VIII. Appendix A: Structural Depth Calculations

VIII. Appendix A: Structural Depth Calculations

i. Design Loads

a. Dead Loads

Floor			Roof		
Quarry Tile Flooring	10	PSF	Metal Roof Sheathing	1	PSF
HVAC	3	PSF	4" Rigid Insulation	6	PSF
Acoustical Ceiling Tile	2	PSF	Steel Deck	3	PSF
Miscellaneous	5	PSF	HVAC	3	PSF
			Acoustical Ceiling Tile	2	PSF
			Miscellaneous	5	PSF
Total	20	PSF	Total	20	PSF
Balcony			Exterior Wall		
Concrete Pavers	12	PSF	4" Brick Façade	40	PSF
Waterproofing Membrane	2	PSF	5/8" Gypsum Board	3	PSF
4" Rigid Insulation	6	PSF	6" Batt Insulation	6	PSF
HVAC	3	PSF	5/8" Gypsum Board	3	PSF
Acoustical Ceiling Tile	2	PSF	Miscellaneous	3	PSF
Miscellaneous	5	PSF			
Total	30	PSF	Total	55	PSF
Partition Wall			Bearing Wall		
5/8" Gypsum Board	3	PSF	8" Fully Grouted CMU	80	PSF
6" Batt Insulation	6	PSF	Total	80	PSF
5/8" Gypsum Board	3	PSF			
Miscellaneous	8	PSF			
			Shear Wall		
			8" Concrete	97	PSF
Total	20	PSF	Total	97	PSF

b. Snow Loads

Flat Roof Snow Load
Terrain Category C
Ce=0.9
Ct=1.0
I=1.1
pg=25 psf
pf equals the larger of:
pf=0.7 Ce Ct I pg
=(0.7)(0.9)(1.0)(1.1)(25 psf)
=18 psf
pf=20I
=20(1.1)
=22 psf
pf=22 psf>LL=20 psf Roof Snow Load Controls

Lower Roof Snow Drift Load
γ=0.13 pg+14
=(0.13)(25 psf)+14
=17.3 pcf<30 pcf OK
hb= pf/γ
=22 psf/17.3 pcf
=1.27 ft
hc=14 ft-1.27 ft
=12.7 ft
hc/ hb=12.7 ft/1.27 ft
=10>0.2 Snow drift required.
hd equals larger of:
higher roof, lu=34.67 ft
$hd=0.43(lu^{1/3})((pg+10)^{1/4})-1.5$
$=0.43(34.67\ ft^{1/3})((25\ psf+10)^{1/4})-1.5$
=1.91 ft
lower roof, lu=49.67 ft

$hd=0.75[0.43(lu^{1/3})((pg+10)^{1/4})-1.5$

$=0.43(49.67\ ft^{1/3})((25\ psf+10)^{1/4})-1.5]$

$=1.78$ ft

$hd=1.91$ ft$<$ $hc=12.7$ ft

$w=4\ hd$

$=4(1.91$ ft$)$

$=7.64$ ft$<8\ hc=8(12.7$ ft$)=101.6$ ft OK

$pd=hd\ \gamma$

$=(1.91$ ft$)(17.3$ pcf$)$

$=33$ psf

c. Wind Loads

Main Wind Force Resisting System

$V=100$ mph

$Kd=0.85$

Occupancy Category III

$I=1.15$

Exposure Category C

15 ft$<z=82$ ft$<$ $zg=900$ ft

$\alpha=9.5$

$Kz=2.01(z/zg)^{2/\alpha}$ (see table below)

$Kzt=1.0$

$Ct=0.020$

$hn=82$ ft

$x=0.9$

$Ta=Cthn^{x}$

$=(0.020)(82\ ft)^{0.9}$

$=1.06$ s

$f=1/T$

$=1/1.06$ s

$=0.943$ Hz<1.0 Hz Flexible Building

North-South Direction

$c=0.20$

$z=0.6h$

$=0.6(82\text{ ft})$

$=49.2\text{ ft}>z_{min}=15\text{ ft}$ OK

$I_z=c(33/z)^{1/6}$

$=(0.20)(33/49.2\text{ ft})^{1/6}$

$=0.187$

$g_Q=3.4$

$B=132.67\text{ ft}$

$h=82\text{ ft}$

$\ell=500$

$\varepsilon=1/5.0$

$L_z=\ell(33/z)^{\varepsilon}$

$=500(33/49.2\text{ ft})^{(1/5.0)}$

$=462\text{ ft}$

$Q=(1/(1+0.63((B+h)/L_z)^{0.63})^{1/2}$

$=(1/1+0.63((132.67\text{ ft}+82\text{ ft})/462)^{0.63})^{1/2}$

$=0.849$

$n1=f$

$=0.637\text{ Hz}$

$g_R=(2\ln(3600n1)^{1/2}+(0.577/(2\ln(3600n1)^{1/2})$

$=(2\ln(3600(0.637))^{1/2}+(0.577/(2\ln(3600(0.637))^{1/2})$

$=3.94$

Assuming $\beta=0.02$

$b=0.65$

$\alpha=1/6.5$

$V_z=b(z/33)^{\alpha}V(88/60)$

$=(0.65)(49.2\text{ ft}/33)^{(1/6.5)}(100\text{ mph})(88/60)$

$=101\text{ mph}$

$N1=n1V_z/L_z$

$=(0.637)(101\text{ mph})/462\text{ ft}$

$=0.139$

$Rn=7.47N1/(1+10.3N1)^{5/3}$

$=7.47(0.139)/(1+10.3(0.139))^{5/3}=$

$=0.236$

$Rh=(1/(4.6n1h/Vz))-((1/2(4.6n1h/Vz)^2)(1-e^{-2(4.6n1h/Vz)}))$

$= (1/(4.6(0.637)(82\ ft)/101\ mph))$

$-((1/2(4.6(0.637)(82\ ft)/101\ mph))^2)(1-e^{-2(4.6(0.637)(82\ ft)/(101\ mph))}))$

$=0.333$

$RB=(1/(4.6n1B/Vz))-((1/2(4.6n1B/Vz)^2)(1-e^{-2(4.6n1B/Vz)}))$

$= (1/(4.6(0.637)(132.67\ ft)/101\ mph))$

$-((1/2(4.6(0.637)(132.67\ ft)/101\ mph)^2)(1-e^{-2(4.6(0.637)(132.67\ ft)/101\ mph)}))$

$=0.226$

$L=101.25\ ft$

$RL=(1/(15.4n1L/Vz))-((1/2(15.4n1L/Vz)^2)(1-e^{-2(15.4n1L/Vz)}))$

$= (1/(15.4(0.637)(101.25\ ft)/101\ mph))$

$-((1/2(15.4(0.637)(101.25\ ft)/101\ mph)^2)(1-e^{-2(15.4(0.637)(101.25\ ft)/101\ mph)}))$

$=0.097$

$R=((1/\beta)RnRhRB(0.53+0.47RL))^{1/2}$

$=((1/0.02)(0.236)(0.333)(0.226)(0.53+0.47(0.097))^{1/2}$

$=0.715$

$gV=3.4$

$G=0.925((1+1.7Iz(gQ^2Q^2+gR^2R^2)^{1/2})/(1+1.7gVIz))$

$=0.925((1+1.7(0.187)((3.4)^2(0.849)^2+(3.94)^2(0.715)^2)^{1/2})/(1+1.7\ (3.4)(0.187)))$

$=1.01$

East-West Direction

$B=101.25\ ft$

$Q=(1/(1+0.63((B+h)/\ Lz)^{0.63})^{1/2}$

$=(1/1+0.63((101.25\ ft+82\ ft)/462)^{0.63})^{1/2}$

$=0.860$

$RB=(1/(4.6n1B/Vz))-((1/2(4.6n1B/Vz)^2)(1-e^{-2(4.6n1B/Vz)}))$

$= (1/(4.6(0.637)(101.25\ ft)/101\ mph))$

$-((1/2(4.6(0.637)(101.25\ ft)/101\ mph)^2)(1-e^{-2(4.6(0.637)(101.25\ ft)/101\ mph)}))$

$=0.283$

$L=132.67\ ft$

$RL=(1/(15.4n1L/Vz))-((1/2(15.4n1L/Vz)^2)(1-e^{-2(15.4n1L/Vz)}))$

$= (1/(15.4(0.637)(132.67\ ft)/101\ mph))$

$-((1/2(15.4(0.637)(132.67\ ft)/101\ mph)^2)(1-e^{-2(15.4(0.637)(132.67\ ft)/101\ mph)}))$

$=0.075$

$R=((1/\beta)RnRhRB(0.53+0.47RL))^{1/2}$

$=((1/0.02)(0.236)(0.333)(0.283)(0.53+0.47(0.075))^{1/2}$

$=0.793$

$G=0.925((1+1.7Iz(gQ^2Q^2+gR^2R^2)^{1/2})/(1+1.7gVIz))$

$=0.925((1+1.7(0.187)((3.4)^2(0.849)^2+(3.94)^2(0.793)^2)^{1/2})/(1+1.7\ (3.4)(0.187)))$

$=1.05$

Windward

$Cp=0.8$

Leeward, North-South Direction

$L=101.25\ ft$

$B=132.67\ ft$

$L/B=101.25\ ft/132.67\ ft$

$=0.763$

$Cp=-0.5$

Leeward, East-West Direction

$L=132.67\ ft$

$B=101.25\ ft$

$L/B=132.67\ ft/101.25\ ft$

$=1.310$

$Cp=-0.438$

$qz=0.00256\ Kz\ Kzt\ KdV^2I$ (see table below)

$q=qz$ windward

$=qh$ leeward

$qi=qh$

$P=qG\ Cp$ (see table below)

			P (psf)			
			North-South Direction		East-West Direction	
z (ft)	Kz	qz (psf)	Windward	Leeward	Windward	Leeward
82	1.21	30.4	24.54	-12.39	25.51	-11.73
80	1.21	30.2	24.42	-12.39	25.38	-11.73
70	1.17	29.4	23.74	-12.39	24.68	-11.73
60	1.14	28.4	22.98	-12.39	23.89	-11.73
50	1.09	27.4	22.12	-12.39	22.99	-11.73
40	1.04	26.1	21.10	-12.39	21.94	-11.73
30	0.98	24.6	19.86	-12.39	20.65	-11.73
25	0.95	23.7	19.11	-12.39	19.87	-11.73
20	0.90	22.6	18.24	-12.39	18.96	-11.73
15	0.85	21.2	17.16	-12.39	17.84	-11.73
0	0.00	0.0	0.00	-12.39	0.00	-11.73

		Story Heights		
Story	Height (ft)	Trib. Height Above (ft)	Trib. Height Below (ft)	Trib. Height (ft)
High Roof	82	0.0	4.5	4.5
6th Floor	73	4.5	8.5	13.0
Low Roof	68	0.0	6.0	6.0
5th Floor	56	8.5	7.0	15.5
4th Floor	42	7.0	7.0	14.0
3rd Floor	28	7.0	7.0	14.0
2nd Floor	14	7.0	7.0	14.0
1st Floor	0	7.0	0.0	7.0

	Story Width (ft)		Story Shear (kips)	
Story	North-South Direction	East-West Direction	North-South Direction	East-West Direction
High Roof	101.0	34.3	16.7	5.7
6th Floor	101.0	34.3	47.8	16.2
Low Roof	66.0	79.7	14.0	16.8
5th Floor	101.0	134.0	54.8	72.2
4th Floor	116.0	134.0	55.2	63.3
3rd Floor	116.0	134.0	53.4	61.1
2nd Floor	116.0	134.0	51.8	59.2
1st Floor	116.0	134.0	25.6	29.2

d. Seismic Loads

Latitude: 39.17° N

Longitude: -75.54° W

From USGS Java Ground Motion Parameter Calculator

Ss=0.172

S1=0.079

Assuming Site Class D (Not reported in Geotechnical Engineer's Report)

Fa=1.6

Fv=2.4

SMS=FaSs

=(1.6)(0.172)

=0.275

SM1=FvS1

=(2.4)(0.079)

=0.190

SDS=2/3 SMS

=(2/3)(0.275)

=0.183

SD1=2/3 SM1

=(2/3)(0.190)

=0.127

TL=6 s

Cu=1.65

Ct=0.020

hn=82 ft

x=0.8

$Ta=Cthn^{x}$

$=(0.020)(82\ ft)^{0.9}$

=1.06 s

$T \leq Cu\ Ta$

=(1.65)(1.06 s)

=1.75 s

Seismic Design Category B

Ordinary Reinforced Concrete Shear Walls

R=5

Occupancy Category III

I=1.25

Cs equals the smallest of:

Cs= SDS/(R/I)

=(0.183)/(5/1.25)

=0.046

T=1.75 s<TL=6 s

Cs= SD1/(T(R/I))

=(0.127)/(1.75(5/1.25))

=0.018

S1=0.079<0.6

Cs=0.018>0.01 OK

V= CsW

=(0.018)(16575 kips)

=298 kips

k=1.63

$Cvx=wxhx^{k}/\Sigma wihi^{k}$

Fx=CvxV

	Floor Weight		
Story	Floor Area (sf)	Floor Dead Load (psf)	Floor Self-Weight (psf)
High Roof	3467	20	26
6th Floor	2929	20	172
Low Roof	5594	20	29
5th Balcony	2517	30	169
5th Floor	7937	20	151
4th Balcony	885	30	145
4th Floor	10453	20	171
3rd Floor	11338	20	171
2nd Floor	11338	20	171
1st Floor	11338	20	171

	Wall Weight							
Story	Tributary Wall Height (ft)				Wall Perimeter (ft)			
	Exterior		Bearing	Shear	Exterior		Bearing	Shear
High Roof	4.5	0.0	4.5	4.5	269.3	0.0	66.8	37.8
6th Floor	13.0	9.5	13.0	13.0	278.0	264.7	131.5	0.0
Low Roof	6.0	0.0	9.0	9.0	658.0	0.0	0.0	157.4
5th Balcony	13.0	10.0	0.0	0.0	108.7	638.0	0.0	0.0
5th Floor	15.5	6.0	15.5	13.0	201.3	618.7	131.5	157.4
4th Balcony	10.0	0.0	0.0	0.0	183.0	0.0	0.0	0.0
4th Floor	14.0	7.0	14.0	14.0	815.0	59.0	131.5	157.4
3rd Floor	14.0	0.0	14.0	14.0	494.2	0.0	131.5	157.4
2nd Floor	14.0	0.0	14.0	14.0	494.2	0.0	131.5	157.4
1st Floor	7.0	0.0	7.0	7.0	494.2	0.0	131.5	157.4

	Wall Weight				
Story	Wall Dead Load (psf)				Total Floor Weight (kips)
	Exterior		Bearing	Shear	
High Roof	55.0	55.0	80.4	97.2	267
6th Floor	55.0	55.0	80.4	97.2	1037
Low Roof	55.0	55.0	80.4	97.2	626
5th Balcony	55.0	55.0	80.4	97.2	930
5th Floor	55.0	55.0	80.4	97.2	2096
4th Balcony	55.0	55.0	80.4	97.2	256
4th Floor	55.0	55.0	80.4	97.2	3009
3rd Floor	55.0	55.0	80.4	97.2	2909
2nd Floor	55.0	55.0	80.4	97.2	2909
1st Floor	55.0	55.0	80.4	97.2	2537
Total					16575

Story Shear							
Story	wx (kips)	hx (ft)	k	wxhx^k	Cvx	V (kips)	Fx (kips)
High Roof	267	82	1.63	351371	0.053624	298	16.0
6th Floor	1037	73	1.63	1129559	0.172386	298	51.4
Low Roof	626	68	1.63	607560	0.092722	298	27.6
5th Balcony	930	56	1.63	657646	0.100366	298	29.9
5th Floor	2096	56	1.63	1482339	0.226226	298	67.4
4th Balcony	256	42	1.63	113065	0.017255	298	5.1
4th Floor	3009	42	1.63	1331600	0.203221	298	60.6
3rd Floor	2909	28	1.63	664613	0.101429	298	30.2
2nd Floor	2909	14	1.63	214729	0.032771	298	9.8
1st Floor	2537	0	1.63	0	0	298	0.0
Total	16575	NA	NA	6552483	1	NA	298

ii. PROPOSED CONCRETE STRUCTURAL SYSTEM

a. Foundation System

FINAL SIZING

FINAL FOUNDATION DESIGNS

USE 18" ϕ PILES, 105 TON, 210K COMPRESSIVE CAPACITY

BEARING CAPACITY OF SOIL = 1500 PSF

PILE CAP DESIGN

SIZE OF PILE CAP BASED INITIALLY ON GEOMERIC CONSTRAINTS

PUNCHING SHEAR

$q = \frac{P_u}{A} = \frac{P_u}{B^2}$ OR $\frac{P_u}{BL}$

$V_c = \phi 4\sqrt{f'_c}; \phi = 0.75$

$d^2\left(2V_c + \frac{q}{2}\right) + d\left(V_c + \frac{q}{2}\right)c_1 + d\left(V_c + \frac{q}{2}\right)c_2 \geq \frac{q}{2}(BL - c_1c_2)$

WIDE BEAM SHEAR

$V_u = ql$

$\phi V_n = \phi 2\sqrt{f'_c}\, bd; \phi = 0.75$

$\rho_{MIN} = 0.0018$

$A_{SMIN} = \rho_{MIN} bh$ - PILE CAP REINFORCEMENT

$A_{SMIN} = 0.005 c_1 c_2$ - COLUMN DOWEL REINFORCEMENT

ASSUMING STRIP FOOTING FOR MASONRY STAIR TOWER APPROXIMATELY ADEQUATE FOR CONCRETE SHEAR WALLS

	D+L (kips)								
Column	1st	2nd	3rd	4th	5th	Low Roof	6th	High Roof	P (kips)
Corner Column-A2	48	58	58	58	68	2	0	0	291
Exterior Column-B2	89	98	98	98	119	11	0	0	513
Interior Column-B5	139	139	139	139	188	55	0	0	798
Interior Column-C5	181	181	181	181	244	27	99	37	1134
Exterior Column-C6	111	111	111	112	158	5	76	19	704
	1.2D+1.6L+0.5Lr								Pu (kips)
Column	1st	2nd	3rd	4th	5th	Low Roof	6th	High Roof	
Corner Column-A2	62	74	74	74	88	2	0	0	353
Exterior Column-B2	116	127	127	127	157	15	0	0	629
Interior Column-B5	179	179	179	179	252	76	0	0	977
Interior Column-C5	210	210	210	210	277	38	115	52	1382
Exterior Column-C6	143	143	143	170	203	8	96	27	867

	Punching Shear				Wide Beam Shear			
Column	q (psi)	vc (psi)	Vl (kips)	Vr (kips)	q (psi)	*l* (in)	Vu (kips)	ϕVn (kips)
Corner Column-A2	88	164	699	159	88	38	3	265
Exterior Column-B2	92	164	700	296	92	54	5	350
Interior Column-B5	106	164	722	467	106	38	4	265
Interior Column-C5	96	164	795	659	96	63	6	414
Exterior Column-C6	94	164	793	402	94	36	3	265

	Pile Cap			
Column	Type	Size	Short Dir. Reinf.	Long Dir. Reinf.
Corner Column-A2	Rectangular	3'-6" x 8'-0" x 3'-1"	4- #8	9- #8
Exterior Column-B2	Triangular	10'-6" x 10'-6" x 10'-6" x 3'-1"	7- #10	7- #10
Interior Column-B5	Square	8'-0" x 8'-0"x 3'-1"	5- #10	5- #10
Interior Column-C5	Rectangular	8'-0" x 12'-6" x 3'-1"	5- #10	8- #10
Exterior Column-C6	Square	8'-0" x 8'-0"x 3'-1"	5- #10	5- #10

	Column				
Column	Size	Normal Reinf.	Normal ρ (%)	Dowel Reinf.	Dowel ρ (%)
Corner Column-A2	20"x20"	8- #10	2.54	4-#8	0.79
Exterior Column-B2	20"x20"	8- #10	2.54	4-#8	0.79
Interior Column-B5	20"x20"	4- #10	1.27	4-#8	0.79
Interior Column-C5	24"x28"	8- #8	0.94	4-#10	0.76
Exterior Column-C6	24"x28"	8- #8	0.94	4-#10	0.76

	Number of Piles	
Column	Required	Actual
Corner Column-A2	1.39	2
Exterior Column-B2	2.44	3
Interior Column-B5	3.80	4
Interior Column-C5	5.40	6
Exterior Column-C6	3.35	4

PRELIMINARY SIZING OF FRAMING SYSTEM

PRELIMINARY TWO-WAY FLAT SLAB THICKNESSES

SPAN WIDTH RATIO - ACI 9.5.3.2

24.42' : 27.67' 27.67' : 33.34'

1 : 1.33 ≤ 2 √OK 1 : 1.20 ≤ 2 √OK

SLAB THICKNESS MINIMUM = ACI 9.5.3.2, TABLE 9.5c

$\frac{\ell_n}{33} = \frac{(33.34')(12)}{33} = 12.12" \rightarrow 12.5" \geq 5"$ √OK

$\frac{\ell_n}{33} = \frac{(27.67')(12)}{33} = 10.06" \rightarrow 10.5" \geq 5"$ √OK

SEE FINAL SIZING: FINAL TWO-WAY FLAT SLAB DESIGNS

PRELIMINARY ONE-WAY SLAB WITH BEAMS THICKNESS

SLAB THICKNESS MINIMUM - ACI 9.5.2.1 - TABLE 9.5a

TWO ENDS CONTINUOUS

$\frac{\ell}{28} = \frac{(27.67')(12)}{28} = 11.86" \rightarrow 12"$

SEE FINAL SIZING: FINAL ONE-WAY SLAB WITH BEAMS DESIGN

FIRE RATING - IBC 2006 TABLE 706.4; TABLE 7.20.1 (3)

OCCUPANCY CATEGORY A

3 HR FIRE RATING

REINFORCED CONCRETE

$t > 2"$

FINAL SIZING

FINAL TWO-WAY FLAT SLAB DESIGNS

DROP PANELS - ACI 13.2.5
THICKNESS
FLOORS 1-4
$\frac{t}{4} = \frac{12''}{4} = 3'' < 6''$ VOK
FLOOR 5
$\frac{t}{4} = \frac{14''}{4} = 3.5'' < 6''$ VOK

WIDTHS
$\frac{\ell}{6} = \frac{12.17'}{6} = 2.028'$
$\frac{\ell}{6} = \frac{15'}{6} = 2.500'$
$\frac{\ell}{6} = \frac{19.17'}{6} = 3.195'$
$\frac{\ell}{6} = \frac{24.42'}{6} = 4.070'$
$\frac{\ell}{6} = \frac{27.67'}{6} = 4.612'$
$\frac{\ell}{6} = \frac{33.34'}{6} = 5.557'$

FINAL ONE-WAY SLAB WITH BEAMS DESIGN

ASSUMING BEAM 24" WIDE BASED ON COLUMN SIZE AND 24" DEEP INCLUDING THE SLAB THICKNESS

SEISMIC DIAPHRAGM LOADS - ASCE 7-05 12.10.1.1

$$F_{px} = \frac{\sum_{i=x}^{n} F_i}{\sum_{i=x}^{n} w_i} w_{px}$$

$0.2 S_{DS} I w_{px} \leq F_{px} \leq 0.4 S_{DS} I w_{px}$

DEFLECTION - PCA SLAB MANUAL 2-54
CONVERTING SHORT TERM DEFLECTION TO LONG TERM DEFLECTION
$\Delta_{TOTAL} = \Delta_{TOTAL,SUSTAINED}(1+\lambda_\Delta) + (\Delta_{LIVE} - \Delta_{LIVE,SUSTAINED})$
$\Delta_{DEAD} = \Delta_{DEAD,SUSTAINED}$
$\Delta_{LIVE} = \Delta_{LIVE,SUSTAINED} + \Delta_{LIVE,UNSUSTAINED}$
$\Delta_{TOTAL\ SUSTAINED} = \Delta_{DEAD} + \Delta_{LIVE,SUSTAINED}$
$\lambda_\Delta = \frac{\xi}{1+50\rho'}$
$\xi = 2.0$ FOR LOAD DURATION OF 5+ YEARS
ρ = RATIO OF COMPRESSIVE STRESS AT MIDSPAN

ACTUAL DEFLECTIONS

IF $\rho' = 0$

$\lambda\Delta = 2$

$\Delta_{TOTAL} = .3(\Delta_{DEAD} + \Delta_{LIVE,SUSTAINED}) + (\Delta_{LIVE} - \Delta_{LIVE,SUSTAINED})$

ALLOWABLE DEFLECTIONS

$\frac{L}{480}$

$\frac{(24.42')(12)}{480} = 0.611''$

$\frac{(27.67')(12)}{480} = 0.692''$

$\frac{(33.34')(12)}{480} = 0.834''$

SEE FRAMING PLANS FOR RESULTS

Diaphragm Seismic Loads						
Story	Fx (kips)	wpx (kips)	0.2*SDS*I*wpx (kips)	Fpx' (kips)	0.4*SDS*I*wpx (kips)	Fpx (kips)
High Roof	16.0	267	12.2	0.0	24.4	0.0
6th Floor	51.4	1037	47.4	26.5	94.9	47.4
Low Roof	27.6	626	28.6	0.0	57.3	0.0
5th Floor	97.3	1556	71.2	70.8	142.4	71.2
4th Floor	65.7	2352	107.6	47.8	215.2	107.6
3rd Floor	30.2	3009	137.7	61.2	275.4	137.7
2nd Floor	9.8	2909	133.1	59.1	266.1	133.1
1st Floor	0.0	2909	133.1	59.1	266.1	133.1
Total	298.0	14664				

Slab Deflection			
Story	Span	Actual Deflection (in)	Allowable Deflection (in)
6th Floor	33'-4"	0.221	0.834
5th Floor	27'-8"	0.372	0.692
	33'-4"	0.484	0.834
4th Floor	27'-8"	0.228	0.692
	33'-4"	0.644	0.834
3rd Floor	27'-8"	0.229	0.692
	33'-4"	0.644	0.834
2nd Floor	27'-8"	0.229	0.692
	33'-4"	0.644	0.834
1st Floor	27'-8"	0.229	0.692
	33'-4"	0.683	0.834

FINAL SIZING

2nd FLOOR CONCRETE TWO-WAY FLAT SLAB INTERIOR BAY BC-45 SPOT CHECK
DIRECT DESIGN
INTERIOR BAY - NORTH-SOUTH DIRECTION
27'-8" x 24'-5"
- ASSUMING FOR SPOT CHECK MORE THAN 3 CONTINUOUS SPANS OF EQUAL LENGTHS & LOADING ✓
- 27.67' : 24.42' → 1.13 : 1 < 2:1 √OK
- w_{LL} = 80 PSF < $w_{DL}+w_{SW}$ = 20 PSF + (145 PCF)(12")(1/12) = 165 PSF √OK
$w_u = 1.2D+1.6L = 1.2(w_{DL}+w_{SW})+1.6\,w_{LL} = 1.2(165\,PSF)+1.6(80\,PSF)$
$= 326$ PSF

$$M_o = \frac{w_u \ell_2 \ell_n^2}{8} = (326\,PSF)(27.67')(24.42' - (20")(1/12))^2(1/1000) = 584^{k'}$$

$M_u^- = 0.65M_o = 0.65(584^{k'}) = 380^{k'}$
$M_u^+ = 0.35M_o = 0.35(584^{k'}) = 204^{k'}$
$\alpha \frac{\ell_2}{\ell_1} = 0$

CS⁻ $M_u = 0.75(380^{k'}) = 285^{k'} \leq 287.52^{k'}$ √OK
MS⁻ $M_u = 0.25(380^{k'}) = 95^{k'} \leq 95.84^{k'}$ √OK
CS⁺ $M_u = 0.60(204^{k'}) = 122^{k'} \leq 124.93^{k'}$ √OK
MS⁺ $M_u = 0.40(204^{k'}) = 82^{k'} \leq 83.28^{k'}$ √OK
$A_{S_{MIN}} = 0.0018(12")(12") = 0.26\ IN^2/1' \rightarrow$ #5" @ 14" O.C. √OK

$$R = \frac{M_u}{\phi b d^2}$$

CS⁻ $R = \frac{285^{k'}(10^3)}{(0.90)(12.21')(12")^2} = 180 \rightarrow$ #5 @ 8" O.C. < #5 @ 6" O.C √OK
MS⁻ $R = \frac{95^{k'}(10^3)}{(0.90)(12.21')(12")^2} = 60 \rightarrow$ #5 @ 14" O.C. = #5 @ 14" O.C. √OK
CS⁺ $R = \frac{122^{k'}(10^3)}{(0.90)(12.21')(12")^2} = 77 \rightarrow$ #5 @ 14" O.C. < #5 @ 13" O.C. √OK
MS⁺ $R = \frac{82^{k'}(10^3)}{(0.90)(12.21')(12")^2} = 52 \rightarrow$ #5 @ 14" O.C. = #5 @ 14" O.C. √OK

$$V_u = \frac{w_u \ell}{2} = \frac{(326\,PSF)(24.42')(1/1000)}{2} = (3.98^{k}/')(24.42') = 97.2^{k} \leq 104.64^{k}$$ √OK

$\phi V_n = \phi 2\sqrt{f'_c}\,b d = (0.75)2\sqrt{5000\,PSI}\,(1/1000)(12")(11") = (14.0^{k}/')(24.42') = 342^{k} \leq 384.22^{k}$ √OK
$V_u = 97.2^{k} < \phi V_n = 342^{k}$ √OK

2nd Floor Concrete Two-Way Flat Slab Interior Bay BC-45 Spot Check PCA Slab Input (see Framing Plans)

```
                                 pcaSlab v1.51 (TM)
                A Computer Program Analysis, Design, and Investigation of
                  Reinforced Concrete Slab and Continuous Beam Systems

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================================================================================
[1] INPUT ECHO
================================================================================

General Information:
====================
   File name: C:\Documents and Settings\Rachel\My Documents\School\Spring 2008\AE 482\work\4. Final Sizing\Slabs\Nor
   Project:
   Frame:                                        Engineer:
   Code: ACI 318-02       Mode: Design           Reinforcement Database: ASTM A615
   Number of supports = 6 + Left cantilever + Right cantilever
   Floor System: Two-Way

   Live load pattern ratio = 100%
   Minimum free edge for punching shear = 10 times slab thickness
   Deflections are based on cracked section properties.
   In negative moment regions, Ig and Mcr DO NOT include flange/slab contribution (if available)
   Compression reinforcement calculations NOT selected.

Material Properties:
====================
              Slabs|Beams       Columns
              ------------   ------------
   wc     =          145            145 lb/ft3
   f'c    =            5              5 ksi
   Ec     =       4074.3         4074.3 ksi
   fr     =      0.53033        0.53033 ksi

   fy     =           60 ksi, Bars are not epoxy-coated
   fyv    =           60 ksi
   Es     =        29000 ksi

Reinforcement Database:
=======================
   Units: Db (in), Ab (in^2), Wb (lb/ft)
   Size       Db       Ab       Wb     Size       Db       Ab       Wb
   ---- -------- -------- --------     ---- -------- -------- --------
     #3     0.38     0.11     0.38       #4     0.50     0.20     0.67
```

#5	0.63	0.31	1.04	#6	0.75	0.44	1.50
#7	0.88	0.60	2.04	#8	1.00	0.79	2.67
#9	1.13	1.00	3.40	#10	1.27	1.27	4.30
#11	1.41	1.56	5.31	#14	1.69	2.25	7.65
#18	2.26	4.00	13.60				

Span Data:

Slabs: L1, wL, wR (ft); t, Hmin (in)

Span	Loc	L1	t	wL	wR	Hmin	
1	Int	1.500	12.00	13.800	13.800	4.00	LC
2	Int	24.420	12.00	13.800	13.800	9.10	
3	Int	24.420	12.00	13.800	13.800	8.15	
4	Int	33.340	12.00	13.800	13.800	10.34	
5	Int	24.420	12.00	13.800	13.800	8.15	
6	Int	24.420	12.00	13.800	13.800	9.10	
7	Int	1.500	12.00	13.800	13.800	4.00	RC

Support Data:

Columns: c1a, c2a, c1b, c2b (in); Ha, Hb (ft)

Supp	c1a	c2a	Ha	c1b	c2b	Hb	Red%
1	20.00	20.00	7.000	20.00	20.00	7.000	100
2	20.00	20.00	7.000	20.00	20.00	7.000	100
3	28.00	24.00	7.000	28.00	24.00	7.000	100
4	28.00	24.00	7.000	28.00	24.00	7.000	100
5	20.00	20.00	7.000	20.00	20.00	7.000	100
6	20.00	20.00	7.000	20.00	20.00	7.000	100

Drop Panels: h (in); L1, L2, W1, W2 (ft)

Supp	h	L1	L2	W1	W2	
1	---NONE---					
2	---NONE---					
3	4.00	4.070	5.557	4.600	4.600	*b
4	4.00	5.557	4.070	4.600	4.600	*b
5	---NONE---					
6	---NONE---					

*b- Standard drop.

Boundary Conditions: Kz (kip/in); Kry (kip-in/rad)

Supp	Spring Kz	Spring Kry	Far End A	Far End B
1	0	0	Fixed	Fixed
2	0	0	Fixed	Fixed
3	0	0	Fixed	Fixed
4	0	0	Fixed	Fixed
5	0	0	Fixed	Fixed
6	0	0	Fixed	Fixed

Load Data:

Load Cases and Combinations:

Case	SELF	Dead	Live
Type	DEAD	DEAD	LIVE
U1	1.200	1.200	1.600

Span Loads:

Span	Case	Wa
Area Loads - Wa (lb/ft2):		
1	Dead	513
2	Dead	20
3	Dead	20
4	Dead	20
5	Dead	20
6	Dead	20
7	Dead	513
2	Live	70
3	Live	80
4	Live	80
5	Live	80
6	Live	70

Support Loads - Fz (kip), My (k-ft):

Supp	Case	Fz	My
1	SELF	0	0
2	SELF	0	0
3	SELF	0	0
4	SELF	0	0

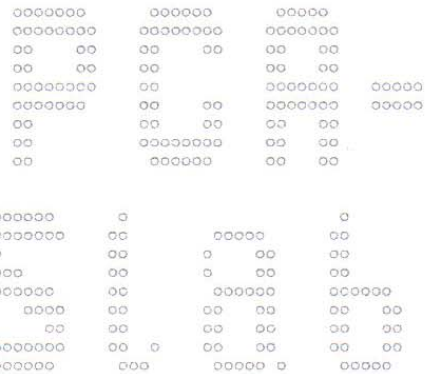
5	SELF	0	0
6	SELF	0	0

Support Displacements - Dz (in), Ry (rad):

Supp	Case	Dz	Ry
1	SELF	0	0
2	SELF	0	0
3	SELF	0	0
4	SELF	0	0
5	SELF	0	0
6	SELF	0	0

Reinforcement Criteria:

	Top bars		Bottom bars		Stirrups		
	Min	Max	Min	Max	Min	Max	
Slabs and Ribs:							
Bar Size	#5	#5	#5	#5			
Bar spacing	1.00	18.00	1.00	18.00			in
Reinf ratio	0.14	5.00	0.14	5.00			%
Cover	0.75		0.75				in
Beams:							
Bar Size	#6	#8	#6	#8	#3	#5	
Bar spacing	1.00	18.00	1.00	18.00	6.00	18.00	in
Reinf ratio	0.14	5.00	0.14	5.00			%
Cover	1.50		1.50				in



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Reinforced Concrete Slab and Continuous Beam Systems

[2] DESIGN RESULTS

Top Reinforcement:

Units: Width (ft), Mmax (k-ft), Xmax (ft), As (in^2), Sp (in)

Span	Strip	Zone	Width	Mmax	Xmax	AsMin	AsMax	SpReq	AsReq	Bars
1	Column	Left	12.21	0.62	0.233	3.165	34.054	13.320	0.013	11-#5
		Middle	12.21	2.07	0.433	3.165	34.054	13.320	0.042	11-#5
		Right	12.21	4.84	0.667	3.165	34.054	13.320	0.098	11-#5
	Middle	Left	15.39	0.00	0.233	3.989	42.924	14.206	0.000	13-#5
		Middle	15.39	0.00	0.433	3.989	42.924	14.206	0.000	13-#5
		Right	15.39	0.00	0.667	3.989	42.924	14.206	0.000	13-#5
2	Column	Left	12.21	124.97	0.833	3.165	34.054	13.320	2.568	11-#5
		Middle	12.21	0.00	12.210	0.000	34.054	0.000	0.000	---
		Right	12.21	308.14	23.587	3.165	34.054	6.977	6.443	21-#5
	Middle	Left	15.39	-0.00	0.833	3.989	42.924	14.206	0.000	13-#5
		Middle	15.39	0.00	12.210	0.000	42.924	0.000	0.000	---
		Right	15.39	102.72	23.587	3.989	42.924	14.206	2.102	13-#5
3	Column	Left	12.21	287.52	0.833	3.165	34.054	6.977	6.000	21-#5
		Middle	12.21	13.26	15.406	3.165	34.054	13.320	0.270	11-#5
		Right	12.21	391.14	23.253	3.960	35.043	5.427	5.972	27-#5
	Middle	Left	15.39	95.64	0.833	3.989	42.924	14.206	1.961	13-#5
		Middle	15.39	4.42	15.406	3.989	42.924	14.206	0.090	13-#5
		Right	15.39	130.38	23.253	3.989	42.924	14.206	2.674	13-#5
4	Column	Left	12.21	536.75	1.167	3.960	35.043	5.427	8.278	27-#5
		Middle	13.80	0.00	16.670	0.000	38.489	0.000	0.000	---
		Right	12.21	536.75	32.173	3.960	35.043	5.427	8.278	27-#5
	Middle	Left	15.39	178.92	1.167	3.989	42.924	14.206	3.683	13-#5

	Middle	13.80	0.00	16.670	0.000	38.489	0.000	0.000	---
	Right	15.39	178.92	32.173	3.989	42.924	14.206	3.683	13-#5
5 Column	Left	12.21	391.14	1.167	3.960	35.043	5.427	5.972	27-#5
	Middle	12.21	13.26	9.014	3.165	34.054	13.320	0.270	11-#5
	Right	12.21	287.54	23.587	3.165	34.054	6.977	6.001	21-#5
	Middle Left	15.39	130.38	1.167	3.989	42.924	14.206	2.674	13-#5
	Middle	15.39	4.42	9.014	3.989	42.924	14.206	0.090	13-#5
	Right	15.39	95.85	23.587	3.989	42.924	14.206	1.961	13-#5
6 Column	Left	12.21	308.16	0.833	3.165	34.054	6.977	6.444	21-#5
	Middle	12.21	0.00	12.210	0.000	34.054	0.000	0.000	---
	Right	12.21	125.00	23.587	3.165	34.054	13.320	2.569	11-#5
	Middle Left	15.39	102.73	0.833	3.989	42.924	14.206	2.103	13-#5
	Middle	15.39	0.00	12.210	0.000	42.924	0.000	0.000	---
	Right	15.39	-0.00	23.587	3.989	42.924	14.206	0.000	13-#5
7 Column	Left	12.21	4.85	0.833	3.165	34.054	13.320	0.099	11-#5
	Middle	12.21	2.07	1.067	3.165	34.054	13.320	0.042	11-#5
	Right	12.21	0.62	1.267	3.165	34.054	13.320	0.013	11-#5
	Middle Left	15.39	0.00	0.833	3.989	42.924	14.206	0.000	13-#5
	Middle	15.39	0.00	1.067	3.989	42.924	14.206	0.000	13-#5
	Right	15.39	0.00	1.267	3.989	42.924	14.206	0.000	13-#5

Top Bar Details:

Units: Length (ft)

		Left				Continuous		Right			
Span	Strip	Bars	Length	Bars	Length	Bars	Length	Bars	Length	Bars	Length
1	Column	---		---		11-#5	1.50	---		---	
	Middle	---		---		13-#5	1.50	---		---	
2	Column	11-#5	8.34	---		---		11-#5	8.34	10-#5	5.38
	Middle	13-#5	5.84	---		---		13-#5	7.70	---	
3	Column	10-#5	8.23	---		11-#5	24.42	8-#5	8.57	8-#5	5.65
	Middle	---		---		13-#5	24.42	---		---	
4	Column	14-#5	11.40	13-#5	7.37	---		14-#5	11.40	13-#5	7.37
	Middle	13-#5	9.99	---		---		13-#5	9.99	---	
5	Column	8-#5	8.57	8-#5	5.65	11-#5	24.42	10-#5	8.23	---	
	Middle	---		---		13-#5	24.42	---		---	
6	Column	11-#5	8.34	10-#5	5.38	---		11-#5	8.34	---	
	Middle	13-#5	7.70	---		---		13-#5	5.84	---	
7	Column	---		---		11-#5	1.50	---		---	
	Middle	---		---		13-#5	1.50	---		---	

Bottom Reinforcement:

Units: Width (ft), Mmax (k-ft), Xmax (ft), As (in^2), Sp (in)

Span	Strip	Width	Mmax	Xmax	AsMin	AsMax	SpReq	AsReq	Bars
1	Column	12.21	0.00	0.000	0.000	34.054	0.000	0.000	---
	Middle	15.39	0.00	0.000	0.000	42.924	0.000	0.000	---
2	Column	12.21	[illegible]	[illegible]	[illegible]	[illegible]	10.466	4.141	14-#5
	Middle	15.39	133.41	11.221	3.989	42.924	14.206	2.737	13-#5
3	Column	12.21	124.93	11.456	3.165	34.054	13.320	2.567	11-#5
	Middle	15.39	83.28	11.456	3.989	42.924	14.206	1.702	13-#5
4	Column	13.80	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5.319	18-#5
	Middle	13.80	170.90	16.545	3.577	38.489	13.800	3.521	12-#5
5	Column	12.21	124.93	12.964	3.165	34.054	13.320	2.567	11-#5
	Middle	15.39	83.28	12.964	3.989	42.924	14.206	1.702	13-#5
6	Column	12.21	200.11	13.199	3.165	34.054	10.466	4.141	14-#5
	Middle	15.39	133.41	13.199	3.989	42.924	14.206	2.737	13-#5
7	Column	12.21	0.00	1.500	0.000	34.054	0.000	0.000	---
	Middle	15.39	0.00	1.500	0.000	42.924	0.000	0.000	---

Bottom Bar Details:

Units: Start (ft), Length (ft)

Span	Strip	Long Bars: Bars	Long Bars: Start	Long Bars: Length	Short Bars: Bars	Short Bars: Start	Short Bars: Length
1	Column	---			---		
	Middle	---			---		
2	Column	14-#5	0.00	24.42	---		
	Middle	13-#5	0.00	24.42	---		
3	Column	11-#5	0.00	24.42	---		
	Middle	13-#5	0.00	24.42	---		
4	Column	18-#5	0.00	33.34	---		
	Middle	12-#5	0.00	33.34	---		
5	Column	11-#5	0.00	24.42	---		
	Middle	13-#5	0.00	24.42	---		
6	Column	14-#5	0.00	24.42	---		
	Middle	13-#5	0.00	24.42	---		
7	Column	---			---		
	Middle	---			---		

Flexural Capacity:

Units: From, To (ft), As (in^2), PhiMn (k-ft)

Span	Strip	From	To	AsTop	AsBot	PhiMn-	PhiMn+
1	Column	0.000	0.233	3.41	0.00	-165.32	0.00
		0.233	0.433	3.41	0.00	-165.32	0.00
		0.433	0.667	3.41	0.00	-165.32	0.00
		0.667	0.750	3.41	0.00	-165.32	0.00
		0.750	1.500	3.41	0.00	-165.32	0.00
	Middle	0.000	0.233	4.03	0.00	-195.56	0.00
		0.233	0.433	4.03	0.00	-195.56	0.00
		0.433	0.667	4.03	0.00	-195.56	0.00
		0.667	0.750	4.03	0.00	-195.56	0.00
		0.750	1.500	4.03	0.00	-195.56	0.00
2	Column	0.000	0.833	3.41	4.34	-165.32	209.53
		0.833	7.168	3.41	4.34	-165.32	209.53
		7.168	8.342	0.00	4.34	0.00	209.53
		8.342	8.797	0.00	4.34	0.00	209.53
		8.797	12.210	0.00	4.34	0.00	209.53
		12.210	15.623	0.00	4.34	0.00	209.53
		15.623	16.078	0.00	4.34	0.00	209.53
		16.078	17.622	0.00	4.34	0.00	209.53
		17.622	19.035	3.41	4.34	-165.32	209.53
		19.035	20.579	3.41	4.34	-165.32	209.53
		20.579	23.587	6.51	4.34	-311.23	209.53
		23.587	24.420	6.51	4.34	-311.23	209.53
	Middle	0.000	0.833	4.03	4.03	-195.56	195.56
		0.833	4.840	4.03	4.03	-195.56	195.56
		4.840	5.840	0.00	4.03	0.00	195.56
		5.840	8.797	0.00	4.03	0.00	195.56
		8.797	12.210	0.00	4.03	0.00	195.56
		12.210	15.623	0.00	4.03	0.00	195.56
		15.623	16.724	0.00	4.03	0.00	195.56
		16.724	17.724	0.00	4.03	0.00	195.56
		17.724	23.587	4.03	4.03	-195.56	195.56
		23.587	24.420	4.03	4.03	-195.56	195.56
3	Column	0.000	0.833	6.51	3.41	-311.23	165.32
		0.833	6.795	6.51	3.41	-311.23	165.32
		6.795	8.232	3.41	3.41	-165.32	165.32
		8.232	8.680	3.41	3.41	-165.32	165.32
		8.680	12.210	3.41	3.41	-165.32	165.32
		12.210	15.406	3.41	3.41	-165.32	165.32
		15.406	15.854	3.41	3.41	-165.32	165.32
		15.854	16.967	3.41	3.41	-165.32	165.32
		16.967	18.769	5.89	3.41	-282.38	165.32
		18.769	19.882	5.89	3.41	-282.38	165.32
		19.882	20.350	8.37	3.41	-396.77	165.32
		20.350	23.253	8.37	3.41	-542.46	165.32
		23.253	24.420	8.37	3.41	-542.46	165.32
	Middle	0.000	0.833	4.03	4.03	-195.56	195.56
		0.833	8.680	4.03	4.03	-195.56	195.56
		8.680	12.210	4.03	4.03	-195.56	195.56
		12.210	15.406	4.03	4.03	-195.56	195.56
		15.406	23.253	4.03	4.03	-195.56	195.56
		23.253	24.420	4.03	4.03	-195.56	195.56

4 Column	0.000	1.167	8.37	5.58	-542.46	268.67
	1.167	5.557	8.37	5.58	-542.46	268.67
	5.557	5.826	8.37	5.58	-396.77	268.67
	5.826	7.369	4.34	5.58	-209.53	268.67
	7.369	9.856	4.34	5.58	-209.53	268.67
	9.856	11.399	0.00	5.58	0.00	268.67
	11.399	12.019	0.00	5.58	0.00	268.67
	12.019	16.670	0.00	5.58	0.00	268.67
	16.670	21.321	0.00	5.58	0.00	268.67
	21.321	21.941	0.00	5.58	0.00	268.67
	21.941	23.484	0.00	5.58	0.00	268.67
	23.484	25.971	4.34	5.58	-209.53	268.67
	25.971	27.514	4.34	5.58	-209.53	268.67
	27.514	27.783	8.37	5.58	-396.77	268.67
	27.783	32.173	8.37	5.58	-542.46	268.67
	32.173	33.340	8.37	5.58	-542.46	268.67
Middle	0.000	1.167	4.03	3.72	-195.56	180.44
	1.167	8.567	4.03	3.72	-195.56	180.44
	8.567	9.992	0.00	3.72	0.00	180.44
	9.992	12.019	0.00	3.72	0.00	180.44
	12.019	16.670	0.00	3.72	0.00	180.44
	16.670	21.321	0.00	3.72	0.00	180.44
	21.321	23.348	0.00	3.72	0.00	180.44
	23.348	24.773	0.00	3.72	0.00	180.44
	24.773	32.173	4.03	3.72	-195.56	180.44
	32.173	33.340	4.03	3.72	-195.56	180.44
5 Column	0.000	1.167	8.37	3.41	-542.46	165.32
	1.167	4.070	8.37	3.41	-542.46	165.32
	4.070	4.538	8.37	3.41	-396.77	165.32
	4.538	5.651	5.89	3.41	-282.38	165.32
	5.651	7.453	5.89	3.41	-282.38	165.32
	7.453	8.566	3.41	3.41	-165.32	165.32
	8.566	9.014	3.41	3.41	-165.32	165.32
	9.014	12.210	3.41	3.41	-165.32	165.32
	12.210	15.740	3.41	3.41	-165.32	165.32
	15.740	16.188	3.41	3.41	-165.32	165.32
	16.188	17.625	3.41	3.41	-165.32	165.32
	17.625	23.587	6.51	3.41	-311.23	165.32
	23.587	24.420	6.51	3.41	-311.23	165.32
Middle	0.000	1.167	4.03	4.03	-195.56	195.56
	1.167	9.014	4.03	4.03	-195.56	195.56
	9.014	12.210	4.03	4.03	-195.56	195.56
	12.210	15.740	4.03	4.03	-195.56	195.56
	15.740	23.587	4.03	4.03	-195.56	195.56
	23.587	24.420	4.03	4.03	-195.56	195.56
6 Column	0.000	0.833	6.51	4.34	-311.23	209.53
	0.833	3.841	6.51	4.34	-311.23	209.53
	3.841	5.385	3.41	4.34	-165.32	209.53
	5.385	6.798	3.41	4.34	-165.32	209.53
	6.798	8.342	0.00	4.34	0.00	209.53
	8.342	8.797	0.00	4.34	0.00	209.53
	8.797	12.210	0.00	4.34	0.00	209.53
	12.210	15.623	0.00	4.34	0.00	209.53
	15.623	16.078	0.00	4.34	0.00	209.53
	16.078	17.253	0.00	4.34	0.00	209.53
	17.253	23.587	3.41	4.34	-165.32	209.53
	23.587	24.420	3.41	4.34	-165.32	209.53
Middle	0.000	0.833	4.03	4.03	-195.56	195.56
	0.833	6.696	4.03	4.03	-195.56	195.56
	6.696	7.696	0.00	4.03	0.00	195.56
	7.696	8.797	0.00	4.03	0.00	195.56
	8.797	12.210	0.00	4.03	0.00	195.56
	12.210	15.623	0.00	4.03	0.00	195.56
	15.623	18.580	0.00	4.03	0.00	195.56
	18.580	19.580	0.00	4.03	0.00	195.56
	19.580	23.587	4.03	4.03	-195.56	195.56
	23.587	24.420	4.03	4.03	-195.56	195.56
7 Column	0.000	0.750	3.41	0.00	-165.32	0.00
	0.750	0.833	3.41	0.00	-165.32	0.00
	0.833	1.067	3.41	0.00	-165.32	0.00
	1.067	1.267	3.41	0.00	-165.32	0.00
	1.267	1.500	3.41	0.00	-165.32	0.00
Middle	0.000	0.750	4.03	0.00	-195.56	0.00
	0.750	0.833	4.03	0.00	-195.56	0.00
	0.833	1.067	4.03	0.00	-195.56	0.00
	1.067	1.267	4.03	0.00	-195.56	0.00
	1.267	1.500	4.03	0.00	-195.56	0.00

Slab Shear Capacity:

Units: b, d (in), Xu (ft), PhiVc, Vu(kip)

Span	b	d	Vratio	PhiVc	Vu	Xu
1	331.20	10.94	1.000	384.22	0.00	0.00
2	331.20	10.94	1.000	384.22	102.81	22.68
3	331.20	10.94	1.000	384.22	104.64	22.34
4	331.20	10.94	1.000	384.22	135.50	21.76
5	331.20	10.94	1.000	384.22	104.64	2.08
6	331.20	10.94	1.000	384.22	102.81	1.74
7	331.20	10.94	1.000	384.22	0.00	0.00

Flexural Transfer of Negative Unbalanced Moment at Supports:

Units: Width (in), Munb (k-ft), As (in^2)

Supp	Width	GammaF*Munb	Comb	Pat	AsReq	AsProv	Additional Bars
1	56.00	106.34	U1	Even	2.217	1.303	3-#5
2	56.00	58.01	U1	Even	1.195	2.488	---
3	72.00	225.80	U1	Even	3.437	4.113	---
4	72.00	225.80	U1	Even	3.437	4.113	---
5	56.00	58.01	U1	Even	1.195	2.488	---
6	56.00	106.34	U1	Even	2.217	1.303	3-#5

Punching Shear Around Columns:

Units: Vu (kip), Munb (k-ft), vu (psi), Phi*vc (psi)

Supp	Vu	vu	Munb	Comb	Pat	GammaV	vu	Phi*vc
1	124.74	122.9	123.64	U1	Even	0.400	176.2	212.1
2	224.64	166.0	-35.58	U1	S2	0.400	177.8	212.1
3	277.42	113.4	230.15	U1	S3	0.412	145.7	212.1
4	277.42	113.4	-230.15	U1	S4	0.412	145.7	212.1
5	224.64	166.0	35.58	U1	S5	0.400	177.8	212.1
6	124.74	122.9	-123.64	U1	Even	0.400	176.2	212.1

Punching Shear Around Drops:

Units: Vu (kip), vu (psi), Phi*vc (psi)

Supp	Vu	Comb	Pat	vu	Phi*vc
1	--- Not applicable ---				
2	--- Not applicable ---				
3	258.62	U1	S3	47.7	152.9
4	258.62	U1	S4	47.7	152.9
5	--- Not applicable ---				
6	--- Not applicable ---				

Maximum Deflections:

Units: Dz (in)

	Frame			Column Strip			Middle Strip		
Span	Dz(DEAD)	Dz(LIVE)	Dz(TOTAL)	Dz(DEAD)	Dz(LIVE)	Dz(TOTAL)	Dz(DEAD)	Dz(LIVE)	Dz(TOTAL)
1	0.012	0.006	0.017	0.021	0.010	0.031	0.004	0.002	0.006
2	-0.068	-0.031	-0.100	-0.114	-0.052	-0.166	-0.032	-0.015	-0.047
3	-0.014	-0.007	-0.021	-0.022	-0.010	-0.032	-0.008	-0.004	-0.012
4	-0.123	-0.110	-0.233	-0.165	-0.149	-0.314	-0.080	-0.072	-0.151
5	-0.014	-0.007	-0.021	-0.022	-0.010	-0.032	-0.008	-0.004	-0.012
6	-0.068	-0.031	-0.100	-0.114	-0.052	-0.166	-0.032	-0.015	-0.047
7	0.012	0.006	0.017	0.021	0.010	0.031	0.004	0.002	0.006

Material Takeoff:

Reinforcement in the Direction of Analysis

Top Bars:	3372.6 lb	<=>	25.16 lb/ft	<=>	0.912 lb/ft^2
Bottom Bars:	3641.2 lb	<=>	27.17 lb/ft	<=>	0.984 lb/ft^2
Stirrups:	0.0 lb	<=>	0.00 lb/ft	<=>	0.000 lb/ft^2
Total Steel:	7013.7 lb	<=>	52.33 lb/ft	<=>	1.896 lb/ft^2
Concrete:	3758.0 ft^3	<=>	28.04 ft^3/ft	<=>	1.016 ft^3/ft^2

FINAL SIZING

FINAL BEAM DESIGNS

LIVE LOAD REDUCTION - ASCE 7-05 4.8

EXTERIOR BEAM - C6 - F6

$A_i = (1.5' + 8.5' + 19.17')(36.34') = 1060\ FT^2 > 400\ FT^2$ √OK

$L = 50\ PSF\left(0.25 + \frac{15}{\sqrt{1060\ FT^2}}\right) = 0.71(50\ PSF) = 36\ PSF$

> 0.50 √OK

INTERIOR BEAM - C5 - F5

$A_i = (8.5' + 19.17' + 27.67')(36.34') = 2011\ FT^2 > 400\ FT^2$ √OK

$L = 50\ PSF\left(0.25 + \frac{15}{\sqrt{2011\ FT^2}}\right) = 0.58(50\ PSF) = 30\ PSF$

> 0.50 √OK

EXTERIOR BEAM - C4 - C5

$A_i = (1.5' + 27.67')(36.34') = 1060\ FT^2 > 400\ FT^2$ √OK

$L = 50\ PSF\left(0.25 + \frac{15}{\sqrt{1060\ FT^2}}\right) = 0.71(50\ PSF) = 36.\ PSF$

> 0.50 √OK

FLEXURE - DESIGN OF CONCRETE STRUCTURE TABLE A.5

$R = \frac{M_u}{\phi b d^2}$

$A_s = \rho b d$

$\rho_{MAX} = 0.0243$

$\rho_{MIN} = 0.0035$

SHEAR - ACI 11.1.1, ACI 11.3.1, ACI 11.5.5

$V_u \leq \phi V_n = \phi V_c + \phi \frac{A_v f_y d}{s}$

$\phi V_c = 2\sqrt{f'_c}\, b_w d$

$A_{v\,MIN} = 0.75\sqrt{f'_c}\frac{b_w s}{f_y} \geq \frac{50\, b_w s}{f_y}$

$0.75\sqrt{5000\ PSI} = 53 > 50$ √OK

SEE FRAMING PLANS FOR RESULTS

Beam	Load Combination	b (in)	d (in)	Gravity Moment (kip*ft)	Lateral Moment (kip*ft)
Exterior Beam-C6-F6	1.2D+1.6WY+L	24	24	317	562
Interior Beam-C5-F5	1.2D+1.6WY+L	24	24	453	429
Exterior Beam-C4-C5	1.237D+1.0EX+L	28	12	168	86

Beam	Mu (kip*ft)	R (psi)	ρ	As	Flexural Reinforcement	As	ρ
Exterior Beam-C6-F6	365	352	0.0061	3.51	3-#10	3.81	0.0066
Interior Beam-C5-F5	501	483	0.0086	4.95	4-#10	5.08	0.0088
Exterior Beam-C4-C5	208	689	0.0126	4.23	4-#10	5.08	0.0151

Beam	Gravity Shear (kip)	Lateral Shear (kip)
Exterior Beam-C6-F6	34.9	2.99
Interior Beam-C5-F5	49.9	2.29
Exterior Beam-C4-C5	24.3	0.54

Beam	Vu (kip)	ϕVc (kip)	Av	Shear Reinforcement	Spacing (in)
Exterior Beam-C6-F6	37.9	61.1	0.11	#3	5"
Interior Beam-C5-F5	52.1	61.1	0.11	#3	5"
Exterior Beam-C4-C5	24.9	35.6	0.12	#3	5"

PRELIMINARY SIZING OF FRAMING SYSTEM

PRELIMINARY COLUMN SIZES

BASED UPON PCA SLAB RESULTS
ALL COLUMNS 16"x16"

SEE FINAL SIZING: FINAL COLUMN DESIGNS

FINAL SIZING

FINAL COLUMN DESIGNS

LIVE LOAD REDUCTION - ASCE 7-05 4.8

CORNER COLUMN A2

FLOORS 1-4

$A_i = (27.67')(24.42') + (27.67')(1.5') + (1.5')(24.42') = 754\ FT^2 > 400\ FT^2$ √OK

FLOOR 5

PUBLIC ASSEMBLY - NO REDUCTION

FLOORS 1-4

$L = (50\ PSF)\left(0.25 + \frac{15}{\sqrt{754\ FT^2}}\right) = 0.80(50\ FT^2) = 40\ PSF$

> 0.50 √OK

EXTERIOR COLUMN B2

FLOORS 1-4

UNBALANCED LOADS - NO REDUCTION

FLOOR 5

PUBLIC ASSEMBLY - NO REDUCTION

INTERIOR COLUMN B5

FLOORS 1-4

$A_i = 3(27.67')(24.42') + (27.67')(8.21') = 2365\ FT^2 > 400\ FT^2$ √OK

FLOOR 5

PUBLIC ASSEMBLY - NO REDUCTION

FLOORS 1-4

$L = (50\ PSF)\left(0.25 + \frac{15}{\sqrt{2365\ FT^2}}\right) = 0.56(50\ PSF) = 28\ PSF$

> 0.50 √OK

INTERIOR COLUMN C5

FLOORS 1-4

$A_i = 2(27.67')(24.42') + 2(27.67')(33.34') = 3196\ FT^2 > 400\ FT^2$ √OK

FLOOR 5

PUBLIC ASSEMBLY - NO REDUCTION

FLOOR 6

$A_i = 2(27.67')(33.34') + 2(27.67')(1.5') = 1928\ FT^2 > 400\ FT^2$ √OK

$A_T = 2(13.84')(16.67') + 2(13.84')(1.5') = 503\ FT^2$

$< (27.67')(1.5(27.67')) = 1148\ FT^2$ √OK

FLOORS 1-4

$L = (50\ PSF)\left(0.25 + \frac{15}{\sqrt{3196\ FT^2}}\right) = 0.52(50\ PSF) = 26\ PSF$

> 0.50 √OK

FLOOR 6

$L = (50\ PSF)\left(0.25 + \frac{15}{\sqrt{1928\ FT^2}}\right) = 0.59(50\ PSF) = 30\ PSF$

> 0.50 √OK

EXTERIOR COLUMN C6

FLOORS 1-3

$A_i = (15')(12.17') + (27.67')(24.42') + (15')(33.34') + (27.67')(33.34')$

$= 2281\ FT^2 > 400\ FT^2$ √OK

FLOOR 4
UNBALANCED LOADS - NO REDUCTION
FLOOR 5
PUBLIC ASSEMBLY - NO REDUCTION
FLOOR 6
$A_i = (27.67')(33.34') + (1.5')(33.34') + (27.67')(1.5') = 1014\ FT^2 > 400 FT^2$ VOK
$A_T = (13.84')(16.67') + (1.5')(16.67') + (13.84')(1.5') = 276\ FT^2$
$< (27.67')(1.5(27.67')) = 1148\ FT^2$ VOK

FLOORS 1-3
$L = (50\ PSF)\left(0.25 + \frac{15}{\sqrt{2281\ FT^2}}\right) = 0.56(50\ PSF) = 28\ PSF$
> 0.50 VOK

FLOOR 6
$L = (50\ PSF)\left(0.25 + \frac{15}{\sqrt{1014\ FT^2}}\right) = 0.72(50\ PSF) = 36\ PSF$
> 0.50 VOK

TOTAL ROOF WEIGHT
LOW ROOF
8(6.6 PLF)(13.17') = 695 LB
4(6.6 PLF)(14') = 370 LB
10(6.6 PLF)(27.67') = 1826 LB
2(14 PLF)(19.17') = 537 LB
2(22 PLF)(19.17') = 843 LB
4(26 PLF)(19.17') = 1994 LB
4(26 PLF)(27.67') = 2878 LB
4(14 PLF)(13.17') = 738 LB
2(14 PLF)(14') = 392 LB
2(55 PLF)(40.67') = 4474 LB
14747 LB / (166.67')(40.67') = 5.44 PSF → 6 PSF
TOTAL WEIGHT = 1.2(6 PSF + 20 PSF) + 1.6(33 PSF) = 84 PSF

HIGH ROOF
46(10 PLF)(33.34') = 15336 LB
4(31 PLF)(27.67') = 3431 LB
2(31 PLF)(19.17') = 1189 LB
2(31 PLF)(24.17') = 1499 LB
3(76 PLF)(33.34') = 7602 LB
4(14 PLF)(9.5') = 532 LB
2(14 PLF)(14.34') = 402 LB
29991 LB / (101')(36.34') = 8.17 PSF → 8.5 PSF
TOTAL = 1.2(8.5 PSF + 20 PSF) + 1.6(33 PSF) = 87 PSF

TRANSFER OF UNBALANCED MOMENT IN SLABS TO COLUMNS
INTERIOR COLUMN - ACI 13.6.9.2
$M_{ub} = 0.07[(q_{DU} + 0.5q_{LU})l_2 l_n^2 - q_{DU}' l_2' l_n'^2]$

EXTERIOR OR CORNER COLUMN - ACI 13.6.3.6, 13.6.2.2
$M_{ub} = 0.3M_0 = 0.3\left(\frac{q_u l_2 l_n^2}{8}\right)$

SLENDERNESS EFFECTS - ACI 10.12.2, 10.11.2

$\frac{k l_u}{r} \leq 34 - 12\left(\frac{M_1}{M_2}\right) \leq 40$

ASSUMING NONSWAY FRAMES

$k = 1.0$

BASEMENT

$l_u = 11'-0''$

FLOORS 1-4

$l_u = 14'-0''$

FLOOR 5

$l_u = 17'-0''$

FLOOR 6

$l_u = 9'-0''$

$r = 0.3 b_1$ or b_2

OVERSIZE COLUMN REDUCTION - ACI 10.8.4

IF $P_u << \phi P_n$ SMALL BAR CONFIGURATION

$A_{s\%}$ ASSMALLGST BAR CONFIGURATION: $\frac{P_u}{\phi P_n} > 0.5$

$\phi M_n = \phi M_n$ SMALLEST BAR CONFIGURATION, $A_{s\%} > M_u$

TIES - CRSI HANDBOOK TABLE 3-2

SPLICE LENGTH - CRSI HANDBOOK TABLE 5-2

SEE FRAMING PLANS FOR RESULTS

	Axial Load (kips)							
Column	1st	2nd	3rd	4th	5th	Low Roof	6th	High Roof
Corner Column-A2	62	74	74	74	88	2	0	0
Exterior Column-B2	116	127	127	127	157	15	0	0
Interior Column-B5	179	179	179	179	252	76	0	0
Interior Column-C5	210	210	210	210	277	38	115	52
Exterior Column-C6	143	143	143	170	203	8	96	27

	Total Axial Load (kips)						
Column	Basement	1st	2nd	3rd	4th	5th	6th
Corner Column-A2	373	311	238	164	90	2	0
Exterior Column-B2	670	554	427	300	172	15	0
Interior Column-B5	1044	865	686	507	328	76	0
Interior Column-C5	1324	1114	903	693	482	206	168
Exterior Column-C6	932	790	647	504	334	131	123

	Transferred Moment North-South Direction (kip*in)					
Column	1st	2nd	3rd	4th	5th	6th
Corner Column-A2	2057	2057	2057	2456	0	0
Exterior Column-B2	2057	2057	2057	2456	0	0
Interior Column-B5	743	743	743	1041	0	0
Interior Column-C5	2279	2279	2279	2851	3541	3546
Exterior Column-C6	2279	2279	2279	4720	5090	3669

	Transferred Moment East-West Direction (kip*in)					
Column	1st	2nd	3rd	4th	5th	6th
Corner Column-A2	2363	2363	2363	2820	0	0
Exterior Column-B2	2363	2363	2363	2820	0	0
Interior Column-B5	1211	1211	1211	1552	0	0
Interior Column-C5	1166	1166	1166	1632	2195	2893
Exterior Column-C6	1166	1166	1166	3850	4152	2993

	Lateral Moment North-South Direction (kip*in)	Lateral Moment East-West Direction (kip*in)
Column	6th	6th
Corner Column-A2	0	0
Exterior Column-B2	0	0
Interior Column-B5	0	0
Interior Column-C5	674	34
Exterior Column-C6	106	0

	Slenderness North-South Direction											
Column	1st		2nd		3rd		4th		5th		6th	
Corner Column-A2	19	34	19	22	19	22	19	24	NA	0	NA	0
Exterior Column-B2	19	34	19	22	19	22	19	24	NA	0	NA	0
Interior Column-B5	19	34	19	22	19	22	19	25	NA	0	NA	0
Interior Column-C5	16	34	16	22	16	22	16	24	16	24	15	40
Exterior Column-C6	16	34	16	22	16	22	16	28	16	23	15	40
	Slenderness East-West Direction											
Column	1st		2nd		3rd		4th		5th		6th	
Corner Column-A2	19	34	19	22	19	22	19	24	NA	0	NA	0
Exterior Column-B2	19	34	19	22	19	22	19	24	NA	0	NA	0
Interior Column-B5	19	34	19	22	19	22	19	25	NA	0	NA	0
Interior Column-C5	14	34	14	22	14	22	14	25	14	25	13	40
Exterior Column-C6	14	34	14	22	14	22	14	30	14	23	13	40

Corner Column A2								
Floor	Load Combination		Pu	Mu N-S	Mu E-W	ϕPn	ϕMn MA	ϕMn MI
Basement	1.2D+1.6L+0.5S		373	0	0	1269	2366	2366
1st Floor	1.2D+1.6L+0.5S		311	2057	2363	1269	2366	2366
2nd Floor	1.2D+1.6L+0.5S		238	2057	2363	1269	2366	2366
3rd Floor	1.2D+1.6L+0.5S		164	2057	2363	1269	2366	2366
4th Floor	1.2D+1.6L+0.5S		90	2456	2820	1586	2800	2800
Floor	Column Size	Bars	Bar Configuration			Ties	Tie Spacing (in)	
Basement	20"x20"	8-#10	3E			#3	18	
1st Floor	20"x20"	8-#10	3E			#3	18	
2nd Floor	20"x20"	8-#10	3E			#3	18	
3rd Floor	20"x20"	8-#10	3E			#3	18	
4th Floor	20"x20"	16-#10	5E			#3	18	
Floor	ρ (%)	Extended Bars				Splice Length (in)		
Basement	2.54	8-#10				38		
1st Floor	2.54	8-#10				38		
2nd Floor	2.54	8-#10				38		
3rd Floor	2.54	8-#10				38		
4th Floor	5.08	NA				NA		

Exterior Column B2								
Floor	Load Combination		Pu	Mu N-S	Mu E-W	ϕPn	ϕMn MA	ϕMn MI
Basement	1.2D+1.6L+0.5S		670	0	0	1269	2366	2366
1st Floor	1.2D+1.6L+0.5S		554	2057	2363	1269	2366	2366
2nd Floor	1.2D+1.6L+0.5S		427	2057	2363	1269	2366	2366
3rd Floor	1.2D+1.6L+0.5S		300	2057	2363	1269	2366	2366
4th Floor	1.2D+1.6L+0.5S		172	2456	2820	1586	2800	2800
Floor	Column Size	Bars	Bar Configuration			Ties	Tie Spacing (in)	
Basement	20"x20"	8-#10	3E			#3	18	
1st Floor	20"x20"	8-#10	3E			#3	18	
2nd Floor	20"x20"	8-#10	3E			#3	18	
3rd Floor	20"x20"	8-#10	3E			#3	18	
4th Floor	20"x20"	16-#10	5E			#3	18	
Floor	ρ (%)		Extended Bars			Splice Length (in)		
Basement	2.54		8-#10			38		
1st Floor	2.54		8-#10			38		
2nd Floor	2.54		8-#10			38		
3rd Floor	2.54		8-#10			38		
4th Floor	5.08		NA			NA		

Interior Column B5								
Floor	Load Combination		Pu	Mu N-S	Mu E-W	ϕPn	ϕMn MA	ϕMn MI
Basement	1.2D+1.6L+0.5S		1044	0	0	1111	2243	2243
1st Floor	1.2D+1.6L+0.5S		865	743	1211	1111	2243	2243
2nd Floor	1.2D+1.6L+0.5S		686	743	1211	668	1350	1350
3rd Floor	1.2D+1.6L+0.5S		507	743	1211	603	1220	1220
4th Floor	1.2D+1.6L+0.5S		328	1041	1552	765	1546	1546
Floor	Column Size	Bars	Bar Configuration			Ties	Tie Spacing (in)	
Basement	20"x20"	4- #10	2E			#3	18	
1st Floor	20"x20"	4- #10	2E			#3	18	
2nd Floor	20"x20"	4- #8	2E			#3	16	
3rd Floor	20"x20"	4- #8	2E			#3	16	
4th Floor	20"x20"	4- #8	2E			#3	16	
Floor	ρ (%)	Extended Bars				Splice Length (in)		
Basement	1.27	4- #10				38		
1st Floor	0.79	4- #10				38		
2nd Floor	0.79	4- #8				30		
3rd Floor	0.79	4- #8				30		
4th Floor	0.79	NA				NA		

Interior Column C5								
Floor	Load Combination		Pu	Mu N-S	Mu E-W	ϕPn	ϕMn MA	ϕMn MI
Basement	1.2D+1.6L+0.5S		1324	0	0	1572	4341	3689
1st Floor	1.2D+1.6L+0.5S		1114	2279	1166	1331	3677	3125
2nd Floor	1.2D+1.6L+0.5S		903	2279	1166	925	2554	2170
3rd Floor	1.2D+1.6L+0.5S		693	2279	1166	925	2554	2170
4th Floor	1.2D+1.6L+0.5S		482	2851	1632	1917	5262	4262
5th Floor	1.2D+1.6L+0.5S		206	3541	2195	1917	5262	4262
6th Floor	1.2D+1.6WY+L+0.5S		168	4220	2927	1917	5262	4262
Floor	Column Size	Bars	Bar Configuration			Ties	Tie Spacing (in)	
Basement	24"x28"	8-#8	3E			#3	16	
1st Floor	24"x28"	8-#8	3E			#3	16	
2nd Floor	24"x28"	8-#8	3E			#3	16	
3rd Floor	24"x28"	8-#8	3E			#3	16	
4th Floor	24"x28"	8-#10	3E			#3	18	
5th Floor	24"x28"	8-#10	3E			#3	18	
6th Floor	24"x28"	8-#10	3E			#3	18	
Floor	ρ (%)		Extended Bars			Splice Length (in)		
Basement	0.94		8-#8			30		
1st Floor	0.94		8-#8			30		
2nd Floor	0.94		8-#8			30		
3rd Floor	0.94		8-#8			30		
4th Floor	1.51		8-#10			38		
5th Floor	1.51		8-#10			38		
6th Floor	1.51		NA			NA		

Exterior Column C6								
Floor	Load Combination		Pu	Mu N-S	Mu E-W	ϕPn	ϕMn MA	ϕMn MI
Basement	1.2D+1.6L+0.5S		932	0	0	980	2707	2300
1st Floor	1.2D+1.6L+0.5S		790	2279	1166	980	2707	2300
2nd Floor	1.2D+1.6L+0.5S		647	2279	1166	980	2707	2300
3rd Floor	1.2D+1.6L+0.5S		504	2279	1166	980	2707	2300
4th Floor	1.2D+1.6L+0.5S		334	4720	3850	1917	5262	4262
5th Floor	1.2D+1.6L+0.5S		131	5090	4152	1917	5262	4262
6th Floor	1.2D+1.6L+0.5S		123	3774	2993	1917	5262	4262
Floor	Column Size	Bars	Bar Configuration			Ties	Tie Spacing (in)	
Basement	24"x28"	8-#8	3E			#3	16	
1st Floor	24"x28"	8-#8	3E			#3	16	
2nd Floor	24"x28"	8-#8	3E			#3	16	
3rd Floor	24"x28"	8-#8	3E			#3	16	
4th Floor	24"x28"	8-#10	3E			#3	18	
5th Floor	24"x28"	8-#10	3E			#3	18	
6th Floor	24"x28"	8-#10	3E			#3	18	
Floor	ρ (%)		Extended Bars			Splice Length (in)		
Basement	0.94		8-#8			30		
1st Floor	0.94		8-#8			30		
2nd Floor	0.94		8-#8			30		
3rd Floor	0.94		8-#8			30		
4th Floor	1.51		8-#10			38		
5th Floor	1.51		8-#10			38		
6th Floor	1.51		NA			NA		

FINAL SIZING

2nd FLOOR COLUMN SPOT CHECK

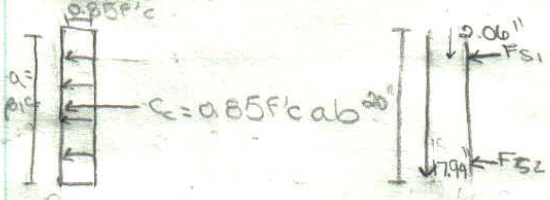
- SHORT COLUMN BASED ON SLENDERNESS CRITERIA PREVIOUSLY DEFINED
- ϕP_n EQUATION FROM ACI 10.3.6.2

$$\phi P_n = 0.80\,\phi\,[0.85 f'_c (A_g - A_{st}) + f_y A_{st}]$$

$$= 0.80(0.65)[0.85(5000\ PSI)((20")(20") - (4)(1.00\ in^2)) + (60000\ PSI)(4)(1.00\ in^2)]/1000$$

$$= 1000^k \times 1077^{\%}$$

- SMALLER THAN TABULATED VALUE DUE TO CHANGE OF ϕ FROM 0.70 TO 0.65, OKAY DUE TO DESIGN CONTROLLED BY BENDING



- ϕM_n PROCESS FROM CRSI HANDBOOK MANUAL EXAMPLE PG. 3-6

$$F_s = f_s A_s = \varepsilon_s E_s A_s = \varepsilon_c \left(1 - \frac{d_s}{c}\right) E_s A_s - 0.85 f'_c A_s$$

$$F_{s1} = (0.003)\left(1 - \frac{2.06"}{c}\right)(29000\ ksi)(2\ in^2) - (0.85)(5000\ PSI)(2\ in^2)(1/1000) = 174 - 8.5 - \frac{358}{c}$$

$$F_{s2} = (0.003)\left(1 - \frac{17.94"}{c}\right)(29000\ ksi)(2\ in^2) - (0.85)(5000\ PSI)(2\ in^2)(1/1000) = 174 - 8.5 - \frac{3122}{c}$$

$$C_c = 0.85 f'_c\, ab = 0.85 f'_c (0.80c) b = 0.85(5000\ PSI)(0.80)c\,(20")/1000 = \frac{68c}{331 + 68c - \frac{3507}{c}} = 1000^k/0.65$$

$$c = 20.3"$$

$$F_{s1} = (0.003)\left(1 - \frac{2.06"}{20.3"}\right)(29000\ ksi)(2\ in^2) - (0.85)(5000\ PSI)(2\ in^2)(1/1000) = 148^k$$

$$F_{s2} = (0.003)\left(1 - \frac{17.94"}{20.3"}\right)(29000\ ksi)(2\ in^2) - (0.85)(5000\ PSI)(2\ in^2)(1/1000) = 12^k$$

$$M_s = F_s\left(\frac{h}{2} - d_s\right)$$

$$M_{s1} = (148^k)\left(\frac{20"}{2} - 2.06"\right) = 1175^{k"}$$

$$M_{s2} = (12^k)\left(\frac{20"}{2} - 17.94"\right) = -95^{k"}$$

$$C_c = 0.85 f'_c\, ab = 0.85 f'_c (0.80c) b = 0.85(5000\ PSI)(0.80)(20.3")(20") \div 1000 = 1380^k$$

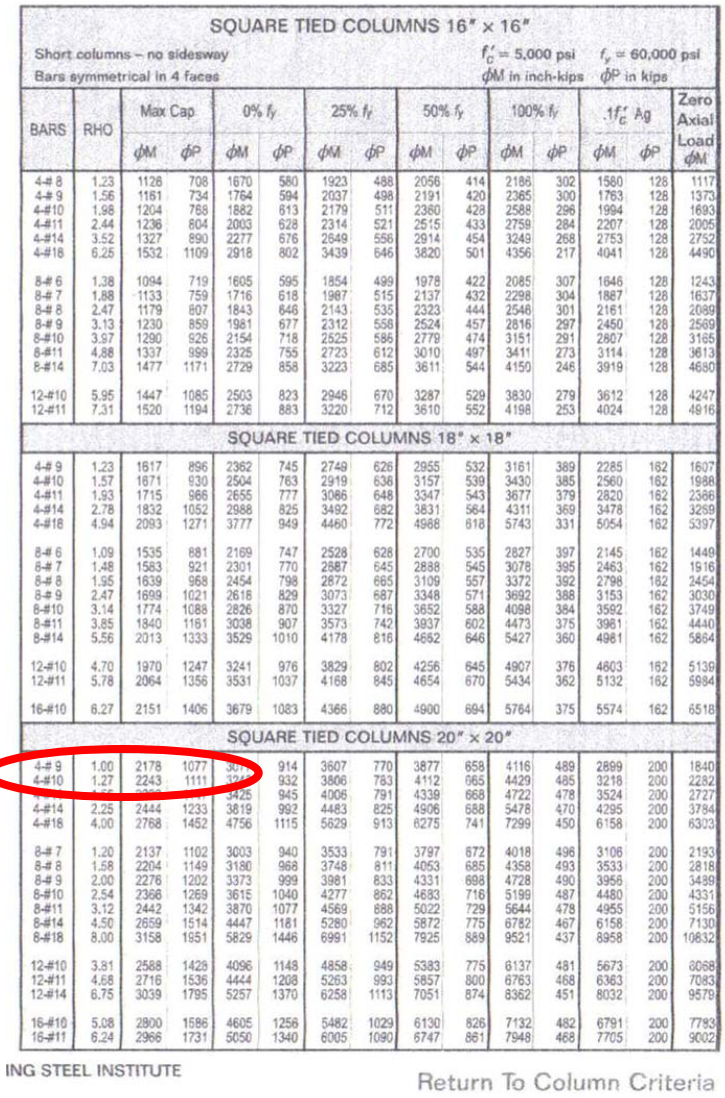
$$M_c = C_c\left(\frac{h}{2} - a\right) = C_c\left(\frac{h - 0.80c}{2}\right) = (1380^k)\left(\frac{20" - (0.80)(20.3")}{2}\right) = 2594^{k"}$$

$$\phi M_n = \phi(M_{s1} + M_{s2} + M_c) = (0.65)(1175 - 95^{k"} + 2594^{k"}) = 2388^{k"} > 2178^{k"} \quad \checkmark\ ok$$

2nd Floor Concrete Column C2 Spot Check CRSI Handbook Results (see Framing Plans)

Floor	Load Combination	Pu	Mu N-S	Mu E-W
2nd Floor	1.2D+1.6L+0.5S	686	743	1211
Design		ϕPn	ϕMn MA	ϕMn MI
Actual		1077	2178	2178
Reduced		668	1350	1350
Column Size		Bars		Bar Spacing
20"x20"		4-#9		2E
20"x20"		4- #8		2E

2nd Floor Concrete Column C2 Spot Check CRSI Handbook Table



SQUARE TIED COLUMNS 16" × 16"

Short columns – no sidesway
Bars symmetrical in 4 faces
f'_c = 5,000 psi f_y = 60,000 psi
ϕM in inch-kips ϕP in kips

BARS	RHO	Max Cap		0% f_y		25% f_y		50% f_y		100% f_y		$.1f'_c$ Ag		Zero Axial Load
		ϕM	ϕP	ϕM	ϕP	ϕM	ϕP	ϕM	ϕP	ϕM	ϕP	ϕM	ϕP	ϕM
4-# 8	1.23	1126	708	1670	580	1923	488	2056	414	2186	302	1560	128	1117
4-# 9	1.56	1161	734	1764	594	2037	498	2191	420	2365	300	1763	128	1373
4-#10	1.98	1204	768	1882	613	2179	511	2360	428	2588	296	1994	128	1693
4-#11	2.44	1236	804	2003	628	2314	521	2515	433	2759	284	2207	128	2005
4-#14	3.52	1327	890	2277	676	2649	556	2914	454	3249	268	2753	128	2752
4-#18	6.25	1532	1109	2918	802	3439	646	3820	501	4356	217	4041	128	4490
8-# 6	1.38	1094	719	1605	595	1854	499	1978	422	2085	307	1646	128	1243
8-# 7	1.88	1133	759	1716	618	1987	515	2137	432	2298	304	1887	128	1637
8-# 8	2.47	1179	807	1843	646	2143	535	2323	444	2548	301	2161	128	2089
8-# 9	3.13	1230	859	1981	677	2312	558	2524	457	2816	297	2450	128	2569
8-#10	3.97	1290	926	2154	718	2525	586	2779	474	3151	291	2807	128	3165
8-#11	4.88	1337	999	2325	755	2723	612	3010	497	3411	273	3114	128	3813
8-#14	7.03	1477	1171	2729	858	3223	685	3611	544	4150	246	3919	128	4680
12-#10	5.95	1447	1085	2503	823	2946	670	3287	529	3830	279	3612	128	4247
12-#11	7.31	1520	1194	2736	883	3220	712	3610	552	4198	253	4024	128	4916
SQUARE TIED COLUMNS 18" × 18"														
4-# 9	1.23	1617	896	2362	745	2749	626	2955	532	3161	389	2285	162	1607
4-#10	1.57	1671	930	2504	763	2919	636	3157	539	3430	385	2560	162	1988
4-#11	1.93	1715	966	2655	777	3066	648	3347	543	3677	379	2820	162	2386
4-#14	2.78	1832	1052	2988	825	3492	682	3831	564	4311	369	3478	162	3259
4-#18	4.94	2093	1271	3777	949	4460	772	4988	618	5743	331	5054	162	5397
8-# 6	1.09	1535	881	2169	747	2528	628	2700	535	2827	397	2145	162	1449
8-# 7	1.48	1583	921	2301	770	2687	645	2888	545	3078	395	2463	162	1916
8-# 8	1.95	1639	968	2454	798	2872	665	3109	557	3372	392	2798	162	2454
8-# 9	2.47	1699	1021	2618	829	3073	687	3348	571	3692	388	3153	162	3030
8-#10	3.14	1774	1088	2826	870	3327	716	3652	588	4098	384	3592	162	3749
8-#11	3.85	1840	1161	3038	907	3573	742	3937	602	4473	375	3981	162	4440
8-#14	5.56	2013	1333	3529	1010	4178	816	4662	646	5427	360	4981	162	5864
12-#10	4.70	1970	1247	3241	976	3829	802	4256	645	4907	376	4603	162	5139
12-#11	5.78	2064	1356	3531	1037	4168	845	4654	670	5434	362	5132	162	5984
16-#10	6.27	2151	1406	3679	1083	4366	880	4900	694	5764	375	5574	162	6518
SQUARE TIED COLUMNS 20" × 20"														
4-# 9	1.00	2178	1077	3675	914	3607	770	3877	658	4116	489	2899	200	1840
4-#10	1.27	2243	1111	3748	932	3806	783	4112	665	4429	485	3218	200	2282
				3825	945	4006	791	4339	668	4722	478	3524	200	2727
4-#14	2.25	2444	1233	3819	992	4483	825	4906	688	5478	470	4295	200	3784
4-#18	4.00	2768	1452	4756	1115	5629	913	6275	741	7299	450	6158	200	6303
8-# 7	1.20	2137	1102	3003	940	3533	791	3797	672	4018	496	3106	200	2193
8-# 8	1.58	2204	1149	3180	968	3748	811	4053	685	4358	493	3533	200	2818
8-# 9	2.00	2276	1202	3373	999	3981	833	4331	698	4728	490	3956	200	3489
8-#10	2.54	2366	1269	3615	1040	4277	862	4683	716	5199	487	4480	200	4331
8-#11	3.12	2442	1342	3870	1077	4569	888	5022	729	5644	478	4955	200	5156
8-#14	4.50	2659	1514	4447	1181	5280	962	5872	775	6782	467	6158	200	7130
8-#18	8.00	3158	1951	5829	1446	6991	1152	7925	889	9521	437	8958	200	10832
12-#10	3.81	2588	1428	4096	1148	4858	949	5383	775	6137	481	5673	200	6068
12-#11	4.68	2716	1536	4444	1208	5263	993	5857	800	6763	468	6363	200	7083
12-#14	6.75	3039	1795	5257	1370	6258	1113	7051	874	8362	451	8032	200	9579
16-#10	5.08	2800	1586	4605	1256	5482	1029	6130	826	7132	482	6791	200	7783
16-#11	6.24	2966	1731	5050	1340	6005	1090	6747	861	7948	468	7705	200	9002

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Return To Column Criteria

FINAL SIZING

FINAL SHEAR WALL DESIGNS

SEISMIC VERTICAL COMBINATIONS - ASCE 7-05 12.2.3.1
ORDINARY REINFORCED CONCRETE SHEAR WALLS / MOMENT FRAMES
EXCEPTION: OTHER SUPPORTED STRUCTURAL SYSTEMS
6th FLOOR & HIGH ROOF = 1037k + 267k = 1304k
10% TOTAL BUILDING WEIGHT = (0.10)(16875k) = 1658k OK
SEE DESIGN LOADS FOR WEIGHTS

RIGID DIAPHRAGMS - ASCE 7-05 12.3.1.2
FLOORS 1-4, 6
SPAN / t = 33.34' / 12" = 2.78' / 1" ≈ 3" / 1" OK
FLOOR 5
SPAN / t = 33.34' / 14" = 2.38' / 1" ≈ 3" / 1" OK
LOW ROOF, HIGH ROOF
FLEXIBLE DIAPHRAGMS

SEISMIC REDUNDANCY FACTOR - ASCE 7-05 12.3.4
SEISMIC DESIGN CATEGORY B
$\rho = 1.0$

WIND LOAD CASES - ASCE 7-05 6.5.12.3
CASE 1
Wx, Wy
CASE 2
$W_{XT} = 0.75 W_X + MT_X$, $W_{YT} = 0.75 W_Y + MT_Y$
CASE 3
$W_X W_Y = 0.75 W_X + 0.75 W_Y$
CASE 4
$W_X W_Y T = 0.563 W_X + 0.563 W_Y + MT$
SEE FINAL SIZING: TORSION FOR MT

SEISMIC LOAD COMBINATIONS - ASCE 7-05 12.4.2.3, 12.4.2.2
$S_{DS} = 0.183 > 0.125$, MUST USE Ev
$(1.2 + 0.2 S_{DS})D + \rho Q_E + L + 0.2S = (1.2 + (0.2)(0.183))D + (1.0)E + L + 0.2S$
$= 1.237D + 1.0E + L + 0.2S$
$(0.9 - 0.2 S_{DS})D + \rho Q_E = (0.9 - (0.2)(0.183))D + (1.0)E = 0.863D + 1.0E$

SEISMIC DIRECTION OF LOADING - ASCE 7-05 12.5.2
SEISMIC DESIGN CATEGORY B
ORTHOGONAL DIRECTIONS MAY BE ANALYZED INDEPENDENTLY

CRACKED SECTIONS - ASCE 7-05 12.7.3
SHEAR WALL PIER – MEMBRANE $f_{22} = 0.70$
SHEAR WALL SPANDREL - MEMBRANE $f_{22} = 0.35$

TOTAL FLOOR MASS PER AREA

$m = \frac{E}{a} = \frac{\text{TOTAL FLOOR WEIGHT}}{(\text{FLOOR AREA})(32.2\ \text{FT/S}^2)(12)^3}$

STRUCTURAL IRREGULARITIES - ASCE 7-05 12.3.3

HORIZONTAL STRUCTURAL IRREGULARITIES - ASCE 7-05 TABLE 12.3-1

1a- TORSIONAL } CONDITIONS OF ASCE 7-05 12.7.3- STRUCTURAL MODELING ALREADY MET

1b. EXTREME TORSIONAL

2. REENTRANT CORNER } NOT APPLICABLE

3. DIAPHRAGM DISCONTINUITY

4. OUT-OF-PLANE OFFSETS

5. NONPARALLEL SYSTEMS

VERTICAL STRUCTURAL IRREGULARITIES - ASCE 7-05 TABLE 12.3-2

1a. STIFFNESS SOFT STORY

1b. STIFFNESS - EXTREME SOFT STORY

2. WEIGHT (MASS)

3. VERTICAL GEOMETRIC

4. IN-PLANE DISCONTINUITY IN VERTICAL LATERAL FORCE RESISTING ELEMENT

5a. DISCONTINUITY IN STRENGTH - WEAK STORY

5b. DISCONTINUITY IN STRENGTH - EXTREME WEAK STORY

ALL NOT APPLICABLE

SEE FRAMING PLANS FOR RESULTS

Additional Masses				
Story	Floor Area (sf)	Floor Dead Load (psf)	Floor Self-Weight (psf)	Total Floor Mass Per Area (kip*s^2/in^3)
High Roof	3467	20	26	1.383E-06
6th Floor	2929	20	172	6.362E-06
Low Roof	5594	20	29	1.006E-06
5th Floor	7937	20	151	9.350E-06
4th Floor	10453	20	171	6.536E-06
3rd Floor	11338	20	171	4.611E-06
2nd Floor	11338	20	171	4.611E-06

Pier	Flexural Reinf.	Spacing (in)	Shear Reinf.	As/s (in^2/ft)	Spacing (in)
WA	#4	12	#4	0.240	10
WA7	#4	12	#4	0.240	10
WG4	#4	12	#4	0.240	10
WH	#4	12	#4	0.240	10
W43A	#4	12	#4	0.240	10
W43H	#4	12	#4	0.240	10
W5A	#4	12	#4	0.240	10
W5H	#4	12	#4	0.240	10
Spandrel	Flexural Reinf.	As (in^2)	Vert. Shear Reinf.	As/s (in^2/ft)	As (in^2)
SA7	4- #4	0.657	4 legs- #4	0.24	0.92
SG4	4- #4	0.743	4 legs- #4	0.24	0.92

Spandrel	Horizontal Shear Reinf.	As/s (in^2/ft)	Spacing (in)
SA7	#4	0.144	12
SG4	#4	0.144	12

FINAL SIZING

2nd FLOOR CONCRETE SHEAR WALL WA SPOT CHECK

THICKNESS: 8"
HEIGHT: 14'-0"
SPAN: 25'-4"

A) CHECK NEED FOR BOUNDARY ELEMENT

$f_c = \frac{M_u h_w/2}{I_g} = \frac{(2380^{k}/_{ft})(14'/2)}{\frac{(8")(1/12)(25.34')^3}{12}} = 184\ ksf\ (1/144) = 0.128\ ksi$

$0.2f'_c = (0.2)(5000\ psi)(1/1000) = 1.00\ ksi$

$f_c = 0.128\ ksi < 0.2f'_c = 1.00\ ksi$

BOUNDARY ELEMENTS NOT REQUIRED ✓OK

B) LONGITUDINAL & TRANSVERSE REINFORCEMENT

$V_u = 132^k < 2A_{cv}\sqrt{f'_c} = 2(8")(25.34')(12)\sqrt{5000\ psi}\ (1/1000) = 344^k$

1 CURTAIN NEEDED - 2 PROVIDED ✓OK

c) REQUIRED ρ_l & ρ_t

$\rho_l, \rho_t > 0.0025$

$A_{cv} = (8")(12") = 96\ in^2/'$

$A_{s\,LONG} = \rho_l, \rho_t A_{cv} = (0.0025)(96\ in^2/') = 0.240\ in^2/' < 2(0.20\ in^2/') = 0.40\ in^2/'$ ✓OK

D) NOMINAL SHEAR CAPACITY

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

$A_{cv} = (8")(25.34')(12") = 2433\ in^2$

$\alpha_c = \frac{14'}{25.34'} = 0.55 < 2$

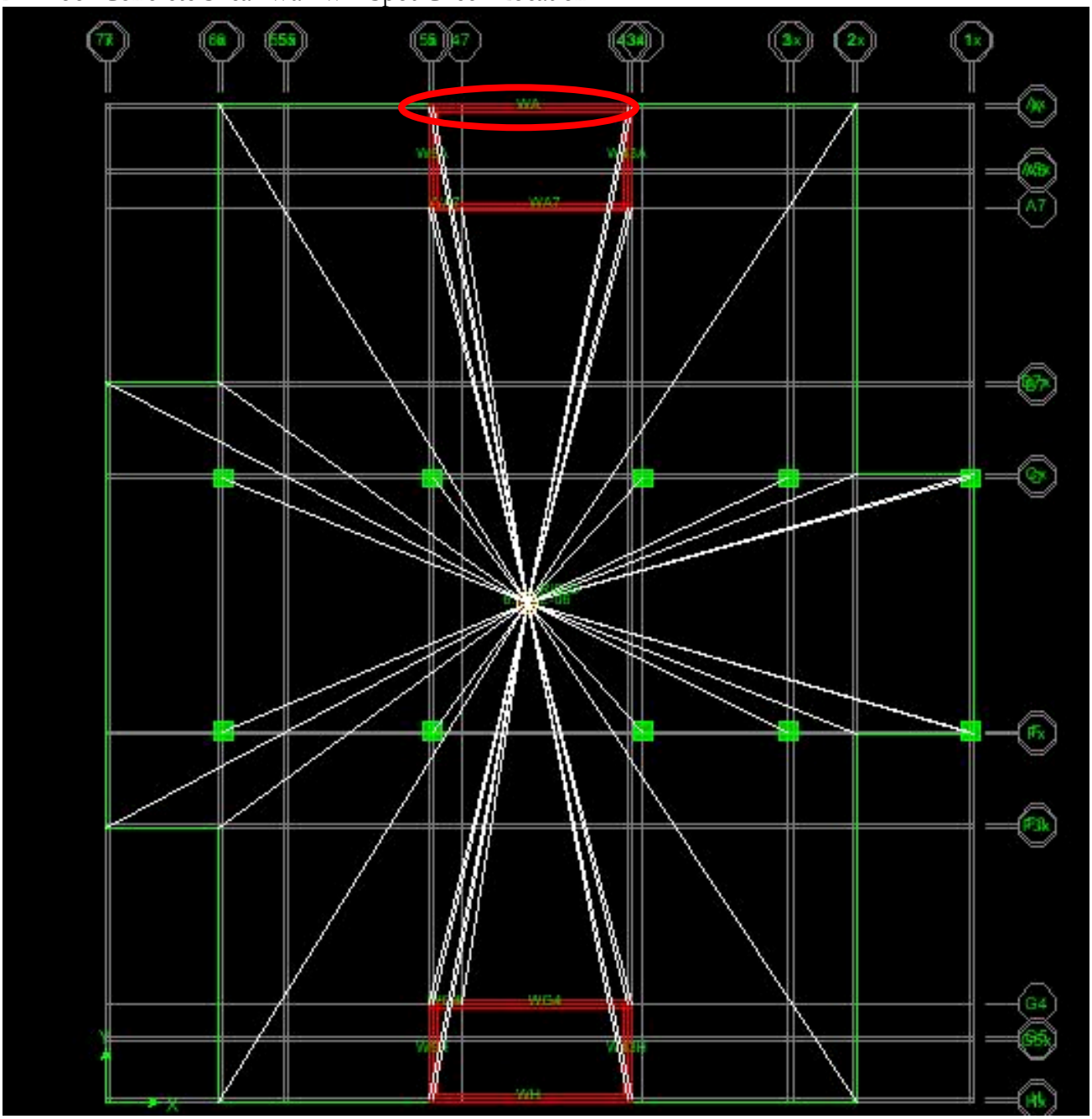
$\phi V_n = (0.60)(2433\ in^2)(0.55\sqrt{5000\ psi}\ (1/1000) + (0.0044)(60.0\ ksi)) = 442^k$

$V_u = 132^k < \phi V_n = 442^k$ ✓OK

2nd Floor Concrete Shear Wall WA Spot Check ETABS Results

Loads-1.2D-1.6WX			Reinforcement			
Pu (kips)	Vu (kips)	Mu (kip*ft)	Reinforcement	Spacing (in)	ρ (%) Provided	ρ (%) Required
225	132	2380	#4	12	0.044	0.040

2nd Floor Concrete Shear Wall WA Spot Check Location



FINAL SIZING

DRIFT

WIND

$\delta_{xw} \leq \delta_a = \frac{h_{sx}}{400} = 0.0025\, h_{sx}$

SEISMIC - ASCE 7-05 12.8.6, ASCE 7-05 12.12.1

$\delta_x = \frac{C_d \delta_{xe}}{I} = \frac{4.5\,\delta_{xe}}{1.25} = 3.6\,\delta_{xe}$

C_d = 4 1/2 ORDINARY REINFORCED CONCRETE SHEAR WALLS
2 1/2 ORDINARY REINFORCED CONCRETE MOMENT FRAMES

C_d = 4 1/2 - ASCE 7-05 12.2.3.2

OCCUPANCY CATEGORY III

$\delta_x = 3.6\,\delta_{xe} \leq \delta_a = 0.015\, h_{sx}$

$\delta_{xe} \leq \delta_a = 0.0042\, h_{sx}$

	Wind Displacement				Seismic Displacement			
Story	δx (in)	Δx (in)	δy (in)	Δy (in)	δx (in)	Δx (in)	δy (in)	Δy (in)
HIGH ROOF	0.0545	0.1605	0.1037	0.3974	0.3342	0.8096	0.2412	1.0641
6TH FLOOR	0.0278	0.1060	0.0571	0.2937	0.1720	0.4755	0.1325	0.8229
LOW ROOF	0.0243	0.0782	0.0769	0.2366	0.1210	0.3035	0.1950	0.6904
5TH FLOOR	0.0178	0.0539	0.0596	0.1597	0.0647	0.1825	0.1688	0.4953
4TH FLOOR	0.0161	0.0361	0.0465	0.1001	0.0570	0.1179	0.1310	0.3266
3RD FLOOR	0.0129	0.0199	0.0359	0.0535	0.0423	0.0608	0.0978	0.1956
2ND FLOOR	0.0070	0.0070	0.0177	0.0177	0.0185	0.0185	0.0978	0.0978

Wind Drift					
Story	Load Combination	δx (in)	Load Combination	δy (in)	δa
HIGH ROOF	1.2D-1.6WX	0.0545	1.2D+1.6WY	0.1037	0.2700
6TH FLOOR	1.2D-1.6WX	0.0278	1.2D+1.6WY	0.0571	0.1500
LOW ROOF	1.2D-1.6WX	0.0243	1.2D+1.6WY	0.0769	0.3600
5TH FLOOR	1.2D-1.6WX	0.0178	1.2D+1.6WY	0.0596	0.4200
4TH FLOOR	1.2D-1.6WX	0.0161	1.2D+1.6WY	0.0465	0.4200
3RD FLOOR	1.2D-1.6WX	0.0129	1.2D+1.6WY	0.0359	0.4200
2ND FLOOR	1.2D-1.6WX	0.0070	1.2D+1.6WY	0.0177	0.3300
Seismic Drift					
Story	Load Combination	δx (in)	Load Combination	δy (in)	δa
HIGH ROOF	1.237D-1.0EX	0.3342	1.237D+1.0EY	0.2412	1.6200
6TH FLOOR	1.237D-1.0EX	0.1720	1.237D+1.0EY	0.1325	0.9000
LOW ROOF	1.237D-1.0EX	0.1210	1.237D+1.0EY	0.1950	2.1600
5TH FLOOR	1.237D-1.0EX	0.0647	1.237D+1.0EY	0.1688	2.5200
4TH FLOOR	1.237D-1.0EX	0.0570	1.237D+1.0EY	0.1310	2.5200
3RD FLOOR	1.237D-1.0EX	0.0423	1.237D+1.0EY	0.0978	2.5200
2ND FLOOR	1.237D-1.0EX	0.0185	1.237D+1.0EY	0.0978	1.9800

FINAL SIZING

OVERTURNING

WIND / SEISMIC OVERTURNING - ASCE 7-05 12.8.5

$\Sigma M_{OVERTURNING} = \sum_{i=\#\,STORIES} F_i h_i$

$\Sigma M_{RESISTING} = \sum_{i=\#\,STORIES} W_i h_i$

F_i = STORY SHEAR
W_i = STORY WEIGHT
h_i = STORY HEIGHT
$\Sigma M_{OVERTURNING} \leq \Sigma M_{RESISTING}$

0.9D+1.6WX					
Story	Height (ft)	Effective Shear (kips)	Effective Weight (kips)	Moverturning (kip*ft)	Mresisting (kip*ft)
High Roof	82	6	267	743	19693
6th Floor	73	16	1037	1888	68117
Low Roof	68	17	626	1829	38313
5th Floor	56	72	3026	6471	152509
4th Floor	42	63	3265	4255	123414
3rd Floor	28	61	2909	2738	73300
2nd Floor	14	59	2909	1326	36650
1st Floor	0	29	2537	0	0
Total				19251	511995
0.9D+1.6WY					
Story	Height (ft)	Effective Shear (kips)	Effective Weight (kips)	Moverturning (kip*ft)	Mresisting (kip*ft)
High Roof	82	17	267	2195	19693
6th Floor	73	48	1037	5577	68117
Low Roof	68	14	626	1524	38313
5th Floor	56	55	3026	4907	152509
4th Floor	42	55	3265	3711	123414
3rd Floor	28	53	2909	2392	73300
2nd Floor	14	52	2909	1160	36650
1st Floor	0	26	2537	0	0
Total				21466	511995

0.863D+1.0EX/0.863D+1.0EY					
Story	Height (ft)	Effective Shear (kips)	Effective Weight (kips)	Moverturning (kip*ft)	Mresisting (kip*ft)
High Roof	82	16	267	1310	18883
6th Floor	73	51	1037	3750	65317
Low Roof	68	28	626	1879	36738
5th Floor	56	97	3026	5450	146239
4th Floor	42	66	3265	2759	118340
3rd Floor	28	30	2909	846	70286
2nd Floor	14	10	2909	137	35143
1st Floor	0	0	2537	0	0
Total				16132	490947

FINAL SIZING

TORSION

WIND ACCIDENTAL TORSION - ASCE 7-05 FIGURE 6-9
CASE 2
$M_{T\,x,y} = 0.75(P_{Wx,y} + P_{Lx,y})\,B_{x,y}\,e_{x,y}$
$e_{x,y} = 0.15\,B_{x,y}$
CASE 4
$M_T = 0.563(P_{Wx} + P_{Lx})\,B_x e_x + 0.563(P_{Wy} + P_{Ly})\,B_y e_y$
$e_{x,e_y} = 0.15\,B_{x,B_y}$

WIND INHERENT TORSION
$M_{T\,x,y} = (\ell$ CENTER OF MASS TO CENTER OF RIGIDITY $\perp)F$

SEISMIC ACCIDENTAL TORSION - ASCE 7-05 12.8.4.2, 12.8.4.3
$M_{a\,x,y} = 0.05(\ell$ CENTER OF MASS TO EDGE $\perp)F$
SEISMIC DESIGN CATEGORY B - NO AMPLIFICATION REQUIRED

SEISMIC INHERENT TORSION - ASCE 7-05 12.8.4.1
$M_{i\,x,y} = (\ell$ CENTER OF MASS TO CENTER OF RIGIDITY $\perp)F$

Wind Accidental Torsion Case 2				
	Force (kips)		Floor Width	
Story	X-Direction	Y-Direction	X-Direction	Y-Direction
High Roof	4.2	12.5	98.67	33.34
6th Floor	12.1	35.8	98.67	33.34
Low Roof	12.6	10.5	66.00	131.00
5th Floor	54.2	41.1	98.67	131.00
4th Floor	47.5	41.4	113.67	131.00
3rd Floor	45.8	40.0	113.67	131.00
2nd Floor	44.4	38.8	113.67	131.00
	Torsional Moment Arm (in)		Torsional Moment (kip*ft)	
Story	X-Direction	Y-Direction	X-Direction	Y-Direction
High Roof	14.80	5.00	32.3	14.5
6th Floor	14.80	5.00	92.2	41.5
Low Roof	9.90	19.65	42.9	187.8
5th Floor	14.80	19.65	412.0	734.3
4th Floor	17.05	19.65	479.4	740.3
3rd Floor	17.05	19.65	462.7	715.8
2nd Floor	17.05	19.65	448.0	694.1

Wind Accidental Torsion Case 4				
	Force (kips)		Floor Width (in)	
Story	X-Direction	Y-Direction	X-Direction	Y-Direction
High Roof	5.7	16.7	98.67	33.34
6th Floor	16.2	47.8	98.67	33.34
Low Roof	16.8	14.0	66.00	131.00
5th Floor	72.2	54.8	98.67	131.00
4th Floor	63.3	55.2	113.67	131.00
3rd Floor	61.1	53.4	113.67	131.00
2nd Floor	59.2	51.8	113.67	131.00
	Torsional Moment Arm (in)		Torsional Moment (kip*ft)	
Story	X-Direction	Y-Direction		
High Roof	14.80	5.00	43.3	
6th Floor	14.80	5.00	123.4	
Low Roof	9.90	19.65	183.9	
5th Floor	14.80	19.65	963.6	
4th Floor	17.05	19.65	1035.5	
3rd Floor	17.05	19.65	1000.4	
2nd Floor	17.05	19.65	969.5	

Wind Inherent Torsion						
	Force (kips)		Center of Mass (in)		Center of Rigidity (in)	
Story	X-Direction	Y-Direction	X-Direction	Y-Direction	X-Direction	Y-Direction
High Roof	16.7	5.7	777	787	802	787
6th Floor	47.8	16.2	777	787	805	788
Low Roof	14.0	16.8	684	788	762	796
5th Floor	54.8	72.2	711	789	753	795
4th Floor	55.2	63.3	668	789	728	794
3rd Floor	53.4	61.1	668	789	690	794
2nd Floor	51.8	59.2	668	789	656	799

	Torsional Moment Arm (in)		Torsional Moment (kip*in)	
Story	X-Direction	Y-Direction	X-Direction	Y-Direction
High Roof	25	0	35	0
6th Floor	28	1	111	1
Low Roof	78	8	91	11
5th Floor	42	6	192	36
4th Floor	60	5	276	26
3rd Floor	22	5	98	25
2nd Floor	12	10	52	49

Seismic Accidental Torsion						
	Force (kips)		Torsional Moment Arm (in)		Torsional Moment (kip*ft)	
Story	X-Direction	Y-Direction	X-Direction	Y-Direction	X-Direction	Y-Direction
High Roof	16.0	16.0	4.93	1.67	6.6	2.2
6th Floor	51.4	51.4	4.93	1.67	21.1	7.1
Low Roof	27.6	27.6	3.30	6.55	7.6	15.1
5th Floor	97.3	97.3	4.93	6.55	40.0	53.1
4th Floor	65.7	65.7	5.68	6.55	31.1	35.9
3rd Floor	30.2	30.2	5.68	6.55	14.3	16.5
2nd Floor	9.8	9.8	5.68	6.55	4.6	5.3

Seismic Inherent Torsion						
	Force (kips)		Center of Mass (in)		Center of Rigidity (in)	
Story	X-Direction	Y-Direction	X-Direction	Y-Direction	X-Direction	Y-Direction
High Roof	16.0	16.0	777	787	802	787
6th Floor	51.4	51.4	777	787	805	788
Low Roof	27.6	27.6	684	788	762	796
5th Floor	97.3	97.3	711	789	753	795
4th Floor	65.7	65.7	668	789	728	794
3rd Floor	30.2	30.2	668	789	690	794
2nd Floor	9.8	9.8	668	789	656	799

	Torsional Moment Arm (in)		Torsional Moment (kip*in)	
Story	X-Direction	Y-Direction	X-Direction	Y-Direction
High Roof	25	0	33	0
6th Floor	28	1	120	4
Low Roof	78	8	180	18
5th Floor	42	6	341	49
4th Floor	60	5	329	27
3rd Floor	22	5	55	13
2nd Floor	12	10	10	8

Final Sizing

Lateral Distribution Spot Check ETABS Results (see Framing Plans)

WX					
Lateral Element	6th Floor	5th Floor	4th Floor	3rd Floor	2nd Floor
	Shear	Shear	Shear	Shear	Shear
Column C1	-0.40	0.00	0.00	0.00	0.00
Column C3	4.01	0.00	0.00	0.00	0.00
Column C4	3.98	0.00	0.00	0.00	0.00
Column C5	3.77	0.00	0.00	0.00	0.00
Column C6	-0.41	0.00	0.00	0.00	0.00
Column F1	-0.40	0.00	0.00	0.00	0.00
Column F3	4.01	0.00	0.00	0.00	0.00
Column F4	3.98	0.00	0.00	0.00	0.00
Column F5	3.77	0.00	0.00	0.00	0.00
Column F6	-0.41	0.00	0.00	0.00	0.00
WA	0.00	33.29	51.39	67.53	78.70
WA7	0.00	22.77	36.02	50.16	64.40
WG4	0.00	22.06	35.39	49.71	65.58
WH	0.00	33.73	51.72	67.69	78.41
Model Shear	21.90	111.85	174.52	235.09	287.09
Direct Shear	21.83	110.87	174.18	235.30	294.48
Torsional Shear	5.37	11.10	15.71	20.16	24.47
Total Shear	27.20	121.97	189.89	255.46	318.95

WY					
Lateral Element	6th Floor	5th Floor	4th Floor	3rd Floor	2nd Floor
	Shear	Shear	Shear	Shear	Shear
Column C1	-0.35	0.00	0.00	0.00	0.00
Column C3	9.74	0.00	0.00	0.00	0.00
Column C4	10.76	0.00	0.00	0.00	0.00
Column C5	12.47	0.00	0.00	0.00	0.00
Column C6	-0.36	0.00	0.00	0.00	0.00
Column F1	-0.35	0.00	0.00	0.00	0.00
Column F3	9.74	0.00	0.00	0.00	0.00
Column F4	10.76	0.00	0.00	0.00	0.00
Column F5	12.47	0.00	0.00	0.00	0.00
Column F6	-0.36	0.00	0.00	0.00	0.00
W43A	0.00	40.82	56.80	71.76	81.06
W43H	0.00	37.06	52.35	66.27	70.97
W5A	0.00	29.44	41.34	53.28	63.72
W5H	0.00	26.52	37.64	46.92	59.05
Model Shear	64.52	133.84	188.13	238.23	274.80
Direct Shear	64.48	133.26	188.48	241.86	293.64
Torsional Shear	1.35	8.77	14.04	19.14	24.07
Total Shear	65.83	142.02	202.52	261.00	317.71

FINAL SIZING

FINAL ROOF FRAMING DESIGN

DECK
LOW ROOF
TOTAL LOAD = 1.2(17 PSF)+1.6(33PSF) = 61 PSF < 131 PSF VOK
TRIPLE SPAN + @ 3'-0"
USE 1 1/2" 22 GAGE GALVANIZED TYPE B STEEL ROOF DECK

HIGH ROOF
SPECIAL ORDER STEEL ROOF DECK ≈ 3 PSF

JOISTS
LOW ROOF
TOTAL LOAD = 1.2(20 PSF)+1.6(33 PSF) = 24 PSF + 53 PSF = 77 PSF
SPAN: 14'-0"
*18K3
550 PLF/77 PSF = 7.14'
*SPACED @ 7'-0" O.C.
TOTAL LOAD = (77 PSF)(7') = 539 PLF < 550 PLF VOK
LIVE LOAD = (53 PSF)(7') = 371 PLF < 550 PLF VOK
USE 3-18K3 SPACED @ 6.39' O.C.
SPAN: 27'-8"
*18K3
240 PLF/77 PSF = 3.12'
*SPACED @ 3'-0" O.C.
TOTAL LOAD = (77 PSF)(3') = 231 PLF < 240 PLF VOK
SNOWLOAD = (53 PSF)(3') = 159 PLF ≈ 157 PLF VOK
USE 5-18K3 SPACED @ 2.80' O.C.

HIGH ROOF
SPECIAL ORDER CURVED ROOF JOISTS ≈ 10 PLF

SEE FRAMING PLANS FOR RESULTS

FINAL SIZING

LOW ROOF STEEL BEAM SPOT CHECK

W24x55

SPAN: 40'-4",

UNBRACED LENGTH: 13'-2"

LOADS: $W_{SW} = 55$ PLF

$W_{DL} = (20\ PSF)(17') = 340$ PLF

$W_S = (33\ PSF)(17') = 561$ PLF

$W_u = 1.2D + 1.6L_r = 1.2(W_{SW} + W_{DL}) + 1.6W_S =$

$1.2(55\ PLF + 340\ PLF) + 1.6(561\ PLF) = 1872\ PLF$

FLEXURE - AISC STEEL MANUAL F2

$M_u = \frac{w_u l^2}{8} = \frac{(1372\ PLF)(1'/1000)(40.34')^2}{8} = 279^{k'} < 325^{k'}$ √ok

1. YIELDING

$\phi M_n = \phi F_y Z_x = (0.90)(50\ ksi)(134\ IN^3)(1'/12) = 503^{k'}$

2. LATERAL TORSIONAL BUCKLING

$L_r = 473'' < L_b = 13.17' < L_p = 13.9'$

$M_p = F_y Z_x = (50\ ksi)(134\ IN^3) = 6700^{k''}$

$C_b = 1.0$ - CONSERVATIVE ASSUMPTION

$\phi M_n = \phi C_b \left[M_p - (M_p - 0.7F_y S_x)\left(\frac{L_b - L_p}{L_r - L_p}\right)\right] \leq M_p$

$= (0.90)(1.0)\left[6700^{k''} - (6700^{k''} - 0.7(50\ ksi)(114\ IN^4))\left[\frac{13.17' - 13.9'}{473' - 13.9'}\right]\right](1'/12)$

$= 486^{k'} \leftarrow$ CONTROLS $> 335^{k'}$ √ok

SHEAR - AISC STEEL MANUAL G

$V_u = \frac{wl}{2} = \frac{(1372\ PLF)(1'/1000)(40.34')}{2} = 27.7^k < 28.9^k$ √ok

1. NOMINAL SHEAR STRENGTH

$\frac{h}{t_w} = 54.6 < 1.10\sqrt{\frac{k_v E}{F_y}} = 1.10\sqrt{\frac{(5)(29000\ ksi)}{50\ ksi}} = 59.2$

$C_v = 1.0$

$\phi V_n = \phi 0.6 F_y A_w C_v = (0.90)(0.6)(50\ ksi)(23.6'')(0.395'')(1.0) = 252^k = 252^k$ √ok

$C_v =$

Gravity Beam Design

RAM Steel v11.0
DataBase: Roof Framing
Building Code: IBC

03/10/08 14:55:10
Steel Code: AISC LRFD

Floor Type: Low Roof **Beam Number = 471**

SPAN INFORMATION (ft): I-End (55.34,82.17) J-End (55.34,122.50)

Minimum Depth specified = 11.90 in
Beam Size (Optimum) = W24X55 Fy = 50.0 ksi
Total Beam Length (ft) = 40.33
Mp (kip-ft) = 562.50

POINT LOADS (kips):

Dist	DL	RedLL	Red%	NonRLL	StorLL	Red%	RoofLL	Red%
2.800	-0.77	0.00	0.0	-1.28	0.00	0.0	0.00	Snow
5.600	-0.77	0.00	0.0	-1.28	0.00	0.0	0.00	Snow
8.400	-0.77	0.00	0.0	-1.28	0.00	0.0	0.00	Snow
11.200	-0.77	0.00	0.0	-1.28	0.00	0.0	0.00	Snow
14.000	-1.49	0.00	0.0	-2.86	0.00	0.0	0.00	Snow
14.000	-0.39	0.00	0.0	-1.24	0.00	0.0	0.00	Snow
16.634	-0.73	0.00	0.0	-1.20	0.00	0.0	0.00	Snow
19.268	-0.73	0.00	0.0	-1.20	0.00	0.0	0.00	Snow
21.902	-0.73	0.00	0.0	-1.20	0.00	0.0	0.00	Snow
24.536	-0.73	0.00	0.0	-1.20	0.00	0.0	0.00	Snow
27.160	-1.43	0.00	0.0	-2.78	0.00	0.0	0.00	Snow
27.160	-0.38	0.00	0.0	-1.22	0.00	0.0	0.00	Snow
29.883	-0.75	0.00	0.0	-1.24	0.00	0.0	0.00	Snow
32.606	-0.68	0.00	0.0	-1.13	0.00	0.0	0.00	Snow
34.830	-0.17	0.00	0.0	-0.88	0.00	0.0	0.00	Snow

LINE LOADS (k/ft):

Load	Dist	DL	LL	Red%	Type
1	0.000	0.000	0.000	---	NonR
	40.330	0.000	0.000		
2	0.000	-0.064	-0.105	---	NonR
	40.330	-0.064	-0.105		
3	0.000	0.055	0.000	---	NonR
	40.330	0.055	0.000		

SHEAR (Ultimate): Max Vu (1.2DL+1.6LL) = 28.94 kips 0.90Vn = 251.69 kips

MOMENTS (Ultimate):

Span	Cond	LoadCombo	Mu kip-ft	@ ft	Lb ft	Cb	Phi	Phi*Mn kip-ft
Center	Max -	1.2DL+1.6LL	-324.6	19.3	13.2	1.01	0.90	335.18
Controlling		1.2DL+1.6LL	-324.6	19.3	13.2	1.01	0.90	335.18

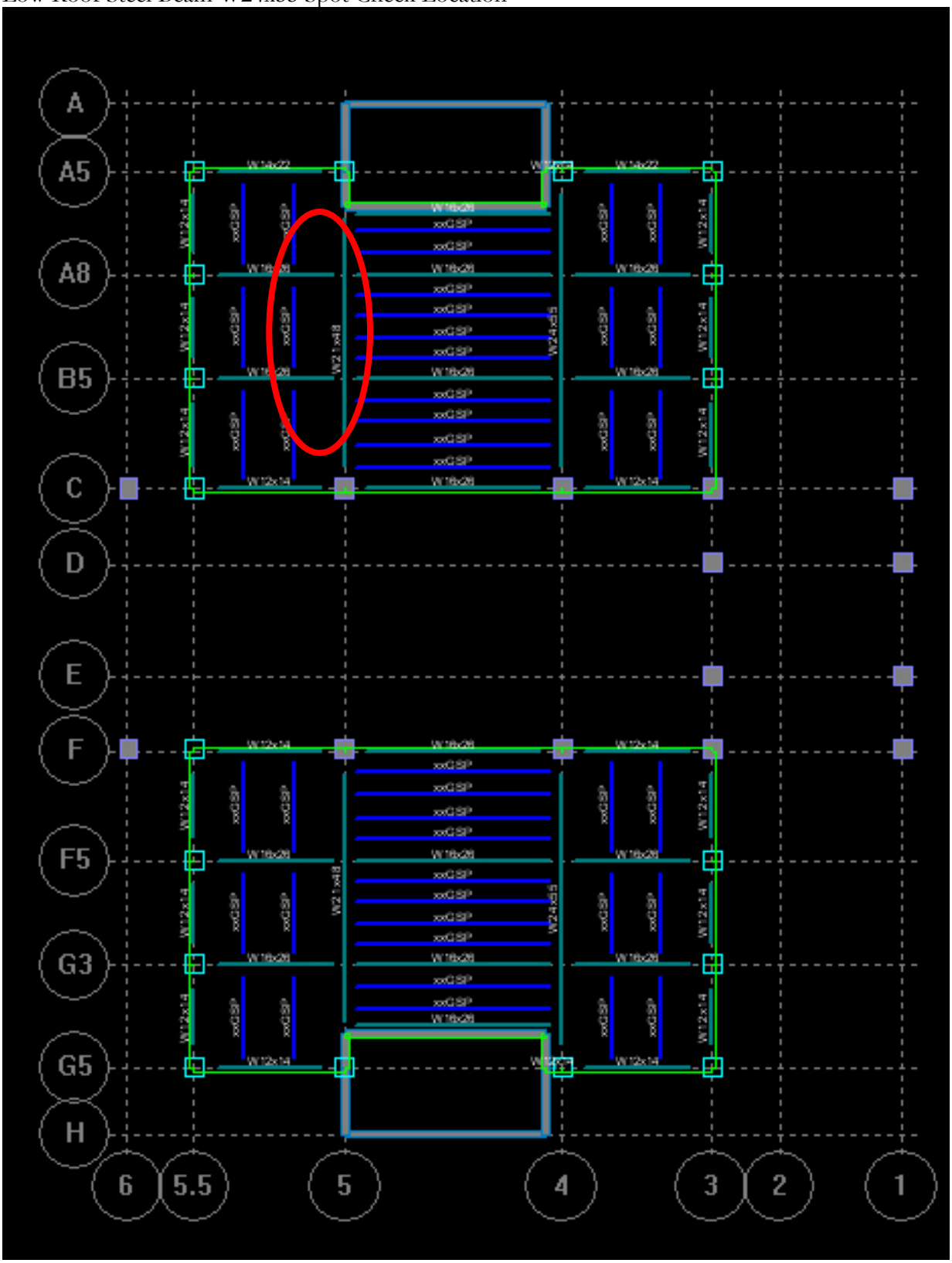
REACTIONS (kips):

	Left	Right
DL reaction	-6.32	-5.32
Max -LL reaction	-13.35	-12.17
Max -total reaction	-28.94	-25.86

DEFLECTIONS:

Dead load (in)	at	19.96 ft	=	0.520	L/D	= 931
Live load (in)	at	20.17 ft	=	1.114	L/D	= 435
Net Total load (in)	at	20.17 ft	=	1.633	L/D	= 296

Low Roof Steel Beam W24x55 Spot Check Location



FINAL SIZING

LOW ROOF STEEL COLUMN SPOT CHECK
HSS 4x4x1/8
HEIGHT: 12'-0"
UNBRACED HEIGHT: 12'-0"
LOADS: P_{SW} = (6.45PLF)(12') = 77.4 LB
P_{DL} = (20PSF)(9.59')(13.17') = 2526 LB
P_S = (33 PSF)(9.59')(13.17') = 4168 LB
$P_u = 1.2D + 1.6L_r = 1.2(P_{SW} + P_{DL}) + 1.6P_S$ =
$= (1.2(77.4\text{LB} + 2526\text{LB}) + 1.6(4168\text{ LB}))(1/1000) = 9.79^k < 830^k$ XNO

COMPRESSION – AISC STEEL MANUAL E3

$\frac{kl}{r} = \frac{(1.0)(12')(12)}{1.58"} = 91.1 < 4.71\sqrt{\frac{E}{F_y}} = 4.71\sqrt{\frac{29000\text{ KSI}}{50\text{KSI}}} = 113$

$F_e = \frac{\pi^2 E}{\left(\frac{kl}{r}\right)^2} = \frac{\pi^2(29000\text{ KSI})}{(91.1)^2} = 34.5$ KSI

$F_{cr} = 0.658^{F_y/F_e} F_y = 0.658^{(50\text{KSI}/34.5\text{KSI})}(50\text{ KSI}) = 37.5$ KSI
$\phi P_n = \phi F_{cr} A_g = (0.90)(37.2\text{ KSI})(1.77\text{ IN}^2) = 43.3^k < 79.7^k$ XNO
- ALL COLUMNS RESIZED TO HSS 4x4x1/2 $123^k >> 79.7^k > 9.79^k$ √OK

Gravity Column Design

RAM Steel v11.0
DataBase: Roof Framing
Building Code: IBC

03/10/08 15:02:13
Steel Code: AISC LRFD

Story level Low Roof, Column Line 3 - A8

Fy (ksi) = 50.00 Column Size = HSS4X4X1/8
Orientation (degrees) = 0.0

INPUT DESIGN PARAMETERS:

		X-Axis	Y-Axis
Lu (ft)		12.00	12.00
K		1	1
Braced Against Joint Translation		Yes	Yes
Column Eccentricity (in)	Top	4.50	4.50
	Bottom	0.00	0.00

CONTROLLING COLUMN LOADS - Load Case 27:

			Dead	Live	Roof
Axial (kips)			-2.14	-3.58	0.00
Moments	Top	Mx (kip-ft)	0.54	1.04	0.00
		My (kip-ft)	0.00	0.30	0.00
	Bot	Mx (kip-ft)	0.00	0.00	0.00
		My (kip-ft)	0.00	0.00	0.00

Single curvature about X-Axis
Single curvature about Y-Axis

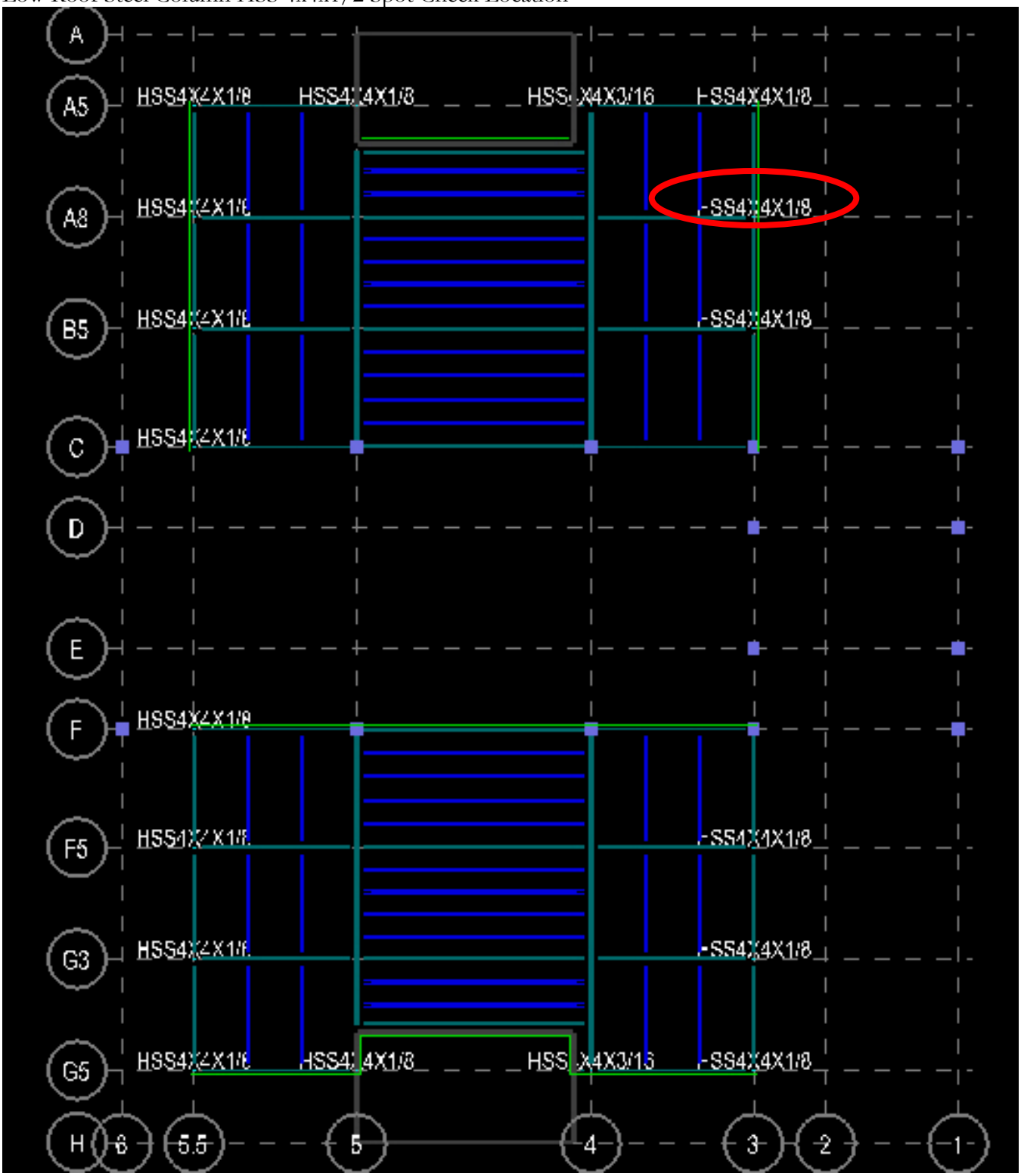
CALCULATED PARAMETERS: (1.2DL + 1.6LL + 0.5RF)

Pu (kips)	=	-8.30	0.90*Pn (kips)	=	79.65
Mux (kip-ft)	=	2.31	0.90*Mnx (kip-ft)	=	8.70
Muy (kip-ft)	=	0.48	0.90*Mny (kip-ft)	=	8.70
Cbx	=	1.75	Cby	=	1.75
Cmx	=	0.60	Cmy	=	0.60
Pex (kips)	=	60.73	Pey (kips)	=	60.73
B1x	=	1.00	B1y	=	1.00

INTERACTION EQUATION

Pu/0.90*Pn = 0.104
Eq H1-1b: 0.052 + 0.265 + 0.055 = 0.373

Low Roof Steel Column HSS 4x4x1/2 Spot Check Location



SYSTEM COMPARISON

MECHANICAL SPACE SAVINGS

STEEL CONTROLLING THICKNESSES
FLOORS 1-4
NORTH-SOUTH DIRECTION W18x35
EAST-WEST DIRECTION W27x84
W27x84 CONTROLS

FLOOR 5
NORTH-SOUTH DIRECTION W27x84
EAST-WEST DIRECTION W27x84
W27x84 CONTROLS

FLOOR 6
NORTH-SOUTH DIRECTION W16x26
EAST-WEST DIRECTION W27x84
W27x84 CONTROLS

FLOOR TO CEILING HEIGHT INCREASE
FLOORS 1-4
W27x84 = 26.7"
14'-0" - 9'-6" = 4'-6" - (26.7")(1'/12) = 2'-3"
14'-0" - 9'-6" = 4'-6" - (9")(1/12) - (6")(1/12) = 3'-0" } INCREASE OF 9"

FLOOR 5
W27x84 = 26.7"
14'-0" - 9'-6" = 4'-6" - (26.7")(1'/12) = 2'-3"
14'-0" - 9'-6" = 4'-6" - (14")(1'/12) - (6")(1/12) = 2'-10" } INCREASE OF 7"

FLOOR 6
W27x84 = 26.7"
17'-0" - 12'-6" = 4'-6" - (26.7")(1'/12) = 2'-3"
17'-0" - 12'-6" = 4'-6" - (12")(1/12) - (12")(1/12) = 2'-6" } INCREASE OF 3"

LOW ROOF & HIGH ROOF
UNABLE TO CALCULATE DUE TO VARYING DESIGN DOCUMENTS & EXISTING CONDITIONS