69.66	1585.584	772.3901
SW-9	3.66	12	0.15	6.588	134	65	882.792	428.22
SW-10	9.33	12	0.15	16.794	143	56.25	2401.542	944.6625
SW-11	16.5	12	0.15	29.7	147	61.75	4365.9	1833.975
SW-12	11	12	0.15	19.8	138.75	61	2747.25	1207.8
SW-13	10	12	0.15	18	129.33	60.66	2327.94	1091.88
SUM				861.5025			86965.21	48756.72
xbar	100.946							
ybar	56.59498							

DERIVATION OF RIGIDITY & DEFLECTION EQUATION

$$\Delta_{SHEAR} = \frac{6}{5} \times \frac{1}{2} \frac{VH}{A_w G}$$

ASSUME UNIFORMLY LOADED SECTION

$$G = \frac{E}{2(1+\nu)} = \frac{E}{2(1+.2)} = \frac{E}{2.4}$$

$$\Delta_{FLEX} = \frac{(WH)H^3}{8EI}$$

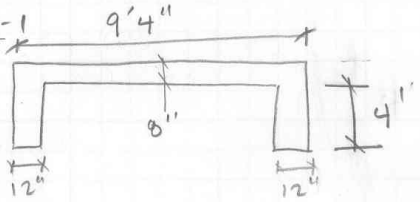
$$\Delta_T = \Delta_{SHEAR} + \Delta_{FLEX} = \left[\frac{0.6H}{A_w G} + \frac{H^3}{8EI}\right] V = \left[\frac{1.44H}{A_w} + \frac{H^3}{8I}\right] \frac{V}{E}$$

FOR RIGIDITY ASSUME V & E TO BE UNITY

$$\Delta_T = \frac{1.44H}{A_w} + \frac{H^3}{8I}$$

SHEAR WALLS | MOMENT OF INERTIA CALCS

SW-1



$A_w = \left(\frac{8"}{12}\right)(9.33') + 2\left(\frac{12"}{12"}\right)(4') = 14.16\ SF$

$A_{web} = (9.33')(8/12) = 6.16^{\square}$

$A_{flange} = (4')(1') = 4^{\square}$

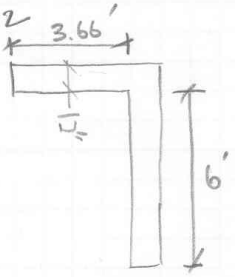
$A_x = 6.16 \times 4.66$	=	28.71
$A_x = 4 \times .5$	=	2
4×8.83	=	35.32
		66.03

$\frac{A\bar{x}}{A} = \frac{66.03}{14.16} = 4.66 = \bar{x}$

$I = \frac{bh^3}{12} + Ax^2$

$2\left[\frac{(4)(1)^3}{12} + (4)(4.17)^2\right] + \frac{\left(\frac{8}{12}\right)(9.33)^3}{12} = 139.78 + 4.836 = 144.6\ ft^4$

SW-2



$A_{web} = 3.66(12/12) = 3.66^{\square}$

$A_{flange} = 6(12/12) = 6.0^{\square}$

$A_{web}\,x = 3.66 \times 3.66/2 = 6.70$

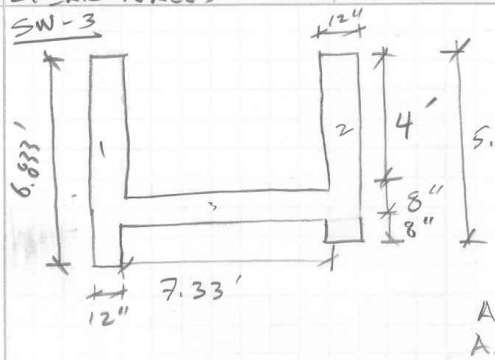
$A_{flange}\,x = 6.0 \times [3.66 + .5] = 24.96$

$\frac{A\bar{x}}{A} = \frac{[24.96 + 6.7]}{[6 + 3.66]} = 3.28'$

$I = \frac{[3.66]^3}{12} + 3.66[3.66 - 3.28)^2 + \frac{6(1)^3}{12} + 6[4.16 - 3.28)^2 = 4.16 + 5.15 = 9.31$

SHEAR WALLS | MOMENT OF INERTIA CALCS

SW-3



$A_1 = 6.833(1) = 6.833\ \square$

$A_2 = 5.33(1) = 5.33\ \square$

$A_3 = 7.33(8/12) = 4.89\ \square$

$A_1x = 6.833(.5) = 3.42$

$A_2x = 5.33(8.83) = 47.06$

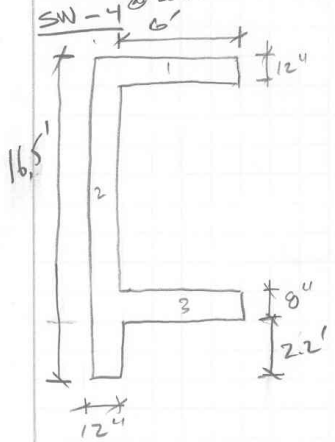
$A_3x = 4.89(4.67) = 22.81$

$$\frac{A\bar{x}}{A} = \frac{(3.42+47.06+22.81)}{(6.833+5.33+4.89)} = 4.3'$$

$$I = \frac{6.833(1)^3}{12} + (4.3-.5)^2(6.833) + \frac{(8/12)(7.33)^3}{12} + 4.89(4.66-4.3)^2 + \frac{5.33(1)^3}{12} + 5.33(8.83-4.3)^2$$

$$= 99.24 + 22.29 + 109.8 = \underline{231.33\ ft^4}$$

SW-4 @ bot.



$A_1 = 6\ \square$

$A_2 = 16.5\ \square$

$A_3 = (8/12)(6') = 4\ \square$

$A_1x = 6\ \square(16') = 96$

$A_2x = 16.5\ \square(8.25') = 136.125$

$A_3x = 4\ \square(2.25') = 9$

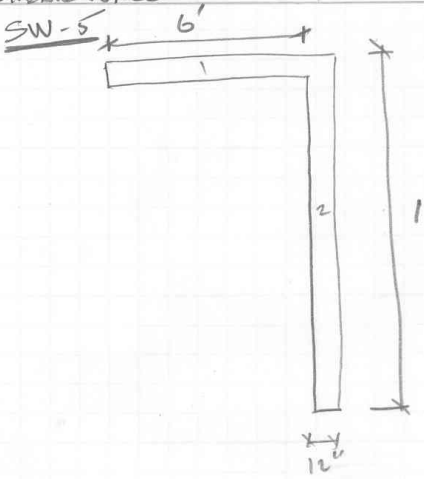
$$\frac{A\bar{x}}{A} = \frac{(96+136.125+9)}{(6+16.5+4)} = 9.1'$$

$$I = \frac{6(1)^3}{12} + (6)(16-9.1)^2 + \frac{(16.5)^3(1)}{12} + 16.5(9.1-8.25)^2 + \frac{6(8/12)^3}{12} + (4)(9.1-2.25)^2$$

$$= 286.16 + 386.27 + 187.84 = \underline{860.27\ ft^4}$$

SHEAR WALL — MOMENT OF INERTIA CALCS

SW-5



$A_1 = 6^{\square}$

$A_2 = 15^{\square}$

$A_1x = 6^{\square}(14.5') = 87'$

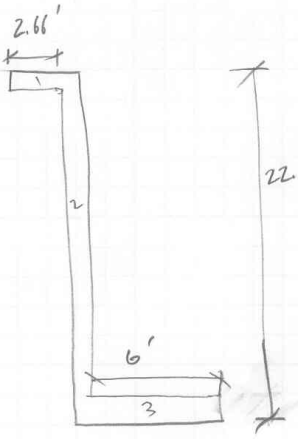
$A_2x = 15^{\square}(7.5') = 112.5$

$\frac{A_2\bar{x}}{A} = \frac{(87+112.5)}{(6+15)} = 9.5'$

$I = \frac{6(1)^3}{12} + 6(14.5-9.5)^2 + \frac{15^3}{12} + 15(9.5-7.5)^2$

$= 150.5 + 341.25 = \underline{491.75\ ft^4}$

SW-6



$A_1 = 2.66^{\square}$

$A_2 = 22.66^{\square}$

$A_3 = 6^{\square}$

$A_1x = 2.66(22.16) = 58.95+3$

$A_2x = 22.66\left(\frac{22.66}{2}\right) = 256.74$

$A_3x = 6(\frac{1}{2}) = 3$

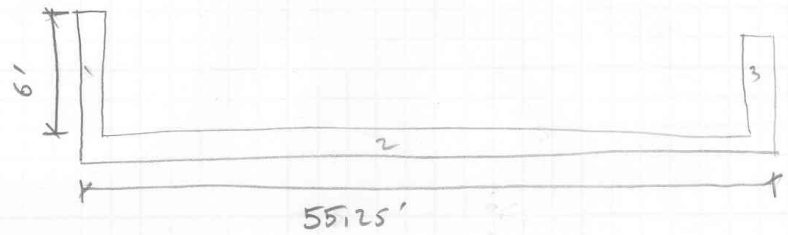
$\frac{A_1\bar{x}}{A} = \frac{58.95+256.74+3}{(2.66+22.66+6)} = 10.18'$

$I = \frac{2.66(1)^3}{12} + 2.66(22.16-10.18)^2 + \frac{1(22.66)^3}{12} + 22.66(11.33-10.18)^2$

$+ \frac{6(1)^3}{12} + 6(10.18-0.5)^2$

$= 381.99 + 999.59 + 562.7 = \underline{1944.3\ ft^4}$

SW-7



$A_1 = 6^{\square}$
$A_2 = 55.25^{\square}$
$A_3 = 6^{\square}$

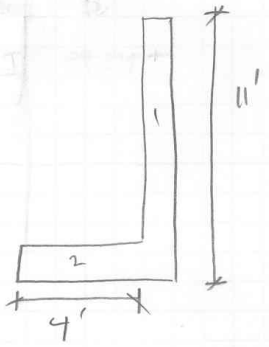
$A_{1x} = 6(.5) = 3$
$A_{2x} = 55.25(27.63) = 1526.56$
$A_3 = 6(54.75) = 328.5$

$\frac{A\bar{x}}{A} = \frac{[1858]}{67.25}$

$\bar{x} = 27.63'$ @ center of gravity

$I = 2\left[\frac{6(1)^3}{12} + 6(27.63-.5)^2\right] + \frac{55.25^3}{12} = 2(4416.72) + 14054.5 = \underline{22887.9\ ft^4}$

SW-5 @ top



$A_1 = 11^{\square}$
$A_2 = 4^{\square}$

$A_{1x} = 11^{\square}(11/2) = 60.5$
$A_{2x} = 4^{\square}(.5) = 2$

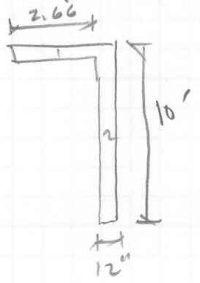
$\bar{x} = \frac{A\bar{x}}{A} = \frac{(60.5+2)}{15} = 4.46'$

$I = \frac{11^3}{12} + 11^{\square}(5.5-4.46)^2 + \frac{4(1)^3}{12} + 4^{\square}(4.46-.5)^2$

$= 122.8 + 63.06 = \underline{185.86\ ft^4}$

SHEAR WALLS | MOMENT OF INERTIA CALCS

SW-6 @ top



$A_1 = 2.66\,\phi$

$A_2 = 10^{\phi}$

$A_{1x} = 9.5(2.66) = 25.27$

$A_{2x} = 10^{\phi}(5) = 50$

$\bar{x} = \frac{\Sigma Ax}{A} = \frac{[50+25.27)}{[10+2.66]} = 5.75'$

$I = \frac{2.66(1)^3}{12} + 2.66(9.5-5.75)^2 + \frac{10^3}{12} + 10[5.75-5]^2$

$= 33.74 + 92.36 = \underline{126.1\ ft^4}$

Floors Ground-6th

Element	Wall Height	Wall Area	I	h^3	1.44h/Area	h^3/8I	$*_{fixed}$	Rigidity	Distance from Zero Reference		R_x	R_y	R_xY	R_yX
									x	y				
	ft	SF	ft^4					(1/* fixed)	ft	ft				
Floor	EXCLUDED	EXCLUDED	EXCLUDED	EXCLUDED	EXCLUDED	EXCLUDED	EXCLUDED	EXCLUDED	100	35	EXCLUDED	EXCLUDED	EXCLUDED	EXCLUDED
SW-1	12	14.16	144.60	1728.00	1.22	1.49	2.71	0.37	61.66	69.66	0.37	X	25.67	X
SW-2	12	9.66	9.31	1728.00	1.79	23.20	24.99	0.04	73.75	65	0.04	X	2.60	X
SW-3	12	17.05	231.33	1728.00	1.01	0.93	1.95	0.51	61.66	56.25	0.51	X	28.89	X
SW-4	12	26.50	860.27	1728.00	0.65	0.25	0.90	1.11	57.5	63	X	1.11	X	63.67
SW-5	12	21.00	491.75	1728.00	0.82	0.44	1.26	0.79	65.75	62.5	X	0.79	X	52.10
SW-6	12	31.32	1944.30	1728.00	0.55	0.11	0.66	1.51	75.25	54.25	X	1.51	X	113.53
SW-7	12	67.25	22887.90	1728.00	0.26	0.01	0.27	3.75	102.33	43.5	3.75	X	163.30	X
SW-8	12	14.16	144.60	1728.00	1.22	1.49	2.71	0.37	143	69.66	0.37	X	25.67	X
SW-9	12	9.66	9.31	1728.00	1.79	23.20	24.99	0.04	134	65	0.04	X	2.60	X
SW-10	12	17.05	231.33	1728.00	1.01	0.93	1.95	0.51	143	56.33	0.51	X	28.93	X
SW-11	12	26.50	860.27	1728.00	0.65	0.25	0.90	1.11	147	61.75	X	1.11	X	162.76
SW-12	12	21.00	491.75	1728.00	0.82	0.44	1.26	0.79	138.75	62.5	X	0.79	X	109.94
SW-13	12	31.32	1944.30	1728.00	0.55	0.11	0.66	1.51	129.33	54.33	X	1.51	X	195.12
										SUM	5.60	6.82	277.64	697.11

$*_{fixed}$= V/E((1.44h/Area)+(h^3/8I))
V=1
E=1

Xbar	102.27
Ybar	49.60

Floors 6th-Roof

Element	Wall Height	Wall Area	I	h^3	1.44h/Area	$h^3/8I$	$*_{fixed}$	Rigidity	Distance from Zero Reference		R_x	R_y	R_xY	R_yX
									x	y				
	ft	SF	ft^4					(1/* fixed)	ft	ft				
Floor	EXCLUDED	EXCLUDED	EXCLUDED	EXCLUDED	EXCLUDED	EXCLUDED	EXCLUDED	EXCLUDED	100.5	55	EXCLUDED	EXCLUDED	EXCLUDED	EXCLUDED
SW-1	12	14.16	144.60	1728.00	1.22	1.49	2.71	0.37	61.66	69.66	0.37	X	25.67	X
SW-2	12	9.66	9.31	1728.00	1.79	23.20	24.99	0.04	73.75	65	0.04	X	2.60	X
SW-3	12	17.05	231.33	1728.00	1.01	0.93	1.95	0.51	61.66	56	0.51	X	28.76	X
SW-4	12	26.50	860.27	1728.00	0.65	0.25	0.90	1.11	57.5	63	X	1.11	X	63.67
SW-5	12	15.00	185.86	1728.00	1.15	1.16	2.31	0.43	65.75	61	X	0.43	X	28.41
SW-6	12	12.66	126.10	1728.00	1.36	1.71	3.08	0.32	75.25	60.66	X	0.32	X	24.45
SW-8	12	14.16	144.60	1728.00	1.22	1.49	2.71	0.37	143	69.66	0.37	X	25.67	X
SW-9	12	9.66	9.31	1728.00	1.79	23.20	24.99	0.04	134	65	0.04	X	2.60	X
SW-10	12	17.05	231.33	1728.00	1.01	0.93	1.95	0.51	143	56.25	0.51	X	28.89	X
SW-11	12	26.50	860.27	1728.00	0.65	0.25	0.90	1.11	147	61.75	X	1.11	X	162.76
SW-12	12	15.00	185.86	1728.00	1.15	1.16	2.31	0.43	138.75	61	X	0.43	X	59.96
SW-13	12	12.66	126.10	1728.00	1.36	1.71	3.08	0.32	129.33	60.66	X	0.32	X	42.02
										SUM	1.84	3.73	114.18	381.26

Xbar	102.26
Ybar	61.92

Eccentricities		
	Ground-6th floor	6th-Roof
ex(wind)	2.27	1.76
ey(wind)	14.60	6.92
ex(seismic)*	11.97	9.66
ey(seismic)*	15.03	6.07
*w/5%offset		

Cn					
Ground-6th			6th-Roof		
	perp to x	perp to y		perp to x	perp to y
SW-1	20.06	x	SW-1	7.74	x
SW-2	15.40	x	SW-2	3.08	x
SW-3	6.65	x	SW-3	5.92	x
SW-4	x	44.77	SW-4	x	44.76
SW-5	x	36.52	SW-5	x	3.83
SW-6	x	27.02	SW-6	x	13.33
SW-7	6.10	x	SW-8	7.74	x
SW-8	20.06	x	SW-9	3.08	x
SW-9	15.40	x	SW-10	5.67	x
SW-10	6.73	x	SW-11	x	44.74
SW-11	x	44.73	SW-12	x	36.49
SW-12	x	36.48	SW-13	x	27.07
SW-13	x	27.06			

GROUND-6TH FLOOR

E-W

Element	Rx	Cn perp to x	Ry	Cn perp to y	RCn	RCn^2	Direct Shear Proportion	Torsional Shear Proportion
SW-1	0.37	20.06		x	7.39	148.2977	0.065817878	0.00079885
SW-2	0.04	15.40		x	0.62	9.493185	0.007148442	6.66098E-05
SW-3	0.51	6.65		x	3.42	22.72647	0.091739615	0.000369208
SW-4			1.11	44.77	49.57	2219.041	0	0.005356888
SW-5			0.79	36.52	28.93	1056.602	0	0.003126945
SW-6			1.51	27.02	40.76	1101.292	0	0.004405207
SW-7	3.75	6.10		x	22.89	139.5764	0.67058813	-0.002473775
SW-8	0.37	20.06		x	7.39	148.2977	0.065817878	-0.00079885
SW-9	0.04	15.40		x	0.62	9.493185	0.007148442	-6.66098E-05
SW-10	0.51	6.73		x	3.46	23.27636	0.091739615	-0.000373648
SW-11			1.11	44.73	49.53	2215.531	0	-0.005352651
SW-12			0.79	36.48	28.91	1054.554	0	-0.003123913
SW-13			1.51	27.06	40.83	1104.93	0	-0.004412477
Sum	5.60					9253.112		

N-S

Element	Rx	Cn perp to x	Ry	Cn perp to y	RCn	RCn^2	Direct Shear Proportion	Torsional Shear Proportion
SW-1	0.37	20.06		x	7.39	148.2977	0	0.00079885
SW-2	0.04	15.40		x	0.62	9.493185	0	6.66098E-05
SW-3	0.51	6.65		x	3.42	22.72647	0	0.000369208
SW-4			1.11	44.77	49.57	2219.041	0.162432426	0.005356888
SW-5			0.79	36.52	28.93	1056.602	0.116236296	0.003126945
SW-6			1.51	27.02	40.76	1101.292	0.221331278	0.004405207
SW-7	3.75	6.10		x	22.89	139.5764	0	-0.002473775
SW-8	0.37	20.06		x	7.39	148.2977	0	-0.00079885
SW-9	0.04	15.40		x	0.62	9.493185	0	-6.66098E-05
SW-10	0.51	6.73		x	3.46	23.27636	0	-0.000373648
SW-11			1.11	44.73	49.53	2215.531	0.162432426	-0.005352651
SW-12			0.79	36.48	28.91	1054.554	0.116236296	-0.003123913
SW-13			1.51	27.06	40.83	1104.93	0.221331278	-0.004412477
Sum			6.816522			9253.112		

6TH FLOOR-ROOF

E-W

Element	Rx	Cn perp to x	Ry	Cn perp to y	RCn	RCn²	Direct Shear Proportion	Torsional Shear Proportion
SW-1	0.37	7.74		x	2.852169	22.07896	0.199604208	0.000528995
SW-2	0.04	3.08		x	0.123295	0.379887	0.021700622	2.28677E-05
SW-3	0.51	5.92		x	3.039658	17.99139	0.27649517	-0.000563769
SW-4		x	1.11	44.76	49.656	2217.977	0	0.009191203
SW-5		x	0.43	3.83	1.655506	6.342432	0	0.000307048
SW-6		x	0.32	13.33	4.3313	57.74105	0	0.000803331
SW-8	0.37	7.74		x	2.852169	22.07896	0.199604208	0.000528995
SW-9	0.04	3.08		x	0.123295	0.379887	0.021700622	2.28677E-05
SW-10	0.51	5.67		x	2.91127	16.50366	0.27649517	-0.000539956
SW-11		x	1.11	44.74	49.54057	2216.595	0	-0.009188339
SW-12		x	0.43	36.49	15.76941	575.4737	0	-0.00292477
SW-13		x	0.32	27.07	8.79607	238.1363	0	-0.001631416
Sum	1.84					5391.678		

N-S

Element	Rx	Cn perp to x	Ry	Cn perp to y	RCn	RCn²	Direct Shear Proportion	Torsional Shear Proportion
SW-1	0.37	7.74		x	2.852169	22.07896	0	0.000528995
SW-2	0.04	3.08		x	0.123295	0.379887	0	2.28677E-05
SW-3	0.51	5.92		x	3.039658	17.99139	0	-0.000563769
SW-4	0.00	x	1.11	44.75697121	49.656	2217.977	0.29696284	0.009191203
SW-5	0.00	x	0.43	3.831114061	1.655506	6.342432	0.115897	0.000307048
SW-6	0.00	x	0.32	13.33111406	4.3313	57.74105	0.08714016	0.000803331
SW-8	0.37	7.74		x	2.852169	22.07896	0	0.000528995
SW-9	0.04	3.08		x	0.123295	0.379887	0	2.28677E-05
SW-10	0.51	5.67		x	2.91127	16.50366	0	-0.000539956
SW-11	0.00	x	1.11	44.74302879	49.54057	2216.595	0.29696284	-0.009188339
SW-12	0.00	x	0.43	36.49302879	15.76941	575.4737	0.115897	-0.00292477
SW-13	0.00	x	0.32	27.07302879	8.79607	238.1363	0.08714016	-0.001631416
Sum			3.728494			5391.678		

STORY 2	
N-S Wind	69
E-W Wind	21
Seismic	6

Element	N-S				E-W			
	Wind		Seismic		Wind		Seismic	
	Dir. Shear	Torsion	Dir. Shear	Torsion	Dir. Shear	Torsion	Dir. Shear	Torsion
SW-1	0.00	0.12	0.00	0.06	1.37	0.24	0.39	0.07
SW-2	0.00	0.01	0.00	0.00	0.15	0.02	0.04	0.01
SW-3	0.00	0.06	0.00	0.03	1.91	0.11	0.55	0.03
SW-4	11.14	0.83	0.97	0.38	0.00	1.63	0.00	0.48
SW-5	7.97	0.49	0.69	0.22	0.00	0.95	0.00	0.28
SW-6	15.17	0.68	1.32	0.31	0.00	1.34	0.00	0.39
SW-7	0.00	-0.38	0.00	-0.18	13.96	-0.75	3.98	-0.22
SW-8	0.00	-0.12	0.00	-0.06	1.37	-0.24	0.39	-0.07
SW-9	0.00	-0.01	0.00	0.00	0.15	-0.02	0.04	-0.01
SW-10	0.00	-0.06	0.00	-0.03	1.91	-0.11	0.55	-0.03
SW-11	11.14	-0.83	0.97	-0.38	0.00	-1.63	0.00	-0.48
SW-12	7.97	-0.49	0.69	-0.22	0.00	-0.95	0.00	-0.28
SW-13	15.17	-0.69	1.32	-0.31	0.00	-1.34	0.00	-0.39

STORY 3	
N-S Wind	61
E-W Wind	19
Seismic	14

Element	N-S				E-W			
	Wind		Seismic		Wind		Seismic	
	Dir. Shear	Torsion	Dir. Shear	Torsion	Dir. Shear	Torsion	Dir. Shear	Torsion
SW-1	0.00	0.11	0.00	0.13	1.27	0.22	0.89	0.16
SW-2	0.00	0.01	0.00	0.01	0.14	0.02	0.10	0.01
SW-3	0.00	0.05	0.00	0.06	1.76	0.10	1.24	0.08
SW-4	9.98	0.75	2.20	0.87	0.00	1.50	0.00	1.09
SW-5	7.14	0.44	1.57	0.51	0.00	0.88	0.00	0.64
SW-6	13.61	0.61	3.00	0.71	0.00	1.24	0.00	0.90
SW-7	0.00	-0.34	0.00	-0.40	12.89	-0.69	9.08	-0.50
SW-8	0.00	-0.11	0.00	-0.13	1.27	-0.22	0.89	-0.16
SW-9	0.00	-0.01	0.00	-0.01	0.14	-0.02	0.10	-0.01
SW-10	0.00	-0.05	0.00	-0.06	1.76	-0.10	1.24	-0.08
SW-11	9.98	-0.75	2.20	-0.87	0.00	-1.50	0.00	-1.09
SW-12	7.14	-0.44	1.57	-0.51	0.00	-0.88	0.00	-0.64
SW-13	13.61	-0.62	3.00	-0.71	0.00	-1.24	0.00	-0.90

STORY 4	
N-S Wind	64
E-W Wind	20
Seismic	22

Element	N-S				E-W			
	Wind		Seismic		Wind		Seismic	
	Dir. Shear	Torsion	Dir. Shear	Torsion	Dir. Shear	Torsion	Dir. Shear	Torsion
SW-1	0.00	0.12	0.00	0.21	1.32	0.23	1.48	0.27
SW-2	0.00	0.01	0.00	0.02	0.14	0.02	0.16	0.02
SW-3	0.00	0.05	0.00	0.10	1.84	0.11	2.06	0.12
SW-4	10.32	0.77	3.64	1.44	0.00	1.57	0.00	1.81
SW-5	7.38	0.45	2.61	0.84	0.00	0.92	0.00	1.05
SW-6	14.06	0.63	4.96	1.18	0.00	1.29	0.00	1.48
SW-7	0.00	-0.36	0.00	-0.66	13.45	-0.72	15.03	-0.83
SW-8	0.00	-0.12	0.00	-0.21	1.32	-0.23	1.48	-0.27
SW-9	0.00	-0.01	0.00	-0.02	0.14	-0.02	0.16	-0.02
SW-10	0.00	-0.05	0.00	-0.10	1.84	-0.11	2.06	-0.13
SW-11	10.32	-0.77	3.64	-1.44	0.00	-1.57	0.00	-1.80
SW-12	7.38	-0.45	2.61	-0.84	0.00	-0.91	0.00	-1.05
SW-13	14.06	-0.64	4.96	-1.18	0.00	-1.29	0.00	-1.49

STORY 5	
N-S Wind	79
E-W Wind	25
Seismic	33

Element	N-S				E-W			
	Wind		Seismic		Wind		Seismic	
	Dir. Shear	Torsion	Dir. Shear	Torsion	Dir. Shear	Torsion	Dir. Shear	Torsion
SW-1	0.00	0.14	0.00	0.31	1.66	0.29	2.15	0.39
SW-2	0.00	0.01	0.00	0.03	0.18	0.02	0.23	0.03
SW-3	0.00	0.07	0.00	0.14	2.32	0.14	2.99	0.18
SW-4	12.90	0.96	5.30	2.09	0.00	1.97	0.00	2.63
SW-5	9.23	0.56	3.79	1.22	0.00	1.15	0.00	1.53
SW-6	17.58	0.79	7.22	1.72	0.00	1.62	0.00	2.16
SW-7	0.00	-0.45	0.00	-0.97	16.93	-0.91	21.89	-1.21
SW-8	0.00	-0.14	0.00	-0.31	1.66	-0.29	2.15	-0.39
SW-9	0.00	-0.01	0.00	-0.03	0.18	-0.02	0.23	-0.03
SW-10	0.00	-0.07	0.00	-0.15	2.32	-0.14	2.99	-0.18
SW-11	12.90	-0.96	5.30	-2.09	0.00	-1.97	0.00	-2.63
SW-12	9.23	-0.56	3.79	-1.22	0.00	-1.15	0.00	-1.53
SW-13	17.58	-0.79	7.22	-1.72	0.00	-1.63	0.00	-2.16

STORY 6	
N-S Wind	81
E-W Wind	26
Seismic	77

Element	N-S				E-W			
	Wind		Seismic		Wind		Seismic	
	Dir. Shear	Torsion	Dir. Shear	Torsion	Dir. Shear	Torsion	Dir. Shear	Torsion
SW-1	0.00	0.15	0.00	0.74	1.71	0.30	5.09	0.93
SW-2	0.00	0.01	0.00	0.06	0.19	0.03	0.55	0.08
SW-3	0.00	0.07	0.00	0.34	2.39	0.14	7.10	0.43
SW-4	13.12	0.98	12.57	4.96	0.00	2.03	0.00	6.23
SW-5	9.39	0.57	8.99	2.90	0.00	1.19	0.00	3.64
SW-6	17.88	0.81	17.13	4.08	0.00	1.67	0.00	5.12
SW-7	0.00	-0.45	0.00	-2.29	17.44	-0.94	51.89	-2.88
SW-8	0.00	-0.15	0.00	-0.74	1.71	-0.30	5.09	-0.93
SW-9	0.00	-0.01	0.00	-0.06	0.19	-0.03	0.55	-0.08
SW-10	0.00	-0.07	0.00	-0.35	2.39	-0.14	7.10	-0.43
SW-11	13.12	-0.98	12.57	-4.96	0.00	-2.03	0.00	-6.22
SW-12	9.39	-0.57	8.99	-2.89	0.00	-1.19	0.00	-3.63
SW-13	17.88	-0.81	17.13	-4.09	0.00	-1.67	0.00	-5.13

STORY 7	
N-S Wind	64
E-W Wind	10
Seismic	29

Element	N-S				E-W			
	Wind		Seismic		Wind		Seismic	
	Dir. Shear	Torsion	Dir. Shear	Torsion	Dir. Shear	Torsion	Dir. Shear	Torsion
SW-1	0.00	0.06	0.00	0.15	2.08	0.04	5.80	0.09
SW-2	0.00	0.00	0.00	0.01	0.23	0.00	0.63	0.00
SW-3	0.00	-0.06	0.00	-0.16	2.90	-0.04	8.08	-0.10
SW-4	19.11	1.04	8.62	2.58	0.00	0.66	0.00	1.62
SW-5	7.46	0.03	3.36	0.09	0.00	0.02	0.00	0.05
SW-6	5.61	0.09	2.53	0.23	0.00	0.06	0.00	0.14
SW-8	0.00	0.06	0.00	0.15	2.08	0.04	5.80	0.09
SW-9	0.00	0.00	0.00	0.01	0.23	0.00	0.63	0.00
SW-10	0.00	-0.06	0.00	-0.15	2.90	-0.04	8.08	-0.10
SW-11	19.11	-1.04	8.62	-2.58	0.00	-0.66	0.00	-1.62
SW-12	7.46	-0.33	3.36	-0.82	0.00	-0.21	0.00	-0.52
SW-13	5.61	-0.18	2.53	-0.46	0.00	-0.12	0.00	-0.29

STORY 8	
N-S Wind	65
E-W Wind	11
Seismic	34

Element	N-S				E-W			
	Wind		Seismic		Wind		Seismic	
	Dir. Shear	Torsion	Dir. Shear	Torsion	Dir. Shear	Torsion	Dir. Shear	Torsion
SW-1	0.00	0.06	0.00	0.18	2.12	0.04	6.85	0.11
SW-2	0.00	0.00	0.00	0.01	0.23	0.00	0.74	0.00
SW-3	0.00	-0.06	0.00	-0.19	2.96	-0.04	9.55	-0.12
SW-4	19.45	1.06	10.18	3.04	0.00	0.68	0.00	1.91
SW-5	7.59	0.04	3.97	0.10	0.00	0.02	0.00	0.06
SW-6	5.71	0.09	2.99	0.27	0.00	0.06	0.00	0.17
SW-8	0.00	0.06	0.00	0.18	2.12	0.04	6.85	0.11
SW-9	0.00	0.00	0.00	0.01	0.23	0.00	0.74	0.00
SW-10	0.00	-0.06	0.00	-0.18	2.96	-0.04	9.55	-0.11
SW-11	19.45	-1.06	10.18	-3.04	0.00	-0.68	0.00	-1.91
SW-12	7.59	-0.34	3.97	-0.97	0.00	-0.22	0.00	-0.61
SW-13	5.71	-0.19	2.99	-0.54	0.00	-0.12	0.00	-0.34

STORY 9	
N-S Wind	67
E-W Wind	11
Seismic	40

Element	N-S				E-W			
	Wind		Seismic		Wind		Seismic	
	Dir. Shear	Torsion	Dir. Shear	Torsion	Dir. Shear	Torsion	Dir. Shear	Torsion
SW-1	0.00	0.06	0.00	0.20	2.20	0.04	7.96	0.13
SW-2	0.00	0.00	0.00	0.01	0.24	0.00	0.86	0.01
SW-3	0.00	-0.07	0.00	-0.22	3.07	-0.04	11.09	-0.14
SW-4	20.01	1.09	11.83	3.54	0.00	0.70	0.00	2.22
SW-5	7.81	0.04	4.62	0.12	0.00	0.02	0.00	0.07
SW-6	5.87	0.10	3.47	0.31	0.00	0.06	0.00	0.19
SW-8	0.00	0.06	0.00	0.20	2.20	0.04	7.96	0.13
SW-9	0.00	0.00	0.00	0.01	0.24	0.00	0.86	0.01
SW-10	0.00	-0.06	0.00	-0.21	3.07	-0.04	11.09	-0.13
SW-11	20.01	-1.09	11.83	-3.54	0.00	-0.70	0.00	-2.22
SW-12	7.81	-0.35	4.62	-1.13	0.00	-0.22	0.00	-0.71
SW-13	5.87	-0.19	3.47	-0.63	0.00	-0.12	0.00	-0.39

STORY 10	
N-S Wind	69
E-W Wind	11
Seismic	46

Element	N-S				E-W			
	Wind		Seismic		Wind		Seismic	
	Dir. Shear	Torsion	Dir. Shear	Torsion	Dir. Shear	Torsion	Dir. Shear	Torsion
SW-1	0.00	0.06	0.00	0.23	2.28	0.04	9.12	0.15
SW-2	0.00	0.00	0.00	0.01	0.25	0.00	0.99	0.01
SW-3	0.00	-0.07	0.00	-0.25	3.17	-0.04	12.71	-0.16
SW-4	20.58	1.12	13.55	4.05	0.00	0.72	0.00	2.55
SW-5	8.03	0.04	5.29	0.14	0.00	0.02	0.00	0.09
SW-6	6.04	0.10	3.98	0.35	0.00	0.06	0.00	0.22
SW-8	0.00	0.06	0.00	0.23	2.28	0.04	9.12	0.15
SW-9	0.00	0.00	0.00	0.01	0.25	0.00	0.99	0.01
SW-10	0.00	-0.07	0.00	-0.24	3.17	-0.04	12.71	-0.15
SW-11	20.58	-1.12	13.55	-4.05	0.00	-0.72	0.00	-2.55
SW-12	8.03	-0.36	5.29	-1.29	0.00	-0.23	0.00	-0.81
SW-13	6.04	-0.20	3.98	-0.72	0.00	-0.13	0.00	-0.45

STORY 11	
N-S Wind	69
E-W Wind	11
Seismic	52

Element	N-S				E-W			
	Wind		Seismic		Wind		Seismic	
	Dir. Shear	Torsion	Dir. Shear	Torsion	Dir. Shear	Torsion	Dir. Shear	Torsion
SW-1	0.00	0.06	0.00	0.26	2.28	0.04	10.33	0.17
SW-2	0.00	0.00	0.00	0.01	0.25	0.00	1.12	0.01
SW-3	0.00	-0.07	0.00	-0.28	3.17	-0.04	14.39	-0.18
SW-4	20.58	1.12	15.35	4.59	0.00	0.72	0.00	2.89
SW-5	8.03	0.04	5.99	0.15	0.00	0.02	0.00	0.10
SW-6	6.04	0.10	4.50	0.40	0.00	0.06	0.00	0.25
SW-8	0.00	0.06	0.00	0.26	2.28	0.04	10.33	0.17
SW-9	0.00	0.00	0.00	0.01	0.25	0.00	1.12	0.01
SW-10	0.00	-0.07	0.00	-0.27	3.17	-0.04	14.39	-0.17
SW-11	20.58	-1.12	15.35	-4.59	0.00	-0.72	0.00	-2.88
SW-12	8.03	-0.36	5.99	-1.46	0.00	-0.23	0.00	-0.92
SW-13	6.04	-0.20	4.50	-0.81	0.00	-0.13	0.00	-0.51

STORY 12	
N-S Wind	71
E-W Wind	12
Seismic	58

Element	N-S				E-W			
	Wind		Seismic		Wind		Seismic	
	Dir. Shear	Torsion	Dir. Shear	Torsion	Dir. Shear	Torsion	Dir. Shear	Torsion
SW-1	0.00	0.07	0.00	0.30	2.34	0.04	2.34	0.19
SW-2	0.00	0.00	0.00	0.01	0.25	0.00	0.25	0.01
SW-3	0.00	-0.07	0.00	-0.32	3.26	-0.05	3.26	-0.20
SW-4	21.03	1.14	17.22	5.15	0.00	0.74	0.00	3.24
SW-5	8.21	0.04	6.72	0.17	0.00	0.02	0.00	0.11
SW-6	6.17	0.10	5.05	0.45	0.00	0.07	0.00	0.28
SW-8	0.00	0.07	0.00	0.30	2.34	0.04	2.34	0.19
SW-9	0.00	0.00	0.00	0.01	0.25	0.00	0.25	0.01
SW-10	0.00	-0.07	0.00	-0.30	3.26	-0.04	3.26	-0.19
SW-11	21.03	-1.14	17.22	-5.15	0.00	-0.74	0.00	-3.24
SW-12	8.21	-0.36	6.72	-1.64	0.00	-0.24	0.00	-1.03
SW-13	6.17	-0.20	5.05	-0.91	0.00	-0.13	0.00	-0.57

STORY 13	
N-S Wind	76
E-W Wind	13
Seismic	65

Element	N-S				E-W			
	Wind		Seismic		Wind		Seismic	
	Dir. Shear	Torsion	Dir. Shear	Torsion	Dir. Shear	Torsion	Dir. Shear	Torsion
SW-1	0.00	0.07	0.00	0.33	2.50	0.05	12.95	0.21
SW-2	0.00	0.00	0.00	0.01	0.27	0.00	1.41	0.01
SW-3	0.00	-0.08	0.00	-0.35	3.49	-0.05	18.05	-0.22
SW-4	22.50	1.22	19.25	5.76	0.00	0.80	0.00	3.62
SW-5	8.78	0.04	7.51	0.19	0.00	0.03	0.00	0.12
SW-6	6.60	0.11	5.65	0.50	0.00	0.07	0.00	0.32
SW-8	0.00	0.07	0.00	0.33	2.50	0.05	12.95	0.21
SW-9	0.00	0.00	0.00	0.01	0.27	0.00	1.41	0.01
SW-10	0.00	-0.07	0.00	-0.34	3.49	-0.05	18.05	-0.21
SW-11	22.50	-1.22	19.25	-5.75	0.00	-0.80	0.00	-3.62
SW-12	8.78	-0.39	7.51	-1.83	0.00	-0.25	0.00	-1.15
SW-13	6.60	-0.22	5.65	-1.02	0.00	-0.14	0.00	-0.64

STORY ROOF	
N-S Wind	41
E-W Wind	7
Seismic	57

Element	N-S				E-W			
	Wind		Seismic		Wind		Seismic	
	Dir. Shear	Torsion	Dir. Shear	Torsion	Dir. Shear	Torsion	Dir. Shear	Torsion
SW-1	0.00	0.04	0.00	0.29	1.37	0.03	11.46	0.18
SW-2	0.00	0.00	0.00	0.01	0.15	0.00	1.24	0.01
SW-3	0.00	-0.04	0.00	-0.31	1.90	-0.03	15.97	-0.20
SW-4	12.24	0.67	17.03	5.09	0.00	0.43	0.00	3.20
SW-5	4.78	0.02	6.65	0.17	0.00	0.01	0.00	0.11
SW-6	3.59	0.06	5.00	0.45	0.00	0.04	0.00	0.28
SW-8	0.00	0.04	0.00	0.29	1.37	0.03	11.46	0.18
SW-9	0.00	0.00	0.00	0.01	0.15	0.00	1.24	0.01
SW-10	0.00	-0.04	0.00	-0.30	1.90	-0.03	15.97	-0.19
SW-11	12.24	-0.67	17.03	-5.09	0.00	-0.43	0.00	-3.20
SW-12	4.78	-0.21	6.65	-1.62	0.00	-0.14	0.00	-1.02
SW-13	3.59	-0.12	5.00	-0.90	0.00	-0.08	0.00	-0.57

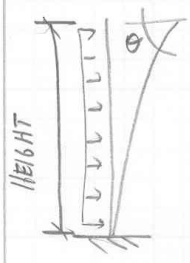
Total Shear from N-S Loading
Kips

Level	SW-4		SW-5		SW-6	
	Wind	Seismic	Wind	Seismic	Wind	Seismic
Roof	12.90	22.12	4.80	6.82	3.65	5.44
13	23.73	25.01	8.82	7.71	6.71	6.15
12	22.17	22.36	8.25	6.89	6.27	5.50
11	21.70	19.94	8.07	6.14	6.14	4.90
10	21.70	17.60	8.07	5.42	6.14	4.33
9	21.10	15.36	7.85	4.73	5.97	3.78
8	20.51	13.23	7.63	4.08	5.80	3.25
7	20.15	11.20	7.49	3.45	5.70	2.75
6	14.11	17.53	9.97	11.89	18.69	21.20
5	13.86	7.39	9.79	5.02	18.37	8.94
4	11.09	5.08	7.84	3.44	14.70	6.14
3	10.73	3.07	7.58	2.08	14.22	3.71
2	11.97	1.35	8.45	0.91	15.86	1.63
SUM	225.72	181.23	104.60	68.58	128.20	77.75

Total Shear from E-W Loading
Kips

Level	SW-1		SW-2		SW-3		SW-7	
	Wind	Seismic	Wind	Seismic	Wind	Seismic	Wind	Seismic
Roof	1.39	11.64	0.15	1.25	1.90	15.97		
13	2.55	13.16	0.27	1.42	3.49	18.05		
12	2.38	2.52	0.26	0.26	3.26	3.26		
11	2.32	10.49	0.25	1.13	3.17	14.39		
10	2.32	9.26	0.25	1.00	3.17	12.71		
9	2.24	8.09	0.24	0.87	3.07	11.09		
8	2.16	6.96	0.23	0.75	2.96	9.55		
7	2.12	5.89	0.23	0.63	2.90	8.08		
6	2.01	6.02	0.21	0.63	2.53	7.53	17.44	51.89
5	1.96	2.54	0.20	0.27	2.45	3.18	16.93	21.89
4	1.55	1.74	0.16	0.18	1.95	2.18	13.45	15.03
3	1.49	1.05	0.16	0.11	1.87	1.32	12.89	9.08
2	1.61	0.46	0.17	0.05	2.02	0.58	13.96	3.98
SUM	26.10	79.84	2.78	8.55	34.73	107.88	74.66	101.87

DEFLECTION



ROTATION OF BASE

* ASSUME UNIFORM LOADING

$H_{base} = 77.25'$

$H_{tower} = 97.25'$

$$1^{k}\theta_{END} = \int_0^H \frac{\left(\frac{Wx^2}{2}\right)(1^{ft\cdot k})}{EI} \Rightarrow \theta = \frac{W}{2EI}\int_0^H x^2$$

$$\theta = \frac{W}{2EI}\left(\frac{x^3}{3}\right)\Big|_0^H \qquad V = Wx$$

$$\theta = \frac{Vx^2}{6EI}\Big|_0^H \qquad E = 4287\,K/in^2 \Rightarrow 617328\,K/FT^2$$

$$\theta = \frac{V(77.25')^2}{6(617328)I} = \frac{.0016\,V_{base}}{I}$$

$$\Delta_{rotation} = \frac{.0016\,V_{base}(97.25)}{I} = \frac{.156\,V_{base}}{I}$$

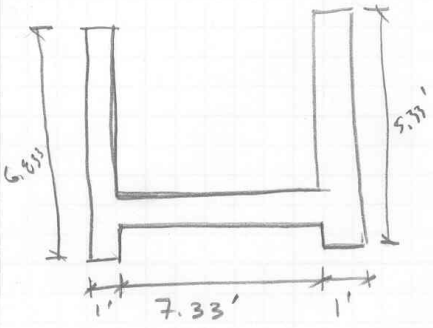
V_{base} is shear from load only applied to base section of building

					Height=	174.5	Feet	$H_{ground-6th}$	77.25
					Width=	12	inches	$H_{6th-roof}$	97.25
WIND					E=	4000	k/in^2		
SW-4	**Area=**	26.50	**I=**	860.27					
• $_{6th-roof}$=	0.59		• $_{top}$=	**0.84**				H/500=	4.188
• $_{ground-6th}$=	0.11							H/400=	5.235
• $_{rotation}$=	0.13								
SW-5	**$Area_{top}$=**	15.00	**I_{top}=**	185.86					
	$Area_{bot}$=	21.00	**I_{bot}=**	491.75					
• $_{6th-roof}$=	1.00		• $_{top}$=	**1.25**					
• $_{ground-6th}$=	0.09								
• $_{rotation}$=	0.17								
SW-6	**$Area_{top}$=**	12.66	**I_{top}=**	126.10					
	$Area_{bot}$=	31.32	**I_{bot}=**	1944.30					
• $_{6th-roof}$=	1.11		• $_{top}$=	**1.26**					
• $_{ground-6th}$=	0.07								
• $_{rotation}$=	0.08								
SEISMIC									
SW-4	**Area=**	26.50	**I=**	860.27					
• $_{6th-roof}$=	0.85		• $_{top}$=	**1.03**					
• $_{ground-6th}$=	0.10								
• $_{rotation}$=	0.07								
SW-5	**$Area_{top}$=**	15.00	**I_{top}=**	185.86					
	$Area_{bot}$=	21.00	**I_{bot}=**	491.75					
• $_{6th-roof}$=	1.18		• $_{top}$=	**1.49**					
• $_{ground-6th}$=	0.22								
• $_{rotation}$=	0.09								
SW-6	**$Area_{top}$=**	12.66	**I_{top}=**	126.10					
	$Area_{bot}$=	31.32	**I_{bot}=**	1944.30					
• $_{6th-roof}$=	1.39		• $_{top}$=	**1.46**					
• $_{ground-6th}$=	0.03								
• $_{rotation}$=	0.04								

- $_{top}=V(1.44h/Area*E+H^3/(8EI))$
- $_{rotation}=.0016(V_{ground-6th})/Moment\ of\ Inertia$

					Height=	174.5	Feet	$H_{ground-6th}$	77.25	
					Width=	12	inches	$H_{6th-roof}$	97.25	
WIND					E=	4000	k/in^2			
SW-1	**Area=**	14.16	**I=**	144.60		**SW-7**	**Area=**	67.25	**I=**	22887.90
• $_{6th-roof}$=	0.37		• $_{top}$=	**0.57**		• $_{6th-roof}$=	0.00		• $_{top}$=	**0.00**
• $_{ground-6th}$=	0.09					• $_{ground-6th}$=	0.00			
• $_{rotation}$=	0.11					• $_{rotation}$=	0.00			
SW-2	**$Area_{top}$=**	9.66	**I_{top}=**	9.31						
	$Area_{bot}$=	9.66	**I_{bot}=**	9.31						
• $_{6th-roof}$=	0.60		• $_{top}$=	**0.90**						
• $_{ground-6th}$=	0.12									
• $_{rotation}$=	0.18									
SW-3	**$Area_{top}$=**	17.05	**I_{top}=**	231.33						
	$Area_{bot}$=	17.05	**I_{bot}=**	231.33						
• $_{6th-roof}$=	0.31		• $_{top}$=	**0.47**						
• $_{ground-6th}$=	0.07									
• $_{rotation}$=	0.09									
SEISMIC										
SW-1	**Area=**	14.16	**I=**	144.60		**SW-7**	**Area=**	67.25	**I=**	22887.90
• $_{6th-roof}$=	2.28		• $_{top}$=	**2.63**		• $_{6th-roof}$=	0.00		• $_{top}$=	**0.01**
• $_{ground-6th}$=	0.20					• $_{ground-6th}$=	0.01			
• $_{rotation}$=	0.15					• $_{rotation}$=	0.00			
SW-2	**$Area_{top}$=**	9.66	**I_{top}=**	9.31						
	$Area_{bot}$=	9.66	**I_{bot}=**	9.31						
• $_{6th-roof}$=	3.76		• $_{top}$=	**4.33**						
• $_{ground-6th}$=	0.32									
• $_{rotation}$=	0.25									
SW-3	**$Area_{top}$=**	17.05	**I_{top}=**	231.33						
	$Area_{bot}$=	17.05	**I_{bot}=**	231.33						
• $_{6th-roof}$=	1.96		• $_{top}$=	**2.16**						
• $_{ground-6th}$=	0.08									
• $_{rotation}$=	0.12									

SW-3 CHECK



$V = 54.04^k$ (SEISMIC)

$\text{Moment} = \frac{54.04^k}{533^k}\left(66,148'^k\right) = 6706.6'^k$

AXIAL FROM SW.

$P_D = (17.05^{SF})(174.5')(.150^{KCF}) = 446.8^k$

$P_U = 0.9(446.8^k) = 401.0^k$

$V_U = 1.0(54.04) = 54.04^k$

$M_U = 1.0(6706.6) = 6706.6'^k$

$f_y = 60^{ksi}$

$f'_c = 5000^{psi}$

LONGITUDINAL & TRANSVERSE REINFORCEMENT

$V_U \geq 2A_{CV}\sqrt{f'_c} \Rightarrow$ 2 curtains req'd.

$2(8" \times 9.33' \times 12"/') \sqrt{5000}/1000 = 126.67^k$

$V_u = 54.04^k$ USE 2 CURTAINS so minimum steel can be #4 @ 12" o.c. & typical for all walls

$\rho_\ell \& \rho_t = \frac{A_{s\ell}}{A_{CV}} \geq .0025$

$A_{CV} = (8")(12") = 96 in^2/ft$ $A_{s\,req'd} = (0.0025)(96) = .24 in^2/ft$

#4 @ 12" o.c. EA WAY EA FACE

$A_{s\ell} = 2(.2) = 0.4 in^2/ft$ ok

*POSSIBLE TO USE #4 @ 16" o.c.
$12/16\,(2)(.2) = .3 > .24 in^2/ft.$
but will use #4 @ 12" o.c. EA. WAY TO REMAIN TYPICAL

SHEAR CAPACITY

$V_n = A_{CV}(\alpha_c\sqrt{f'_c} + \rho_t f_y)$

$\frac{h_w}{l_w} = \frac{174.5'}{9.33} = 18.7 > 2 \Rightarrow \alpha_c = 2.0$

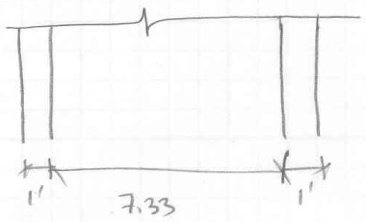
$A_{CV} = (8")(9.33 \times 12) = 895.68 in^2$

$\rho_t = \frac{2(0.2)}{8(12)} = .0042$

$V_n = 895.68 in^2 (2\sqrt{5000} + .0042(60,000))/1000 = 352.38^k$

$\phi V_n = 0.6(352.38^k) = 211.43^k$

SW-3 CHECK



$A_g = 17.05\ SF$

$I_g = 231.33\ ft^4$

$$f_c = \frac{401.0}{17.05} + \frac{6706.6 \cdot \frac{9.33}{2}}{231.33\ ft^4}$$

$$= 23.56 + 135.25$$

$$= \frac{158.8\ kSF}{144} = 1.1^{ksi} = 1^{ksi} = f_c' \text{ allowable}$$

BOUNDARY ELEMENTS NOT REQUIRED

SW-4 CHECK

$V = 112.62^k$ (WIND)

NEGLECT GRAVITY LOAD FROM FLOORS

$\text{Moment} = \frac{112.62^k}{877^k}(81934^{ft\cdot k})$

$= 10521.6^{ft\cdot k}$

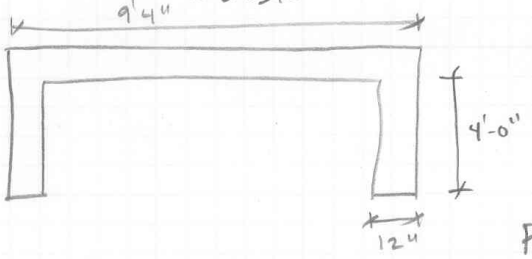
AXIAL FROM SW OF WALL

$= (26.5\,SF)(174.5')(.150\,KCF)$

$= 693.6^k$

$f_y = 60^{ksi}$

$f'_c = 5000^{psi}$



$P_u = 0.9(693.6^k)$

$= 624.24^k$

$M_u = 1.6(10521.6^{ft\cdot k})$

$= 16834.6^{ft\cdot k}$

LONGITUDINAL & TRANSVERSE REINFORCEMENT

$V_u \geq 2A_{cv}\sqrt{f'_c} \Rightarrow$ 2 curtains reqd.

$2(12" \times 9.33' \times 12"/1')\sqrt{5000}/1000 = 190^k$

$V_u = 112.62^k \times 1.6 = 180.2^k$ USE 2 CURTAINS B/C CLOSE

ℓ_ℓ & $\ell_t = \frac{A_{sl}}{A_{cv}} \geq .0025$

$A_{cv} = (12")(12") = 144 in^2/ft$

$A_{sreqd} = (0.0025)(144) = .36 in^2/ft$

ASSUME #4 @ 12" EA WAY EA FACE

$A_{sl} = 2(.2) = 0.4 in^2/ft$ ok

NOMINAL SHEAR CAPACITY

$V_n = A_{cv}(\alpha_c\sqrt{f'_c} + \ell_t f_y)$ $\quad \frac{h_w}{\ell_w} = \frac{174.5}{9.33'} = 18.7 > 2 \therefore \alpha_c = 2.0$

$A_{cv} = (12)(9.33 \times 12) = 1343.5 in^2$

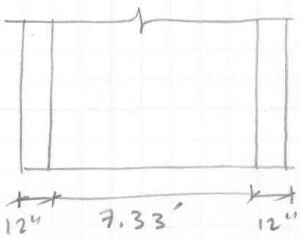
$\ell_t = \frac{2(0.2)}{(12 \times 12)} = .00278$

$V_n = 1343.5(2.0\sqrt{5000} + .00278(60{,}000))/1000$

$= 414.1^k$

$\phi V_n = 0.75(414.1^k) = 310.6^k > 180.2^k$ ok

SW-4 CHECK.



$$C_V = \frac{P_u}{2} + \frac{M_u}{d} = \frac{624.24^{k}}{2} + \frac{16834.6^{1k}}{7.33'}$$

$$= 2,608.79^{k}$$

$$T_V = \frac{P_u}{2} - \frac{M_u}{d} = \frac{624.24^{k}}{2} - \frac{16834.6^{1k}}{7.33'}$$

$$= -1984.47^{k}$$

BOUNDARY ELEMENTS

$A_g = 26.5\ ft^2 \qquad I = 860.27\ ft^4$

$$f_c = \frac{624.24}{26.5} + \frac{16834.6^{1k} \cdot \frac{9.33}{2}}{860.27\ ft^4}$$

$$= 23.56 + 91.29$$

$$= \frac{114.85^{k}}{144}\ ksf = .8^{ksi}$$

$0.2 f'_c = 0.2(5000) = 1^{ksi} > f_c = 0.8^{ksi}$

NO BOUNDARY ELEMENTS REQUIRED