Appendices

Appendix A: Typical Plans

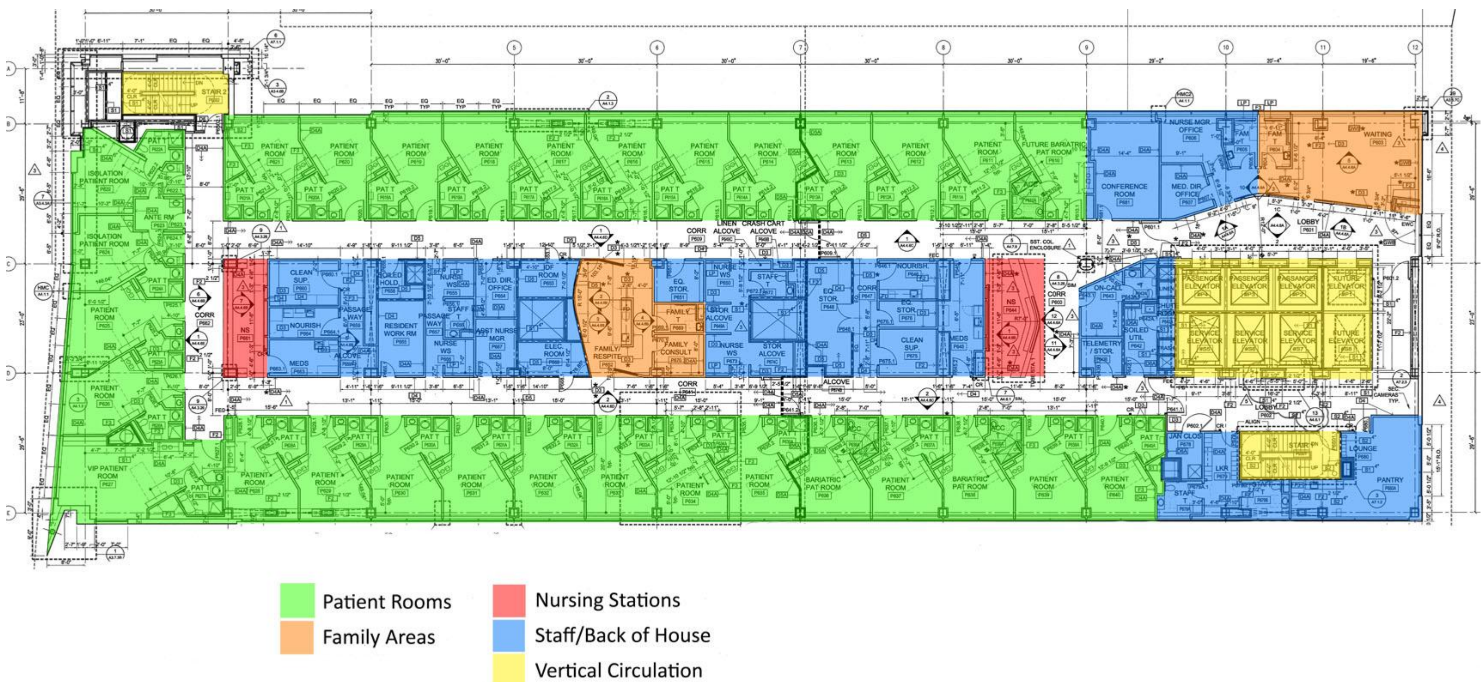

Figure 34: Typical patient floor

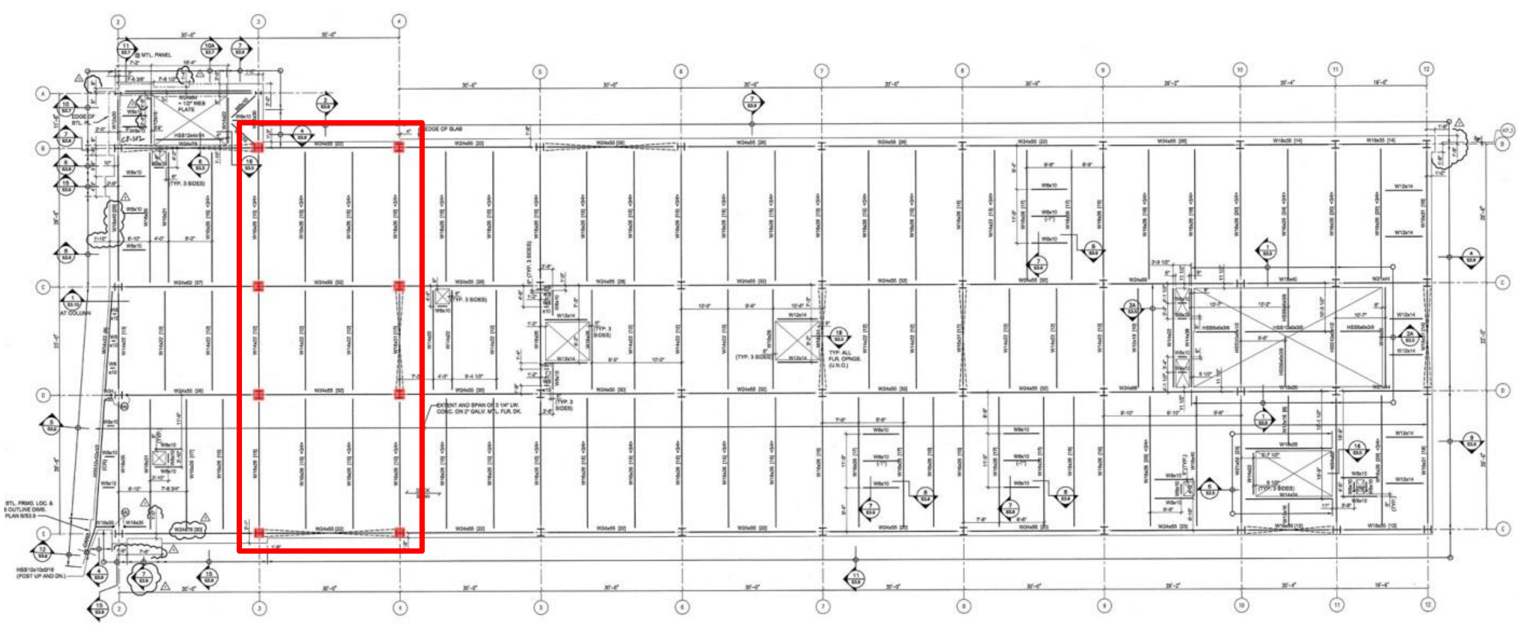

Figure 35: Typical bay - steel frame

Figure 37: Lobby layout

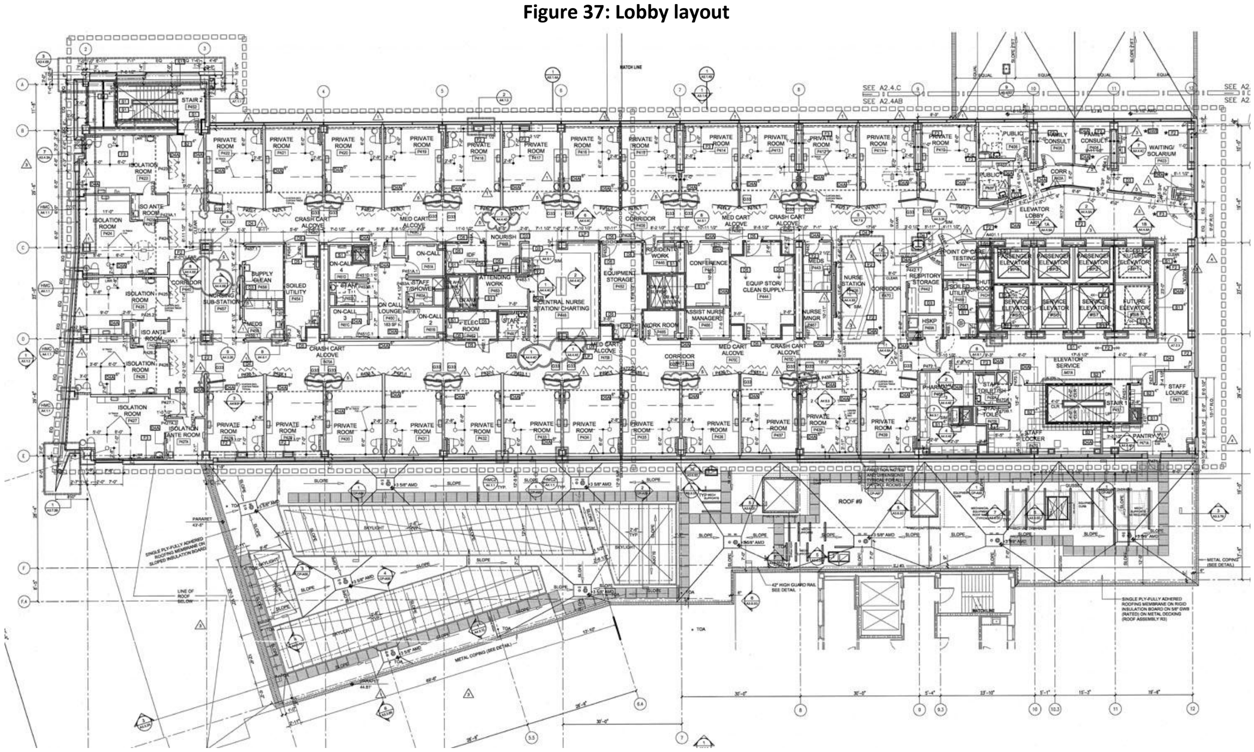

Figure 36: 4th Floor/Lobby roof plan

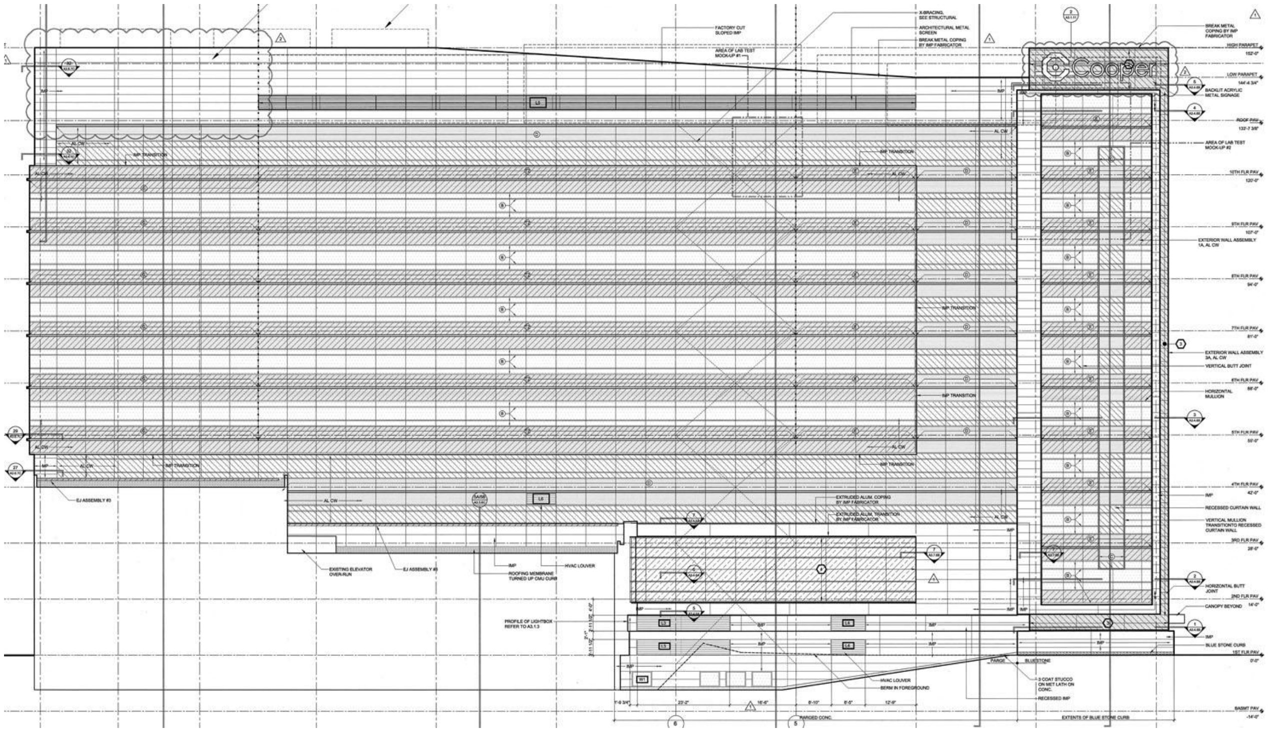

Figure 39: East elevation

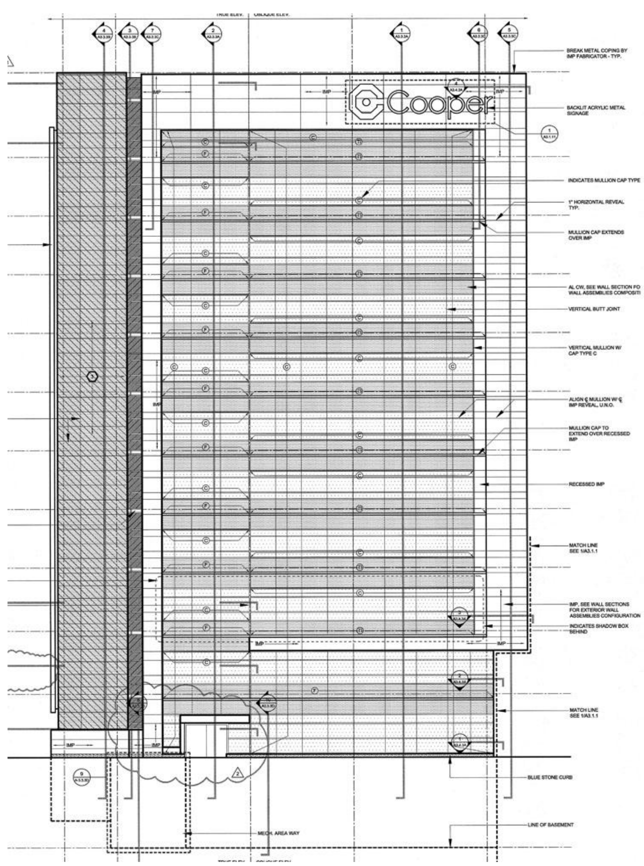

Figure 38: North elevation

Appendix B: Wind Load Calculations

Wind Loads | Tech 1 Report | Andrew Voorhees | 1

Wind Load Parameters • ASCE 7-05

$V = 90$ mph — Location: Camden, NJ (Fig 6-1)
$I = 1.15$ — Occupancy Category IV (Table 6-1) (Table 1-1)
Exposure C (§6.5.6.2)
$K_d = 0.85$ — Building MWRFS (Table 6-4)
$K_{zt} = 1.0$ — Homogeneous Topography

G = see below
$GC_{pi} = \pm 0.18$ — Enclosed Bldg (Fig. 6-5)

$K_z = 1.38$ @ 152' $\quad \frac{152-140}{160-140} = \frac{K_z - 1.36}{1.39 - 1.36}$ (Table 6-3)

Velocity Pressures

Building Height	K_z	q_z (psf)
0-15	0.85	17.23
20	0.90	18.24
25	0.94	19.05
30	0.98	19.86
40	1.04	21.08
50	1.09	22.09
60	1.13	22.90
70	1.17	23.72
80	1.21	24.53
90	1.24	25.13
100	1.26	25.54
120	1.31	26.55
140	1.36	27.57
152	1.38	27.97

$$q_z = 0.00256\, K_z K_{zt} K_d V^2 I$$

@ 152': $q_z = 0.00256(1.38)(1.0)(0.85)(90)^2(1.15) = 27.97$ psf

Calculating G

Fundamental frequency → $n_1 = 100/H = 100/152 = 0.658$
$n_1 = 75/H = 75/152 = 0.493$

$n_1 = 0.493 < 1$ — * More conservative to use lower bound

∴ Consider Building as Flexible (§6.5.8.2)

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$g_Q = g_v = 3.4$

$$g_R = \sqrt{2\ln(3600 n_1)} + \frac{0.577}{\sqrt{2\ln(3600 n_1)}}$$

$$= \sqrt{2\ln(3600 \times 0.493)} + \frac{0.577}{\sqrt{2\ln(3600 \times 0.493)}} = \boxed{4.0174}$$

$$I_{\bar{z}} = c\left(\frac{33}{\bar{z}}\right)^{1/6}$$

$c = 0.2$ (Table 6-2)

$\bar{z} = 0.6h = 0.6(152) = 91.2$

$$= 0.2\left(\frac{33}{91.2}\right)^{1/6} = \boxed{0.1688}$$

Determine Q:

$$L_{\bar{z}} = \ell\left(\frac{\bar{z}}{33}\right)^{\bar{\epsilon}}$$

$\bar{\epsilon} = 1/5$ (Table 6-2)

$\ell = 500$ (Table 6-2)

$$= 500\left(\frac{91.2}{33}\right)^{1/5} = 612.73$$

Q: N-S

$B = 86'$

$$Q = \sqrt{\frac{1}{1+0.63\left(\frac{B+h}{L_{\bar{z}}}\right)^{0.63}}} = \sqrt{\frac{1}{1+0.63\left(\frac{86+152}{612.73}\right)^{0.63}}} = \boxed{0.8616}$$

Q: E-W

$B = 285'$

$$Q = \sqrt{\frac{1}{1+0.63\left(\frac{285+152}{612.73}\right)^{0.63}}} = \boxed{0.8140}$$

Wind Loads	Tech 1 Report	Andrew Voorhees	3

$\bar{V}_{\bar{z}} = \bar{b}\left(\frac{\bar{z}}{33}\right)^{\bar{\alpha}} V\left(\frac{88}{60}\right)$ $\bar{\alpha} = 1/6.5$ (Table 6-2), $\bar{b} = 0.65$ (Table 6-2), $V = 90$ mph

$= 0.65\left(\frac{91.2}{33}\right)^{1/6.5} 90\left(\frac{88}{60}\right)$

$= 100.32$ ft/s

$N_1 = \frac{n_1 L_{\bar{z}}}{\bar{V}_{\bar{z}}} = \frac{0.493 \times 612.73}{100.32} = 3.01$

$R_n = \frac{7.47 N_1}{(1 + 10.3 N_1)^{5/3}} = \frac{7.47(3.01)}{[1 + 10.3(3.01)]^{5/3}} = 0.0697$

$\eta_h = \frac{4.6 n_1 h}{\bar{V}_{\bar{z}}} = \frac{4.6(0.493)(152)}{100.32} = 3.436$

$R_h = \frac{1}{\eta_h} - \frac{1}{2\eta_h^2}(1 - e^{-2\eta_h}) = \frac{1}{3.436} - \frac{1}{2(3.436^2)}(1 - e^{-2(3.436)})$

$= 0.2487$

$\eta_B = \frac{4.6 n_1 B}{\bar{V}_{\bar{z}}}$ $B = 86'$ N-S $\Rightarrow \frac{4.6(0.493)(86')}{100.32} = 1.944$ N-S

$B = 285'$ E-W $\Rightarrow \frac{4.6(0.493)(285)}{100.32} = 6.443$ E-W

$R_B = \frac{1}{\eta_B} - \frac{1}{2\eta_B^2}(1 - e^{-2\eta_B}) = \frac{1}{1.944} - \frac{1}{2(1.944^2)}(1 - e^{-2(1.944)}) = 0.3848$ N-S

$= \frac{1}{6.443} - \frac{1}{2(6.443^2)}(1 - e^{-2(6.443)}) = 0.1432$ E-W

$\eta_L = \frac{15.4 n_1 L}{\bar{V}_{\bar{z}}}$ $L = 285'$ N-S $\Rightarrow \frac{15.4(0.493)(285)}{100.32} = 21.569$ N-S

$L = 86'$ E-W $\Rightarrow \frac{15.4(0.493)(86)}{100.32} = 6.508$ E-W

$R_L = \frac{1}{\eta_L} - \frac{1}{2\eta_L^2}(1 - e^{-2\eta_L}) = \frac{1}{21.569} - \frac{1}{2(21.569^2)}(1 - e^{-2(21.569)}) = 0.0453$ N-S

$= \frac{1}{6.508} - \frac{1}{2(6.508^2)}(1 - e^{-2(6.508)}) = 0.1419$ E-W

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Assume $\beta = 0.01$ (§ C6.5.8)

$$R = \sqrt{\frac{1}{\beta} R_n R_h R_B (0.53 + 0.47 R_L)}$$

N-S: $R = \sqrt{\frac{1}{0.01}(0.0697)(0.2487)(0.3848)(0.53 + 0.47 \times 0.0453)}$

$= 0.6064$ N-S

E-W: $R = \sqrt{\frac{1}{0.01}(0.0697)(0.2487)(0.1432)(0.53 + 0.47 \times 0.1419)}$

$= 0.3849$ E-W

Determine G_f:

$$G_f = 0.925 \left[\frac{1 + 1.7 I_{\bar{z}} \sqrt{g_Q^2 Q^2 + g_R^2 R^2}}{1 + 1.7 g_v I_{\bar{z}}} \right]$$

N-S: $G_f = 0.925 \left[\frac{1 + 1.7(0.1688)\sqrt{3.4^2(0.8616^2) + 4.0174^2(0.6064^2)}}{1 + 1.7(3.4)(0.1688)} \right]$

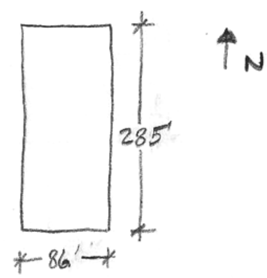
$G_f = 0.98$ N-S

E-W: $G_f = 0.925 \left[\frac{1 + 1.7(0.1688)\sqrt{3.4^2(0.8140^2) + 4.0174^2(0.3849^2)}}{1 + 1.7(3.4)(0.1688)} \right]$

$G_f = 0.89$ E-W

Design Wind Pressures for MWRFS

Simplified Building shape



Cp : Walls

N-S

Windward wall pressure coeff. = 0.8
Leeward wall pressure coeff. :

$L/B = 279/82 = 3.4$

$$\frac{3.4-2}{4-2} = \frac{C_p-(-0.3)}{-0.2-(-0.3)} \Rightarrow C_p = -0.23$$

E-W

Windward wall pressure coeff. = 0.8
Leeward wall pressure coeff. :

$L/B = 82/279 = 0.29$

$0 < 0.29 < 1 \Rightarrow C_p = -0.5$

Cp : Roof

$0 = \theta < 10°$

$h/L = 152/279 = 0.54 \Rightarrow$

0 - h/2	Cp = -0.9
h/2 - h	Cp = -0.9
h - 2h	Cp = -0.5
> 2h	Cp = -0.3

$152/82 = 1.85$

⇓

0 - h/2	Cp = -1.3
> h/2	Cp = -0.7

See Excel tables for calculations

Appendix C: Slab Design

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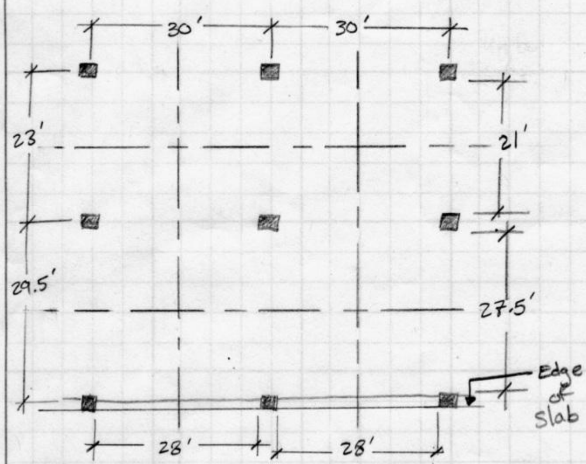
Using the Direct Design Method



* Assume Column Dimensions of 24" x 24"

Using Drop panels and Edge Beams

Loads

Live = 80 psf
Dead
- MEP = 5 psf
- SDL = 10 psf

ACI 318-11
From Table 9.5 (c): Minimum slab thickness - $h = l_n/36$ for Ext. + Int. panels
Two-way slab with drop panels ($f_y = 60{,}000$)

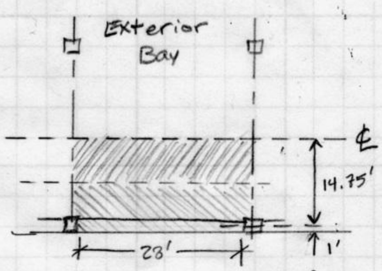
$$\frac{l_n}{36} = \frac{28' \times 12''}{36} = 9.33''$$

use h = 10"

Self weight of slab

$$= \left(\frac{10''}{12''}\right) \times 150\,pcf = 125\,psf$$

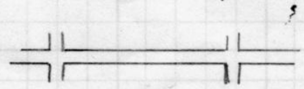
$$q_u = 1.6(80) + 1.2(15 + 125) = 296\,psf = 0.296\,ksf$$



$$M_o = \frac{q_u\, l_2\, l_n^2}{8}$$

$$= \frac{0.296\,ksf\,(15.75')(28')^2}{8}$$

$$M_o = 457\ ^{ft\text{-}k}$$



* considered an "interior" span

Moment Distribution Coefficients

$M_u^- = 0.65\,M_o$ $M_u^+ = 0.35\,M_o$

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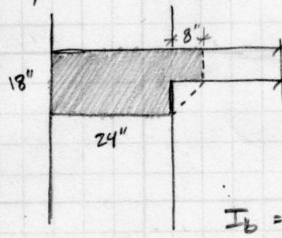
$M_u^- = 0.65(457) = 297^{ftk}$ $M_u^+ = 0.35(457) = 160^{ftk}$

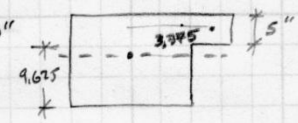
Design Edge Beams

$\alpha_f \geq 0.8$

Try 24" × 18"

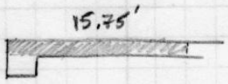
$\text{Centroid} = \frac{24(18)(9) + (8)(10)(13)}{24(18) + (8)(10)} = 9.625"$ from bottom





$I_b = \frac{24(18^3)}{12} + 24(18)(0.625)^2 + \frac{8(10)^3}{12} + 8(10)(3.375)^2$

$I_b = 13410.67 \text{ in}^4$



$I_s = (15.75 \times 12") \frac{\times 10^3}{12} = 15750 \text{ in}^4$

$\alpha_f = \frac{I_b}{I_s} = \frac{13410.67}{15{,}750} = 0.85 \geq 0.80$ ✓ ok

$\alpha_f l_2 / l_1 = 0.85(15.75/30) = 0.446 \leq 1.0$

$l_2/l_1 = \frac{15.75}{30} = 0.525$

Neg. Moment

	0.5	0.525	1.0
0	75	75	75
0.446		81.36	
1.0	90	89.25	75

To Col. Strip

$M_u^- = \frac{81.36}{100}(297) = 241.64^{ftk}$

To Mid. Strip

$M_u^- = 55.36^{ftk}$

Pos Moment

	0.5	0.525	1.0
0	60	60	60
0.446		73.05	
1.0	90	89.25	75

To Col. Strip

$M_u^+ = 0.7305(160) = 116.88^{ftk}$

To Mid. Strip

$M_u^+ = 43.12^{ftk}$

3.

Col. Strip Distributes to Beam + Col. Strip as well

ACI 318-11 § 13.6.5.2 → Beam strip portion interpolated

$\alpha_{f1} l_2 / l_1 = 0.446 \leq 1.0$

$\therefore \frac{85 - 0}{1.0 - 0} = \frac{x - 0}{0.446 - 0} \quad x = 37.91\ \%$

To Beam

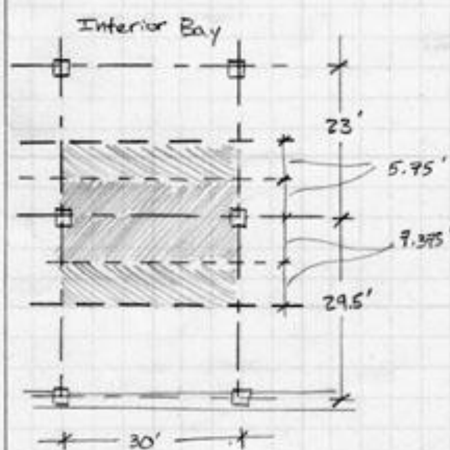
$M_u^- = 0.3791(241.64) = \boxed{91.6 \text{ ft-k}}$

$M_u^+ = 0.3791(116.88) = \boxed{44.31 \text{ ft-k}}$

To Slab

$M_u^- = \boxed{150.04 \text{ ft-k}}$

$M_u^+ = \boxed{72.57 \text{ ft-k}}$



$q_u = 0.296$ ksf

$M_o = \frac{q_u l_2 l_n^2}{8}$

$= \frac{0.296(26.25')(28')^2}{8}$

$\boxed{M_o = 761.5 \text{ ft-k}}$

$M_u^- = 0.65 M_o \qquad M_u^+ = 0.35 M_o$

$M_u^- = 0.65(761.5) \qquad = 0.35(761.5)$

$M_u^- = 495 \text{ ft-k} \qquad M_u^+ = 266.5 \text{ ft-k}$

Distribute to Col + Mid Strips

Col. strip = 5.75 + 7.375 = 13.125 ft

No interior Beams ⇒ $\alpha_f = 0$

M_u^- Col. strip = 0.75 (495) = $\boxed{371.25 \text{ ft-k}}$

M_u^- Mid strip = 0.25 (495) = $\boxed{123.75 \text{ ft-k}}$ → Half to each strip

M_u^+ Col. strip = 0.6 (266.5) = $\boxed{160 \text{ ft-k}}$

M_u^+ Mid strip = 0.4 (266.5) = $\boxed{106.6 \text{ ft-k}}$ → Half to each strip

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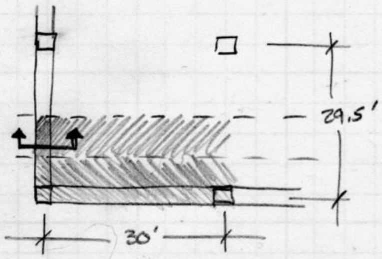
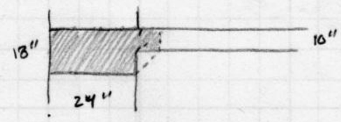
Corner Bay



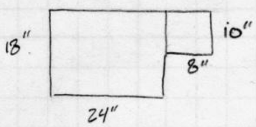
Int. Support $M_u^- = 0.70$

Ext. Support $M_u^- = 0.30$

$M_u^+ = 0.50$



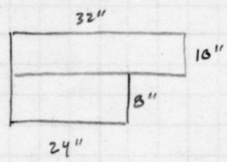
Calculate C:



$$C = \Sigma\left(1 - 0.63\,x/y\right)\frac{x^3 y}{3}$$

$$= \left[1 - 0.63\left(\frac{18}{24}\right)\right]\frac{18^3(24)}{3} + \left[1 - 0.63\left(\frac{8}{10}\right)\right]\frac{8^3(10)}{3}$$

$= 25{,}457.55$ controls



$$C = \left[1 - 0.63(10/32)\right]\frac{10^3(32)}{3} + \left[1 - 0.63(8/24)\right]\frac{8^3(24)}{3}$$

$= 11802.51$

$\beta_t = \dfrac{C}{2I_s}$ $\qquad I_s = 15{,}750\ in^4$

$$\beta_t = \frac{25457.55}{2(15{,}750)} = 0.808$$

Interpolate

$\alpha_{f1}\, l_2/l_1 = 0$:

β_t \ l_2/l_1	0.5	0.525	1.0
0	100	100	100
0.808		91.92	
2.5	75	75	75

$\alpha_{f1}\, l_2/l_1 \geq 1.0$:

β_t \ l_2/l_1	0.5	0.525	1.0
0	100	100	100
0.808		96.53	
2.5	90	89.25	75

$\alpha_{f1}\, l_2/l_1 = 0.446$

0	91.92
0.446	x
1.0	96.53

$$\frac{x - 91.92}{0.446} = \frac{96.53 - 91.92}{1.0} \qquad x = 93.98\ \%$$

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Int. Support $M_u^- = 0.70(457) = 319.9$

81.36 % to Col. Strip ⇒ **260.27 ftk**

to Mid Strip ⇒ **59.63 ftk**

Ext. Support $M_u^- = 0.3(457) = 137.1$ ftk

93.98 % to Col. Strip ⇒ **128.85 ftk**

to Mid strip = **8.25 ftk**

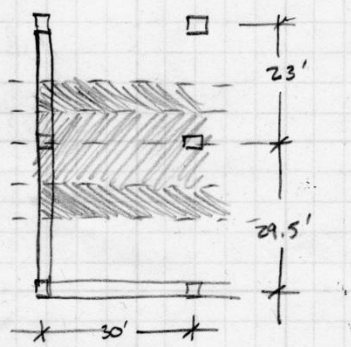
Pos. Moment $M_u^+ = 0.5(457) = 228.5$

73.05 % to Col strip ⇒ **166.92 ftk**

to mid strip ⇒ **61.58 ftk**

*Distribute Col. Strip Moments to Col. + Beam strips
— See excel calculations

Exterior Span



$M_o = 761.5$ ftk $\alpha_{f1} = 0$, No Beams

$I_s = \frac{12 \times 26.25' \times 10^3}{12} = 26250$

$\beta_t = \frac{25457.55}{2(26,250)} = 0.485$

β_t			
= 0	100	100	100
0.485		95.15	
2.5	75	75	75

Int. Support
$M_u^- = 0.70(761.5) = 533.05$

75% to Col. Strip ⇒ **399.79** to mid Strip = **133.26 ftk**

Ext. Support
$M_u^- = 0.3(761.5) = 228.45$ ftk

95.15% to Col. Strip = **217.37 ftk** to Mid Strip = **11.08 ftk**

Pos Moment $M_u^+ = 0.5(761.5) = 380.75$ ftk

0.60 (380.75) to Col strip = **228.45 ftk** to Midstrip = **152.3 ftk**

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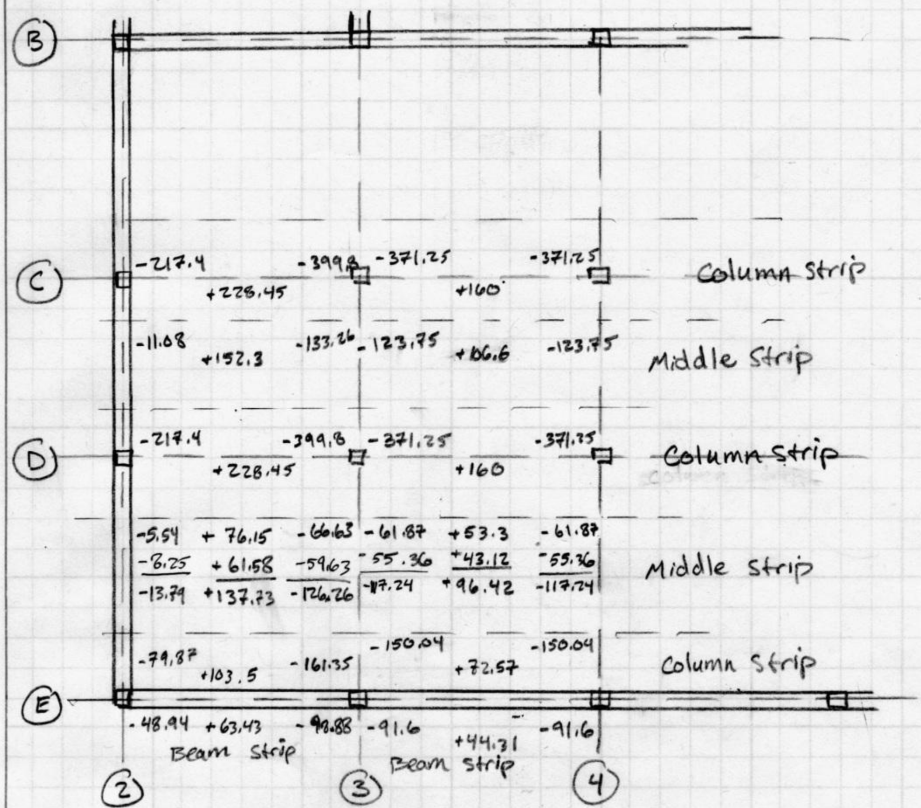
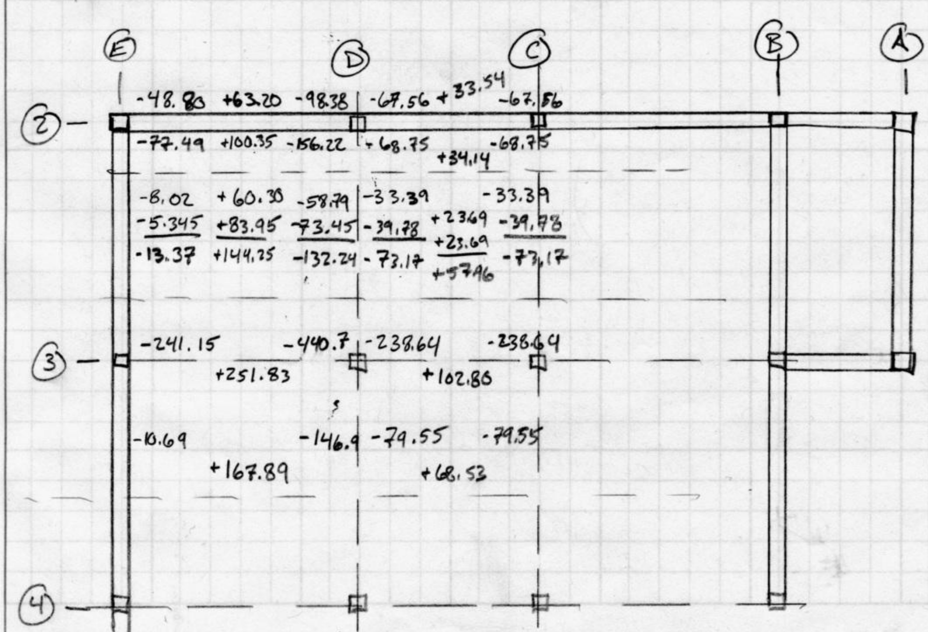




Shear Checks | Final Report | Andrew Voorhees | 1

Check one-way shear

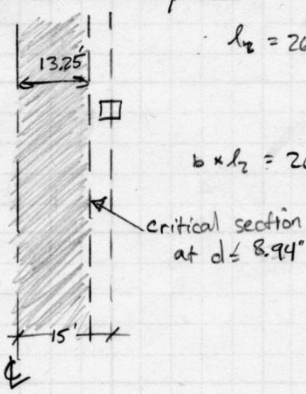
Assuming #5 bars $d_b = 0.625''$

for Long direction $d = 10'' - 3/4'' - \frac{d_b}{2}$

$d = 8.94''$

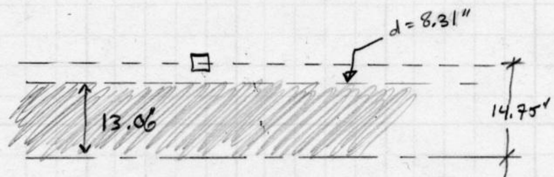
for short direction $d = 10'' - 3/4'' - \frac{3}{2} d_b$

$d = 8.31''$



$l_2 = 26.25'$

$b \times l_2 = 26.25' \times 13.25' = 347.81$



$b \times l_2 = 30' \times 13.06 = 391.8$ ← controls

$q_u = 0.296$ ksf

$V_u = 0.296 \times 391.8 = 115.97^k$

$V_c = 2\lambda\sqrt{f'_c}\,bd = 2\sqrt{4000}\,(13.06 \times 12)(8.31) = 164.73^k$

$\phi V_c = 0.75(164.73) = 123.5 > 115.97 = V_u$

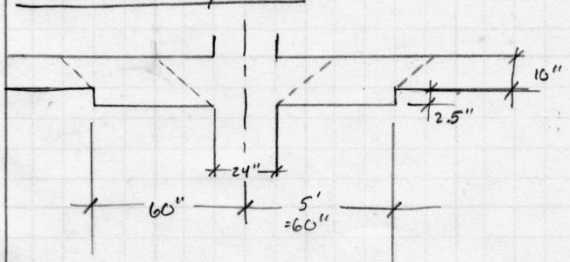
√ ok

Check Two-Way Shear

Min drop panel thickness

$1.25h = 2.5''$ below slab

width $\geq l/6 = 30/6 = 5'$ in each direction



b_o around column $= 2(24'' + 24'' + 2(8.31 + 2.5)) = 139.24'' = 34.81'' \times 34.81''$

b_o around drop panel $= 2(120 + 120 + 2(8.31)) = 513.24 = 128.31'' \times 128.31''$

q_{du} drop panel $= 1.2(2.5/12)(150) = 37.5$ psf

$V_u = 0.296^{ksf}\left[(26.25 \times 30) - \left(\frac{34.81}{12}\right)^2\right] + 0.0375\left[10^2 - \left(\frac{34.81}{12}\right)^2\right]$

$= 234.04^k$

Shear Checks | Final Report | Andrew Voorhees | 2

$$V_c \leq \begin{cases} 2 + 4/\beta = 6 \\ \frac{\alpha_s d}{b_o} + 2 = \frac{40(10.81)}{139.24} + 2 = 5.1 \\ 4 = 4 \leftarrow \text{controls} \end{cases}$$

$$\phi V_c = 4(0.75)(1)\sqrt{4000}(139.24)(10.81) = 285.6^k$$

$$\phi V_c > V_u \qquad 285.6 > 234.04^k$$

✓ ok

Check shear around drop panel

$$V_u = 0.296\left[(26.25 \times 30) - \left(\frac{128.31}{12}\right)^2\right] = 199.26^k$$

$$V_c \leq \begin{cases} 2 + 4/\beta = 6 \\ \frac{\alpha_s d}{b_o} + 2 = \frac{40(8.31)}{513.24} + 2 = 2.65 \leftarrow \text{controls} \\ 4 = 4 \end{cases}$$

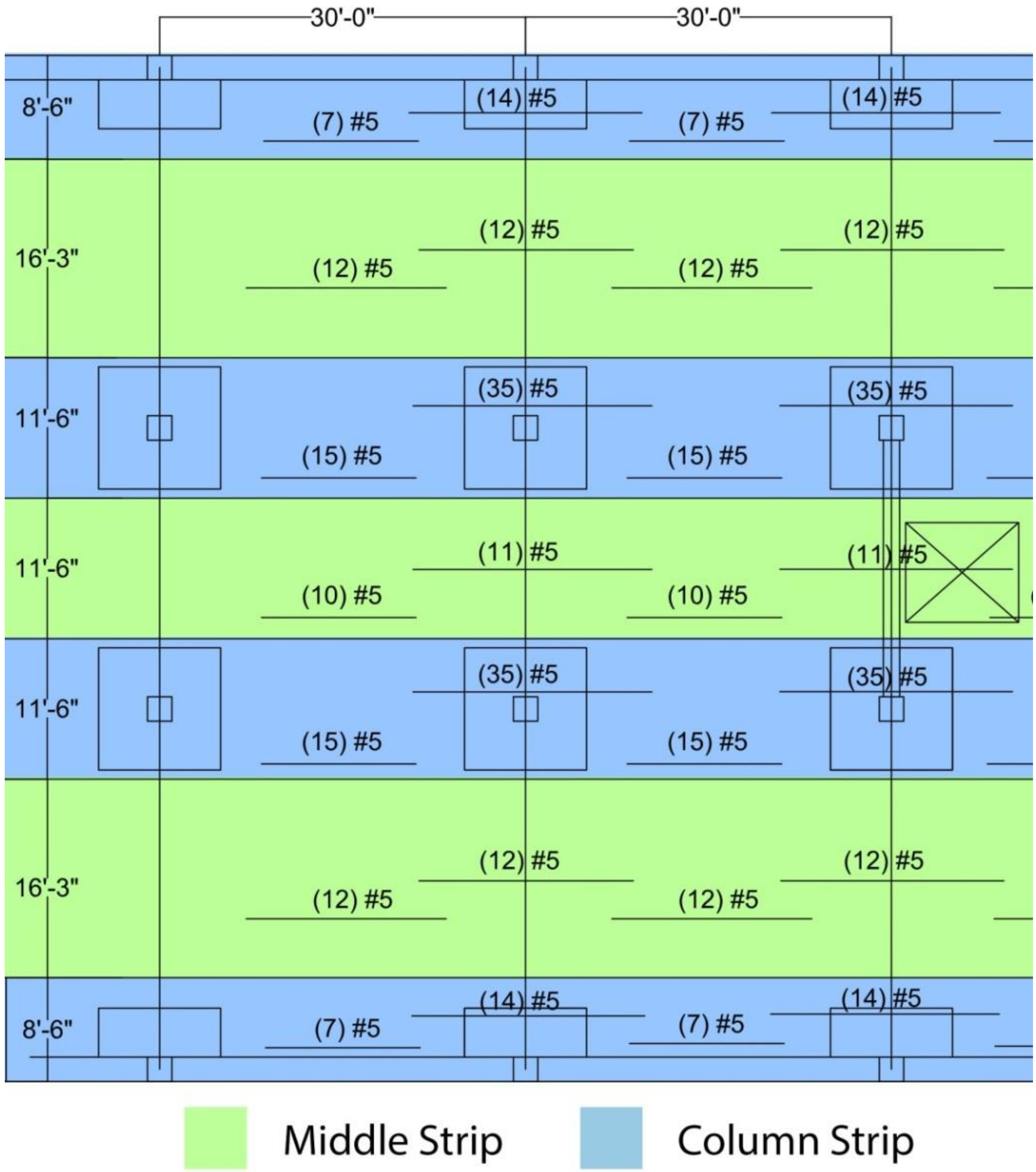
$$\phi V_c = 2.65(0.75)\sqrt{4000}(513.24)(8.31)$$

$$= 536.12^k > V_u = 199.26^k$$

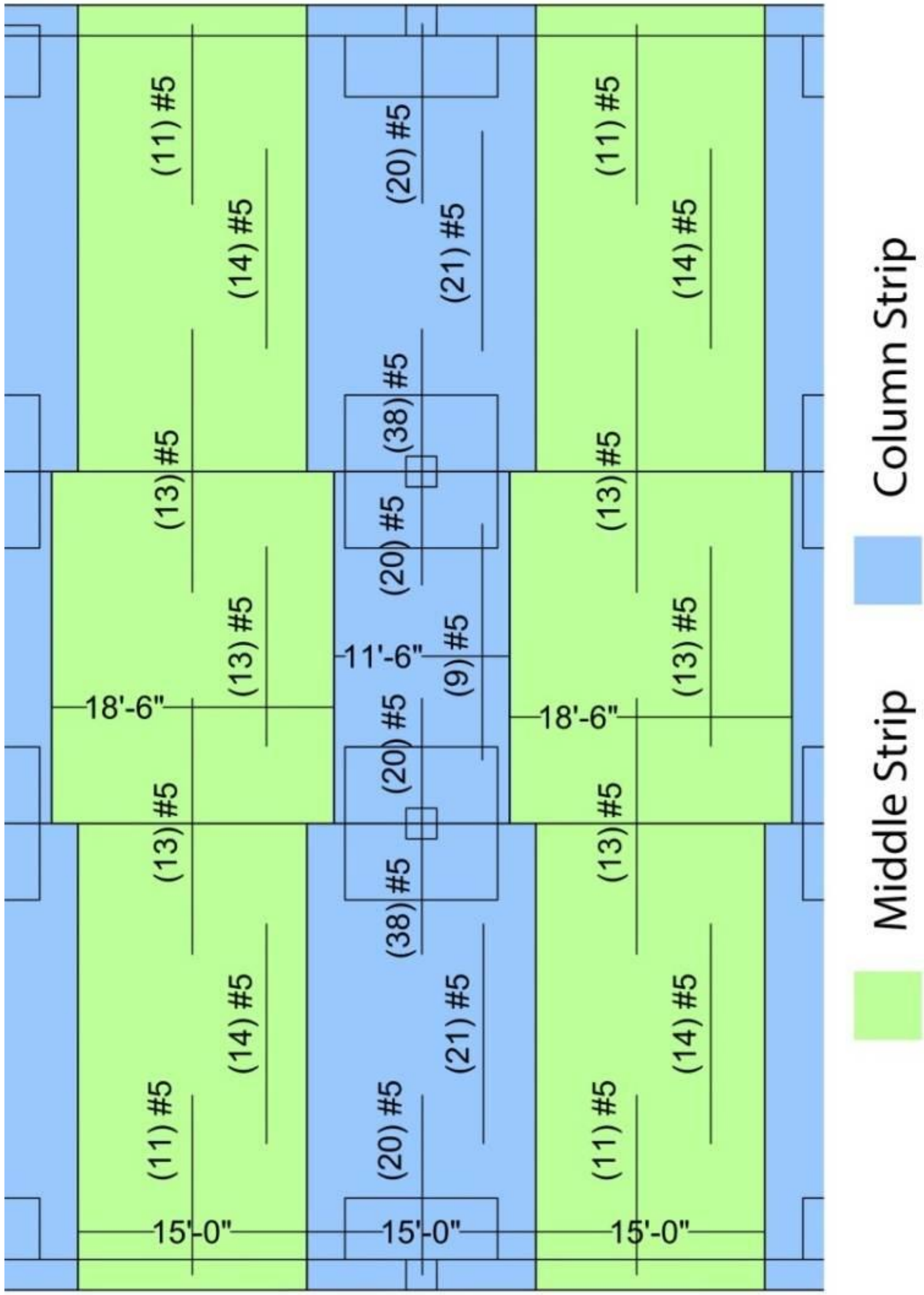
✓ ok

Appendix D: Slab Reinforcement

N-S Gridlines



E-W Gridlines



DDM vs EFM - Reinforcing

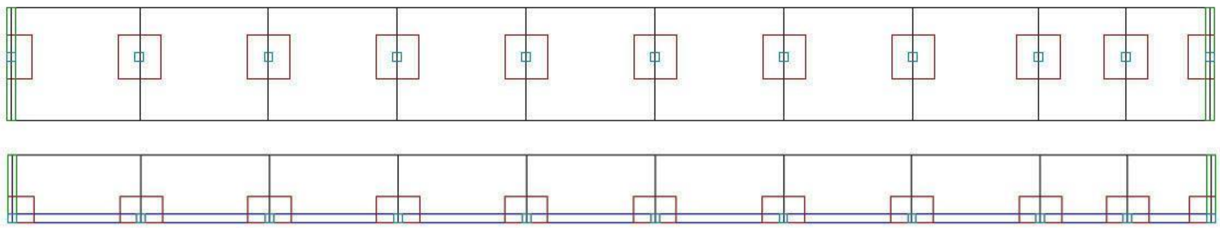


Figure 41: spSlab input

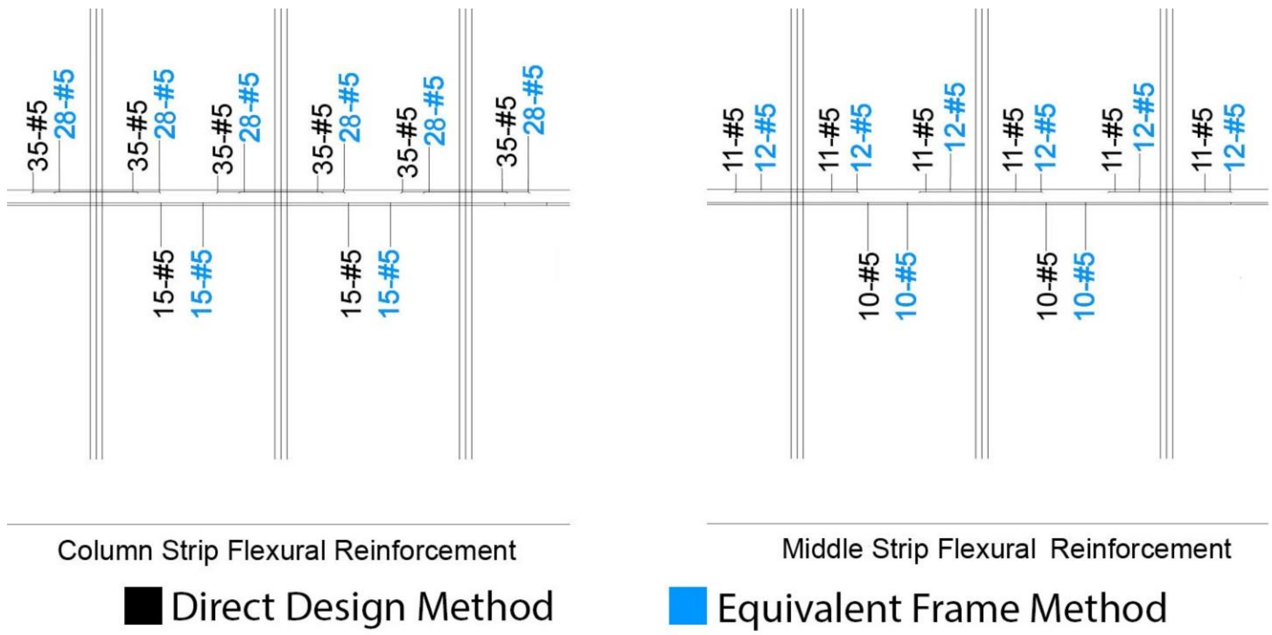


Figure 40: Interior frame

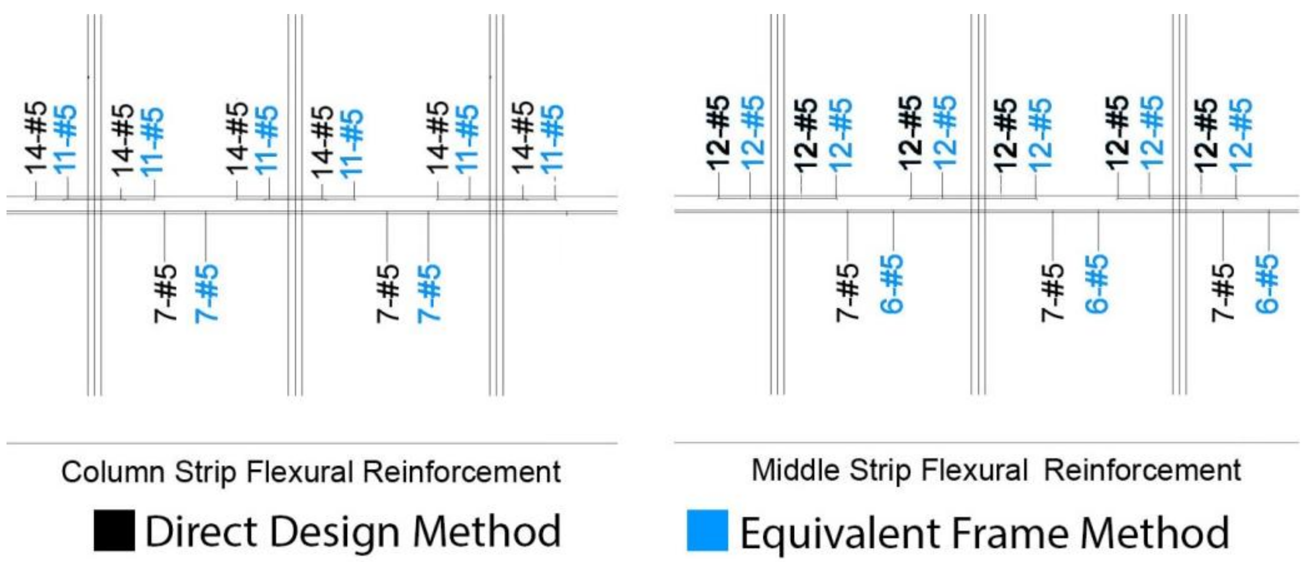
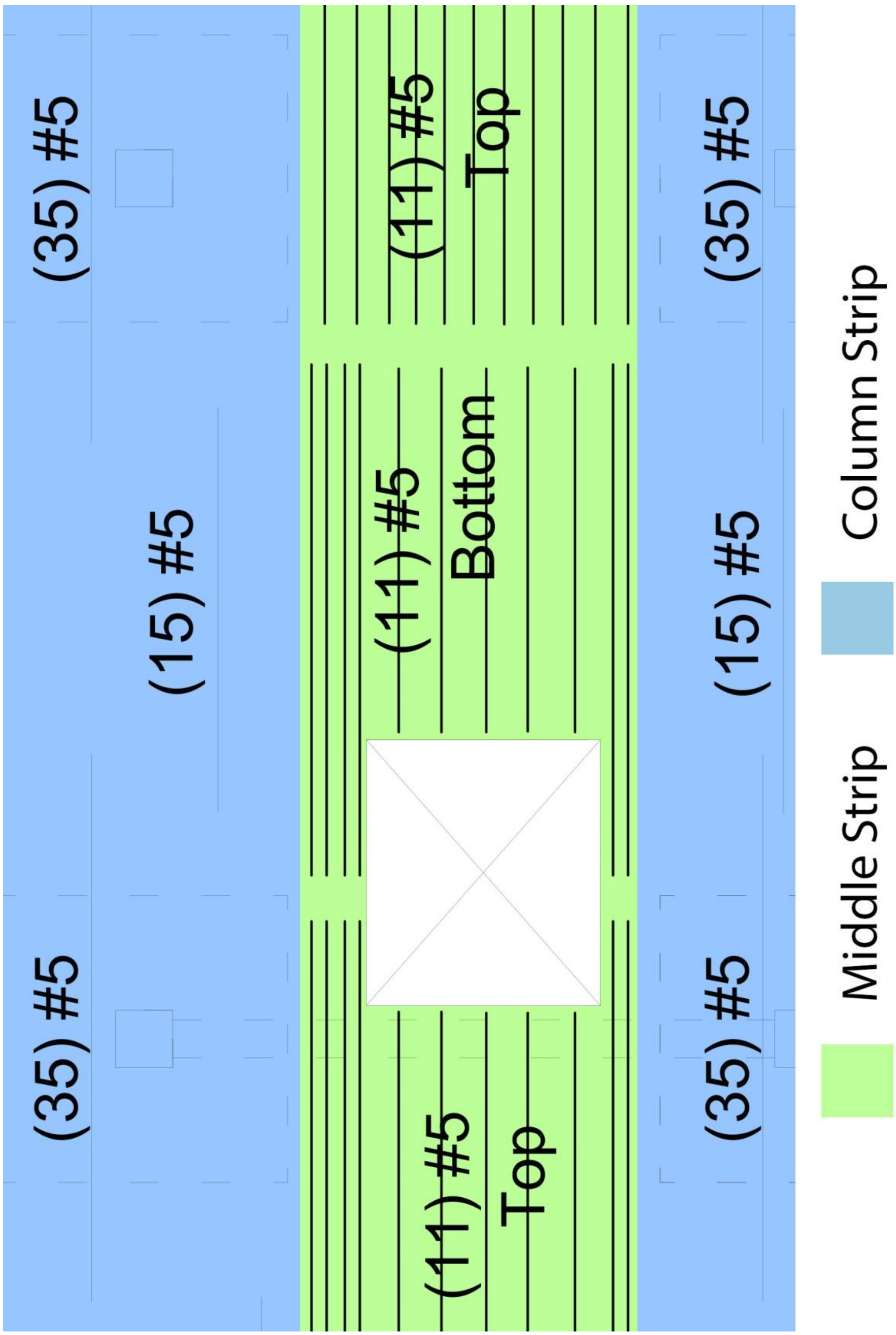


Figure 42: Exterior frame

Appendix E: Slab Opening Details

N-S Details



E-W Details


(14) #5
Top
(6) #5
(6) #5
(13) #5
Top
(9) #5
Bottom
(13) #5
Bottom
(14) #5
Top
(6) #5
(6) #5
(13) #5
Top
Column Strip
Middle Strip

Appendix F: Sample Excel Spreadsheet – Slab Calculations

Column Strip Interior Neg. Moments

l_2/l_1	0.5	0.525	1	0.525	2
$\alpha_f L_2/L_1 = 0$	75	75	75	75	75
0.4470	x	81.37	x	81.37	x
$\alpha_f L_2/L_1 > 1$	90	89.25	75	89.25	45

Column Strip Exterior Neg. Moments ($\alpha_f L_2/L_1 = 0$)

l_2/l_1	0.5	0.525	1	0.525	2
$\beta_t = 0$	100	100	100	100	100
0.8082	x	91.92	x	91.92	x
$\beta_t = 2.5$	75	75	75	75	75

Column Strip Exterior Neg. Moments ($0 < \alpha_f L_2/L_1 < 1$)

l_2/l_1	0.5	0.525	1	0.525	2
$\alpha_f L_2/L_1 = 0$	x	91.92	x	91.92	x
0.4470	x	93.98	x	93.98	x
$\alpha_f L_2/L_1 = 1$	x	96.52	x	96.52	x

Column Strip Exterior Neg. Moments ($\alpha_f L_2/L_1 > 1$)

l_2/l_1	0.5	0.525	1	0.525	2
$\beta_t = 0$	100	100	100	100	100
0.8082	x	96.52	x	96.52	x
$\beta_t = 2.5$	90	89.25	75	89.25	45

Column Strip Positive Moments

l_2/l_1	0.5	0.525	1	0.525	2
$\alpha_f L_2/L_1 = 0$	60	60	60	60	60
0.4470	x	73.08	x	73.08	x
$\alpha_f L_2/L_1 > 1$	90	89.25	75	89.25	45

No Beams	Coeff	M	With Beams	Coeff	M
Column Strip	0.814	241.64	Column Strip	0.620	149.83
			Beam	0.380	91.82
Middle Strip	0.186	55.33			
Column Strip	0.919	272.97	Column Strip	0.620	169.25
			Beam	0.380	103.72
Middle Strip	0.081	24.00			
Column Strip	0.940	279.08	Column Strip	0.620	173.04
			Beam	0.380	106.04
Middle Strip	0.060	17.89			
Column Strip	0.965	286.65	Column Strip	0.620	177.73
			Beam	0.380	108.92
Middle Strip	0.035	10.32			
Column Strip	0.731	116.85	Column Strip	0.620	72.45
			Beam	0.380	44.40
Middle Strip	0.269	43.05			

L_1	30	ft
L_n	28	ft
L_2	15.75	ft
h	10	in
L	80	psf
D	15	psf
Self Wt	125	psf
S	94	psf
L_R	30	psf
q_u	0.296	ksf
M_o	456.88	k-ft
Span Type	1	

I_b (calc)	13410.67	in^3
I_s	15750	in^4
α_f	0.8515	
$\alpha_f L_2/L_1$	0.4470	
C	25457.55	
β_t	0.808176	

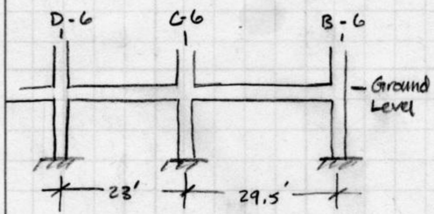
		Int M_u^-	M_u^+	Int M_u^-
1	Interior	0.65	0.35	0.65
		Int M_u^-	M_u^+	Ext M_u^-
2	End No Edge Beam	0.7	0.52	0.26
3	End w/ Edge Beam	0.7	0.5	0.3
4	Ext Edge Fully Restrained	0.65	0.35	0.65
		M_u^-	M_u^+	M_u^-
	Coeff (from above)	0.65	0.35	0.65
	M =	297	160	297

Figure 43: Input data

Appendix G: Column Design Hand Calculations

Column Design | Final Report | Andrew Voorhees | 1

C-6 Interior Column (Ground Floor)



Unbalanced Moment

$M_u = 453.47 - 264.43 = 189.04^{ft\text{-}k}$

$P_u = 2219.81^k$ from Excel Tabulations

$e = \frac{M_u}{P_u} = \frac{189.04 \times 12}{2219.81} = 1.02''$

*Assume $d' = 2.5''$

$\frac{h-2(d')}{h} = \frac{24'' - 2(2.5'')}{24} = 0.79 = \gamma \qquad e/h = 1.02/24'' = 0.0425$

$\frac{\phi P_n}{bh} = \frac{2219.81}{24(24)} = 3.85$

$\frac{\phi M_n}{bh^2} = \frac{189.04 \times 12}{24(24^2)} = 0.164$

Using MacGregor + Wight Design Aids

$f'_c = 6000$ psi $\quad f_y = 60$ ksi

$\gamma = 0.75$ $\quad\quad \gamma = 0.90$

$\rho = 4.3\%$ $\quad\quad \rho = 4.3\%$

$\therefore \gamma = 0.79$

$\rho = 4.3\% < 5\%$ ✓ok

$A_s = \frac{4.3}{100}(24 \times 24) = 24.77\ in^2 \implies$ #10's — 20 bars; #11's — 16 bars ← use

use (16) #11's, #4 ties

$S_{ties} \le \begin{cases} 16(1.410) = 22.56 \leftarrow \text{controls} \\ 48(0.5) = 24 \\ 24 \end{cases}$ use ties @ 18"

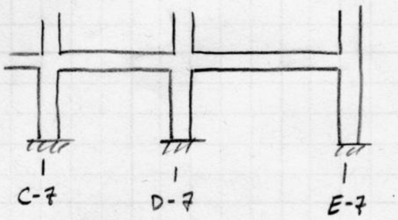
check b_{min}

$= 1.5''(2) + 2(0.5'') + 5(1.410) + 4(1.5 \times 1.410) = 19.51 < 24''$ ✓ok

$\therefore$ use (16) #11's on 4 faces with #4 ties @ 18"

Column Design | Final Report | Andrew Voorhees | 2

B-7 Edge Column (Ground Floor)



Unbalanced Moment

$M_u = 242$ ft-k
$P_u = 1429$ k   Tabulated in Excel

$e = \frac{M_u}{P_u} = \frac{242 \times 12}{1429} = 2.03''$

assume $d' = 2.5''$

$\frac{h - 2(d')}{h} = \frac{24 - 2(2.5)}{24} = 0.79 = \gamma$ $e/h = 2.03/24 = 0.085$

$\frac{\phi P_n}{bh} = \frac{1429}{24(24)} = 2.48$

$\frac{\phi M_n}{bh} = \frac{242 \times 12}{24(24)^2} = 0.21$

using Wight & MacGregor Design Aids

$f'_c = 6000$ psi $f_y = 60$ ksi

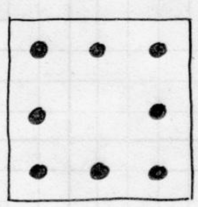
$\gamma = 0.75$ $\gamma = 0.90$
$\rho = 1.0\%$ $\rho = 1.0\%$

$\therefore$ @ $\gamma = 0.79$ — $\rho = 1.0\%$

$A_s = \rho bh = 0.01(24 \times 24) = 5.76$ in²   → $\rho = 1.10\%$

→ (8) #8 = 6.32 in² ← use #8's
(6) #9 = 6.0 in²
(5) #10 = 6.35

use (8) #8's, #4 ties @ 18"



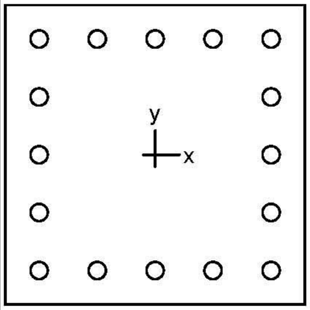
bar spacing
$24 - [2(1.5'') + 2(0.5) + 2(0.5)] = 19''$

$19/2 = 9.5 - 2(0.5) = 8.5''$ clr. spacing ✓ok

use (8) #8 with #4 ties @ 18"

Appendix H: sp Column Output

Column C-6



24 x 24 in

Code: ACI 318-11

Units: English

Run axis: About X-axis

Run option: Design

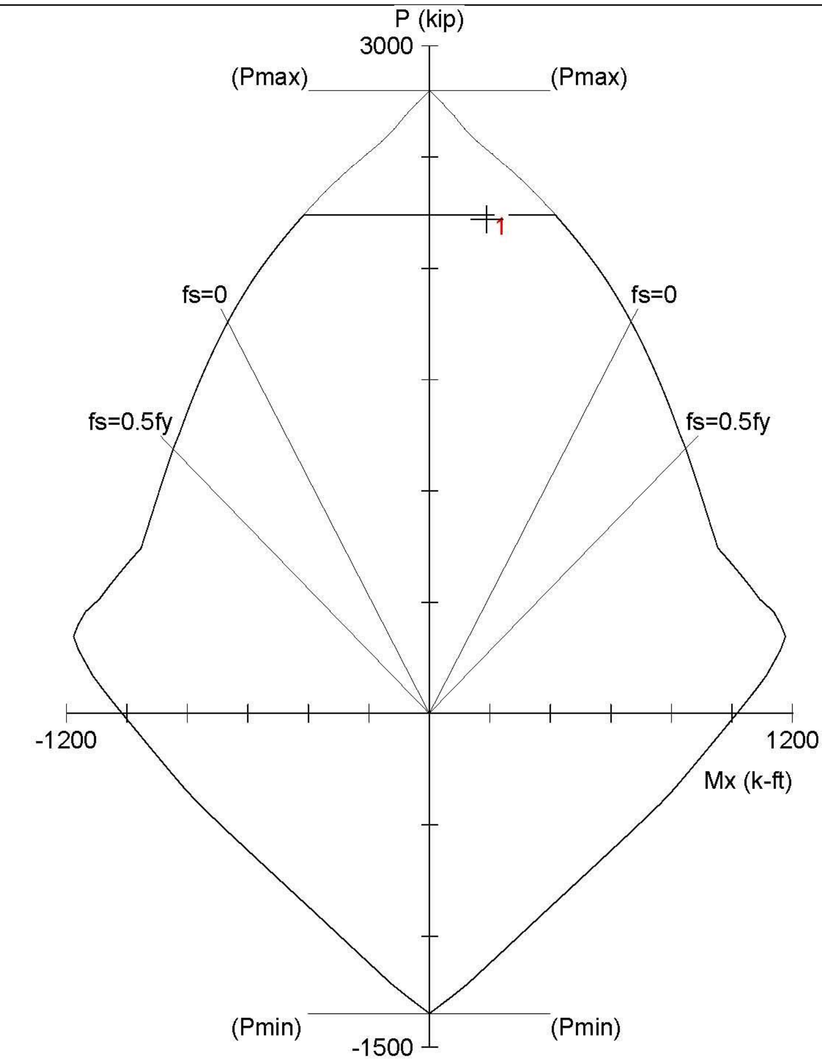
Slenderness: Not considered

Column type: Structural

Bars: ASTM A615

Date: 01/29/13

Time: 15:14:09



spColumn v4.81. Licensed to: Penn State University. License ID: 59919-1033951-4-22545-2CF68

File: F:\Spring\Columns\C - 6 (2).col

Project: Cooper Hospital

Column: C - 6

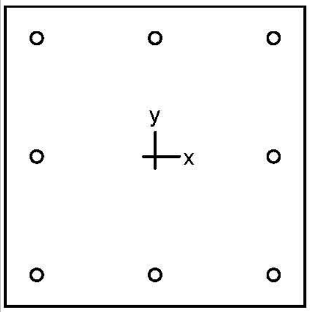
Engineer: Andrew

f'c = 6 ksi	fy = 60 ksi	Ag = 576 in^2	16 #11 bars
Ec = 4415 ksi	Es = 29000 ksi	As = 24.96 in^2	rho = 4.33%
fc = 5.1 ksi		Xo = 0.00 in	Ix = 27648 in^4
e_u = 0.003 in/in		Yo = 0.00 in	Iy = 27648 in^4
Beta1 = 0.75		Min clear spacing = 3.24 in	Clear cover = 2.00 in

Confinement: Tied

phi(a) = 0.8, phi(b) = 0.9, phi(c) = 0.65

Column B-7



24 x 24 in

Code: ACI 318-11

Units: English

Run axis: About X-axis

Run option: Design

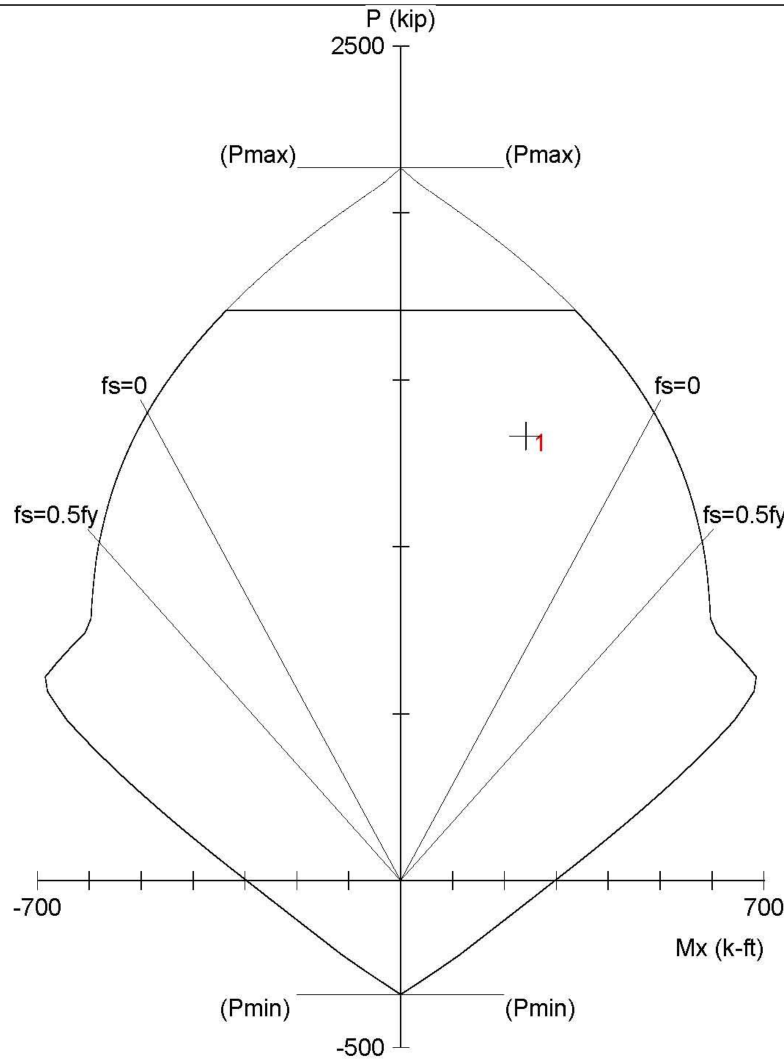
Slenderness: Not considered

Column type: Structural

Bars: ASTM A615

Date: 02/05/13

Time: 14:10:47



spColumn v4.81. Licensed to: Penn State University. License ID: 59919-1033951-4-22545-2CF68

File: F:\Spring\Columns\B-7.col

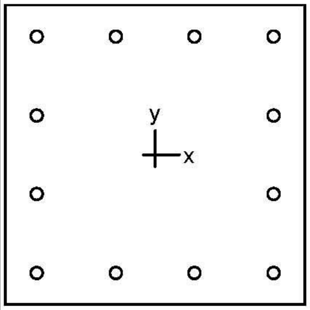
Project: Cooper Hospital

Column: C - 6		Engineer: Andrew	
f'c = 6 ksi	fy = 60 ksi	Ag = 576 in^2	8 #8 bars
Ec = 4415 ksi	Es = 29000 ksi	As = 6.32 in^2	rho = 1.10%
fc = 5.1 ksi		Xo = 0.00 in	Ix = 27648 in^4
e_u = 0.003 in/in		Yo = 0.00 in	Iy = 27648 in^4
Beta1 = 0.75		Min clear spacing = 8.50 in	Clear cover = 2.00 in

Confinement: Tied

phi(a) = 0.8, phi(b) = 0.9, phi(c) = 0.65

Column C-6 Upper Floor



24 x 24 in

Code: ACI 318-11

Units: English

Run axis: About X-axis

Run option: Design

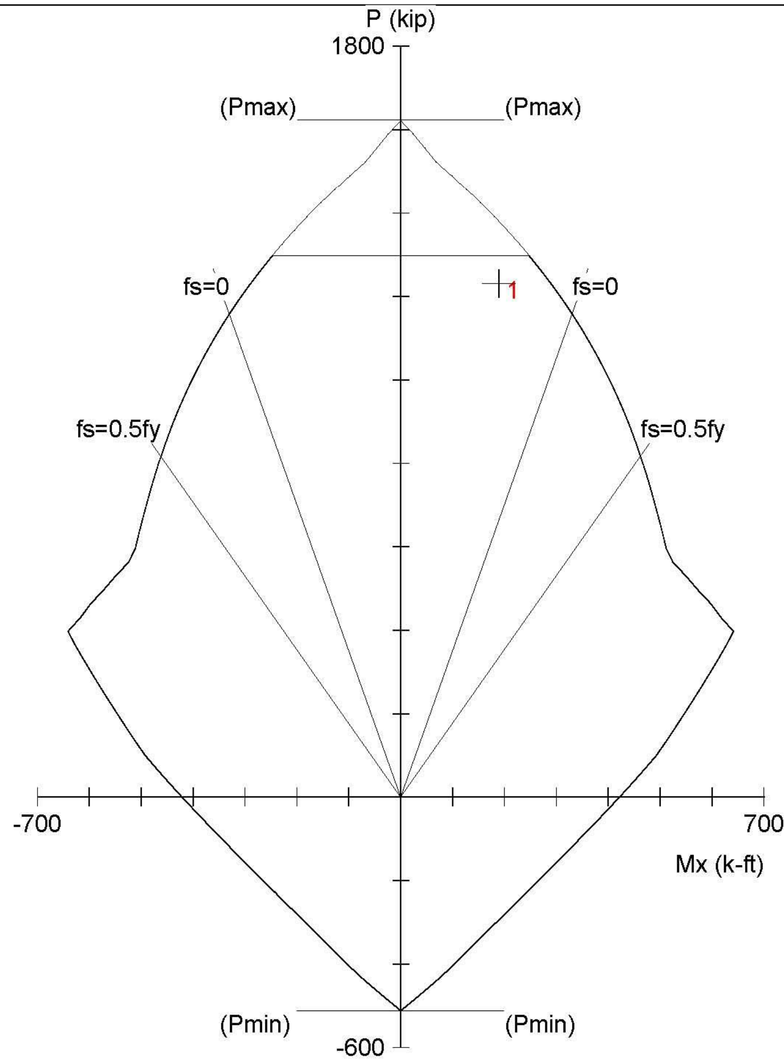
Slenderness: Not considered

Column type: Structural

Bars: ASTM A615

Date: 02/05/13

Time: 15:05:13



spColumn v4.81. Licensed to: Penn State University. License ID: 59919-1033951-4-22545-2CF68

File: F:\Spring\Columns\C-6 (6th floor).col

Project:

Column: C-6 6th Flr		Engineer:	
f'c = 4 ksi	fy = 60 ksi	Ag = 576 in^2	12 #8 bars
Ec = 3605 ksi	Es = 29000 ksi	As = 9.48 in^2	rho = 1.65%
fc = 3.4 ksi		Xo = 0.00 in	Ix = 27648 in^4
e_u = 0.003 in/in		Yo = 0.00 in	Iy = 27648 in^4
Beta1 = 0.85		Min clear spacing = 5.33 in	Clear cover = 2.00 in
Confinement: Tied			
phi(a) = 0.8, phi(b) = 0.9, phi(c) = 0.65			

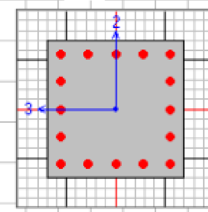
Appendix I: Column Load Calculations

C - 6 Interior Column														
Level	Trib Area	Live Load	Reduced Live Load	Dead	Super	Snow	1.6 L	1.2 D	1.6 S	1.6 L x A_T	1.2 D x A_T	1.6 S x A_T	1.2 x Swt.	Total Wt.
Penthouse Roof	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mech Platform	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Roof	787.5	30	15.52	125	30	94	-	186	150	-	146.475	118.44	-	264.92
10	787.5	80	41.38	125	15	-	66	168	-	52.14	132.3	-	8.64	457.99
9	787.5	80	41.38	125	15	-	66	168	-	52.14	132.3	-	8.64	651.07
8	787.5	80	41.38	125	15	-	66	168	-	52.14	132.3	-	8.64	844.15
7	787.5	80	41.38	125	15	-	66	168	-	52.14	132.3	-	8.64	1037.23
6	787.5	80	41.38	125	15	-	66	168	-	52.14	132.3	-	8.64	1230.31
5	615	80	44.19	125	15	-	71	168	-	43.49	103.32	-	-	-
	172.5	100	80	-	-	-	128	-	-	22.08	-	-	8.64	1407.84
4	615	80	44.19	125	15	-	71	168	-	43.49	103.32	-	-	-
	172.5	100	80	-	-	-	128	-	-	22.08	-	-	8.64	1585.37
3	442.5	100	80	125	15	-	128	168	-	56.64	74.34	-	-	-
	345	125	100	-	-	-	160	-	-	55.20	-	-	9.36	1780.91
2	787.5	100	80	125	15	-	128	168	-	100.80	132.3	-	9.36	2023.37
Ground	345	100	80	125	15	-	128	168	-	44.16	57.96	-	-	-
	442.5	150	120	-	-	-	192	-	-	84.96	-	-	9.36	2219.81
										Sum (No Col DL)		2131.25	**Sum**	**2219.81**

B - 2 Corner Column														
Level	Trib Area	Live Load	Reduced Live Load	Dead	Super	Snow	1.6 L	1.2 D	1.6 S	1.6 L x A_T	1.2 D x A_T	1.6 S x A_T	1.2 x Swt.	Total Wt.
Penthouse Roof	87.5	30	31.55	125	15	94	-	168	150	-	14.7	13.16	-	27.86
Mech Platform	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Roof	221.25	30	22.63	125	30	94	-	186	150	-	41.1525	33.276	-	-
	87.5	100	80				80	-	-	7.00	-	-	8.64	117.9285
10	221.25	80	60.34	125	15	-	97	168	-	21.36	37.17	-	-	-
	87.5	100	80				128	-	-	11.20	-	-	8.64	196.298
9	221.25	80	60.34	125	15	-	97	168	-	21.36	37.17	-	-	-
	87.5	100	80				128	-	-	11.20	-	-	8.64	274.6675
8	221.25	80	60.34	125	15	-	97	168	-	21.36	37.17	-	-	-
	87.5	100	80				128	0	-	11.20	-	-	8.64	353.037
7	221.25	80	60.34	125	15	-	97	168	-	21.36	37.17	-	-	-
	87.5	100	80				128	0	-	11.20	-	-	8.64	431.4065
6	221.25	80	60.34	125	15	-	97	168	-	21.36	37.17	-	-	-
	87.5	100	80				128	-	-	11.20	-	-	8.64	509.776
5	221.25	80	60.34	125	15	-	97	168	-	21.36	37.17	-	-	-
	87.5	100	80				128	-	-	11.20	-	-	8.64	588.1455
4	221.25	80	60.34	125	15	-	97	168	-	21.36	37.17	-	-	-
	87.5	100	80				128	-	-	11.20	-	-	8.64	667.235
3	308.75	100	80	125	15	-	128	168	-	39.52	51.87	-	9.36	767.985
2	308.75	100	80	125	15	-	128	168	-	39.52	51.87	-	9.36	868.735
Ground	640.625	100	80	125	15	-	128	168	-	82.00	107.63	-	9.36	1067.72
										Sum (No Col DL)		969.80	**Sum**	**1067.72**

B-7 Edge Column														
Level	Trib Area	Live Load	Reduced Live Load	Dead	Super	Snow	1.6 L	1.2 D	1.6 S	1.6 L x A_T	1.2 D x A_T	1.6 S x A_T	1.2 x S.wt	Total Wt.
Penthouse Roof	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mech Platform	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Roof	442.5	30	18.20	125	30	94	-	186	150	-	82.305	66.552	8.64	157.50
10	442.5	80	48.52	125	15	-	78	168	-	34.35	74.34	-	8.64	274.83
9	442.5	80	48.52	125	15	-	78	168	-	34.35	74.34	-	8.64	392.17
8	442.5	80	48.52	125	15	-	78	168	-	34.35	74.34	-	8.64	509.50
7	442.5	80	48.52	125	15	-	78	168	-	34.35	74.34	-	8.64	626.83
6	442.5	80	48.52	125	15	-	78	168	-	34.35	74.34	-	8.64	744.17
5	442.5	80	48.52	125	15	-	78	168	-	34.35	74.34	-	8.64	861.50
4	442.5	80	48.52	125	15	-	78	168	-	34.35	74.34	-	9.36	979.56
3	442.5	100	80	125	15	-	128	168	-	56.64	74.34	-	9.36	1119.90
2	442.5	100	80	125	15	-	128	168	-	56.64	74.34	-	9.36	1260.24
Ground	442.5	150	120	125	15	-	192	168	-	84.96	74.34	-	9.36	1428.90
										Sum (No Col DL)		1330.98	**Sum**	**1428.90**

Appendix J: Etabs Column Output




```
ACI 318-08/IBC 2009 COLUMN SECTION DESIGN  Type: Non Sway  Units: Kip-ft  (Summary)

Level        :  1ST FLOOR             L=15.000
Element      :  C40                   B=2.000          D=2.000          dc=0.208
Section ID   :  C-6                   E=576000.000     fc=864.000       Lt.Wt. Fac.=1.000
Combo ID     :  COMB1                 fy=8640.000      fys=8640.000
Station Loc  :  15.000                RLLF=0.800

Phi(Compression-Spiral): 0.750
Phi(Compression-Tied):   0.650
Phi(Tension Controlled): 0.900
Phi(Shear):              0.750
Phi(Seismic Shear):      0.600
Phi(Joint Shear):        0.850

AXIAL FORCE & BIAXIAL MOMENT CHECK FOR PU, M2, M3
            Capacity      Design      Design      Design     Minimum     Minimum
               Ratio          Pu          M2          M3          M2          M3
               0.808    2214.408       0.000    -287.316     198.995     198.995

AXIAL FORCE & BIAXIAL MOMENT FACTORS
                              Cm    Delta_ns     Delta_s           K           L
                          Factor      Factor      Factor      Factor      Length
   Major Bending(M3)       1.000       1.444       1.000       1.000      15.000
   Minor Bending(M2)       1.000       1.444       1.000       1.000      15.000

SHEAR DESIGN FOR V2,V3
                           Rebar       Shear       Shear       Shear       Shear
                            Av/s          Vu      phi*Vc      phi*Vs          Vp
   Major Shear(V2)         0.000       0.000     154.102       0.000       0.000
   Minor Shear(V3)         0.000       0.000     154.102       0.000       0.000

JOINT SHEAR DESIGN
                     Joint Shear       Shear       Shear       Shear       Joint
                           Ratio       VuTop       VuTot      phi*Vc        Area
   Major Shear(V2)           N/A         N/A         N/A         N/A         N/A
   Minor Shear(V3)           N/A         N/A         N/A         N/A         N/A

(6/5) BEAM/COLUMN CAPACITY RATIOS
                           Major       Minor
                           Ratio       Ratio
                             N/A         N/A

Notes:
   N/A: Not Applicable
   N/C: Not Calculated
   N/N: Not Needed
```

Appendix K: Wind Loads

Wind Forces							
		N-S			E-W		
Level	Story Height, hx (ft)	Trib Area (SF)	Story Force, F_x (k)	Overturning Moment (k-ft)	Trib Area (SF)	Story Force, F_y (k)	Overturning Moment (k-ft)
Ground	0	559	16.35	0.00	1852.5	68.56	0.00
2	13	1118	33.17	431.18	3705	107.78	1401.12
3	26	1118	34.52	897.43	3705	141.26	3672.81
4	39	1075	35.35	1378.51	3562.5	142.39	5553.40
5	51	1032	36.63	1868.12	3420	146.33	7462.98
6	63	1032	37.77	2379.53	3420	149.83	9439.51
7	75	1032	38.97	2922.91	3420	153.52	11514.12
8	87	1032	39.85	3466.78	3420	156.21	13590.22
9	99	1032	40.72	4031.67	3420	158.90	15730.83
10	111	1032	41.44	4599.49	3420	161.09	17880.45
Roof	123	2150	88.65	10903.80	7125	342.72	42154.56
Sum			**443.41**	**32,879.42**		**1728.60**	**128,400.00**

Appendix L: Wind Drift

Case 1

Level	P_x				P_y				Δ_{allow}
	δ_x	δ_y	Δ_x	Δ_y	δ_x	δ_y	Δ_x	Δ_y	
Roof	1.0924	-0.0591	0.0483	-0.0049	-0.0262	0.4322	-0.0024	0.0435	0.24
10	1.0441	-0.0542	0.0660	-0.0052	-0.0238	0.3887	-0.0025	0.0450	0.24
9	0.9781	-0.0490	0.0807	-0.0055	-0.0213	0.3437	-0.0026	0.0456	0.24
8	0.8974	-0.0435	0.0944	-0.0058	-0.0187	0.2981	-0.0027	0.0462	0.24
7	0.8030	-0.0377	0.1081	-0.0061	-0.0160	0.2519	-0.0028	0.0461	0.24
6	0.6949	-0.0316	0.1213	-0.0064	-0.0132	0.2058	-0.0027	0.0452	0.24
5	0.5736	-0.0252	0.1302	-0.0068	-0.0105	0.1606	-0.0027	0.0428	0.24
4	0.4434	-0.0184	0.1521	-0.0085	-0.0078	0.1178	-0.0023	0.0416	0.26
3	0.2913	-0.0099	0.1601	-0.0065	-0.0055	0.0762	-0.0027	0.0368	0.26
2	0.1312	-0.0034	0.1300	-0.0039	-0.0028	0.0394	-0.0028	0.0394	0.26
Ground	0	0	0	0	0	0	0	0	0

Case 2

Level	$0.75\ P_x\ (+e_x)$				$0.75\ P_x\ (-e_x)$				Δ_{allow}
	δ_x	δ_y	Δ_x	Δ_y	δ_x	δ_y	Δ_x	Δ_y	
Roof	0.8224	0.0647	0.0368	0.0058	0.8512	-0.1534	0.0388	-0.0131	0.24
10	0.7856	0.0589	0.0500	0.0061	0.8124	-0.1403	0.0522	-0.0139	0.24
9	0.7356	0.0528	0.0611	0.0063	0.7602	-0.1264	0.0633	-0.0146	0.24
8	0.6745	0.0465	0.0715	0.0065	0.6969	-0.1118	0.0738	-0.0153	0.24
7	0.6030	0.0400	0.0815	0.0067	0.6231	-0.0965	0.0841	-0.0158	0.24
6	0.5215	0.0333	0.0914	0.0067	0.5390	-0.0807	0.0942	-0.0163	0.24
5	0.4301	0.0266	0.0977	0.0062	0.4448	-0.0644	0.1010	-0.0165	0.24
4	0.3324	0.0204	0.1131	0.0060	0.3438	-0.0479	0.1183	-0.0186	0.26
3	0.2193	0.0144	0.1197	0.0061	0.2255	-0.0293	0.1238	-0.0159	0.26
2	0.0996	0.0083	0.0996	0.0083	0.1017	-0.0134	0.1017	-0.0134	0.26
Ground	0	0	0	0	0	0	0	0	0

Level	$0.75\ P_y\ (+e_y)$				$0.75\ P_y\ (-e_y)$				Δ_{allow}
	δ_x	δ_y	Δ_x	Δ_y	δ_x	δ_y	Δ_x	Δ_y	
Roof	-0.0515	0.4332	-0.0043	0.0421	0.0123	0.2873	0.0008	0.0283	0.24
10	-0.0472	0.3911	-0.0046	0.0437	0.0115	0.2590	0.0008	0.0289	0.24
9	-0.0426	0.3474	-0.0048	0.0447	0.0107	0.2301	0.0009	0.0294	0.24
8	-0.0378	0.3027	-0.0049	0.0455	0.0098	0.2007	0.0009	0.0298	0.24
7	-0.0329	0.2572	-0.0052	0.0459	0.0089	0.1709	0.0010	0.0298	0.24
6	-0.0277	0.2113	-0.0052	0.0453	0.0079	0.1411	0.0011	0.0294	0.24
5	-0.0225	0.1660	-0.0055	0.0435	0.0068	0.1117	0.0014	0.0285	0.24
4	-0.0170	0.1225	-0.0058	0.0435	0.0054	0.0832	0.0025	0.0321	0.26
3	-0.0112	0.0790	-0.0058	0.0386	0.0029	0.0511	0.0017	0.0253	0.26
2	-0.0054	0.0404	-0.0054	0.0404	0.0012	0.0258	0.0012	0.0258	0.26
Ground	0	0	0	0	0	0	0	0	0

Case	Level	$0.75 P_x + 0.75 P_y$ δ_x	δ_y	Δ_x	Δ_y	$0.75 P_x - 0.75 P_y$ δ_x	δ_y	Δ_x	Δ_y	Δ_{allow}
Case 3	Roof	2.2995	0.3217	0.1047	0.0303	0.8750	-0.9655	0.0414	-0.0979	0.24
	10	2.1948	0.2914	0.1433	0.0312	0.8336	-0.8676	0.0549	-0.1010	0.24
	9	2.0515	0.2602	0.1754	0.0318	0.7787	-0.7666	0.0662	-0.1027	0.24
	8	1.8761	0.2284	0.2058	0.0324	0.7125	-0.6639	0.0767	-0.1040	0.24
	7	1.6703	0.1960	0.2352	0.0329	0.6358	-0.5599	0.0869	-0.1037	0.24
	6	1.4351	0.1631	**0.2636**	0.0328	0.5489	-0.4562	0.0969	-0.1017	0.24
	5	1.1715	0.1303	**0.2797**	0.0333	0.4520	-0.3545	0.1035	-0.0965	0.24
	4	0.8918	0.0970	**0.3153**	0.0404	0.3485	-0.2580	0.1189	-0.0939	0.26
	3	0.5765	0.0566	**0.3194**	0.0307	0.2296	-0.1641	0.1256	-0.0812	0.26
	2	0.2571	0.0259	0.2571	0.0259	0.1040	-0.0829	0.1040	-0.0829	0.26
	Ground	0	0	0	0	0	0	0	0	0

Case	Level	$0.563 P_x (-e_x) + 0.563 P_y (-e_y)$ δ_x	δ_y	Δ_x	Δ_y	$0.563 P_x (-e_x) + 0.563 P_y (+e_y)$ δ_x	δ_y	Δ_x	Δ_y	Δ_{allow}
Case 4	Roof	1.9387	0.8757	0.0963	0.0796	1.8834	0.8656	0.0949	0.0820	0.24
	10	1.8424	0.7961	0.1265	0.0836	1.7885	0.7836	0.1248	0.0861	0.24
	9	1.7159	0.7125	0.1514	0.0867	1.6637	0.6975	0.1496	0.0890	0.24
	8	1.5645	0.6258	0.1750	0.0898	1.5141	0.6085	0.1729	0.0916	0.24
	7	1.3895	0.5360	0.1977	0.0919	1.3412	0.5169	0.1953	0.0930	0.24
	6	1.1918	0.4441	0.2196	0.0925	1.1459	0.4239	0.2160	0.0924	0.24
	5	0.9722	0.3516	0.2328	0.0915	0.9299	0.3315	0.2253	0.0882	0.24
	4	0.7394	0.2601	**0.2636**	0.1018	0.7046	0.2433	0.2476	0.0876	0.26
	3	0.4758	0.1583	**0.2630**	0.0829	0.4570	0.1557	0.2499	0.0767	0.26
	2	0.2128	0.0754	0.2128	0.0754	0.2071	0.0790	0.2071	0.0790	0.26
	Ground	0	0	0	0	0	0	0	0	0
	Level	**$0.563 P_x (+e_x) + 0.563 P_y (-e_y)$ δ_x**	**δ_y**	**Δ_x**	**Δ_y**	**$0.563 P_x (+e_x) + 0.563 P_y (+e_y)$ δ_x**	**δ_y**	**Δ_x**	**Δ_y**	**Δ_{allow}**
	Roof	0.8694	-1.4541	0.0488	-0.1393	0.7437	-1.0141	0.0398	-0.0977	0.24
	10	0.8206	-1.3148	0.0602	-0.1457	0.7039	-0.9164	0.0504	-0.1014	0.24
	9	0.7604	-1.1691	0.0693	-0.1499	0.6535	-0.8150	0.0592	-0.1040	0.24
	8	0.6911	-1.0192	0.0782	-0.1537	0.5943	-0.7110	0.0676	-0.1062	0.24
	7	0.6129	-0.8655	0.0864	-0.1556	0.5267	-0.6048	0.0755	-0.1073	0.24
	6	0.5265	-0.7099	0.0944	-0.1545	0.4512	-0.4975	0.0829	-0.1062	0.24
	5	0.4321	-0.5554	0.1005	-0.1489	0.3683	-0.3913	0.0862	-0.1027	0.24
	4	0.3316	-0.4065	0.1162	-0.1500	0.2821	-0.2886	0.0977	-0.1113	0.26
	3	0.2154	-0.2565	0.1175	-0.1294	0.1844	-0.1773	0.0995	-0.0893	0.26
	2	0.0979	-0.1271	0.0979	-0.1271	0.0849	-0.0880	0.0849	-0.0880	0.26
	Ground	0	0	0	0	0	0	0	0	0

Appendix M: Seismic Parameters

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Ordinary Reinforced Concrete Moment Frames (N-S)

$R = 3 \quad C_d = 2.5 \quad \Omega_0 = 3$

Ordinary Reinforced Concrete Shear Walls (E-W)

$R = 4 \quad C_d = 4 \quad \Omega_0 = 2.5$

$I = 1.5$
Use group III
Design Category C
Site Class D

$S_s = 0.267$
$S_1 = 0.059$
$S_{DS} = 0.282$
$S_{D1} = 0.095$
$T_L = 6$ sec.

Approximate Fundamental Period for N-S direction

$T_a = C_t h_n^x$ for conc Moment-resiting Frames (Table 12.8-2)

$C_t = 0.016$
$x = 0.9$
$h_n = 123^{ft}$

$T_a = 0.016(123)^{0.9}$

$= 1.22$ sec

Fundamental Period for N-S direction

$T = T_a C_u$ (from Table 12.8-1)

$C_u = 1.7$

$T = 1.22(1.7) = 2.074$ sec → shall not exceed

Seismic Response Coefficient (N-S)

$C_s = \frac{S_{DS}}{(R/I)} = \frac{0.282}{3(1.5)} = 0.141$

$T < T_L \therefore C_s \le \frac{S_{D1}}{T(R/I)} = \frac{0.095}{1.22(3/1.5)} = 0.0389 < 0.141 = C_s$

controls

$C_s = 0.0389$ N-S direction

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Approximate Fundamental Period for E-W direction

$T_a = C_t h_n^x$ for concrete shear walls (other systems)

$= 0.02(123)^{0.75}$ $C_t = 0.02$, $x = 0.75$

$= 0.739$ sec

Fundamental Period for E-W direction

$T = T_a C_u = 1.7(0.739) = 1.256$ sec ← shall not exceed

Seismic Response Coefficient

$C_s = \frac{S_{DS}}{(R/I)} = 0.141$

$T < T_L \therefore C_s \le \frac{S_{D1}}{T(R/I)} = \frac{0.095}{0.739(3/1.5)} = 0.0643 < 0.141 = C_s$

controls

$C_s = 0.0643$ E-W direction

Base Shears

$W = 48,794.30^k$

North - South Conc. Mom.-Resisting Frames	East - West Conc. shear walls
$C_s = 0.0389$	$C_s = 0.0643$
$V_b = C_s W$	$V_b = C_s W$
$= 0.0389(48,794.3)$	$= 0.0643(48,794.3)$
$V_b = 1898^k$	$V_b = 3138^k$

These values are much larger than those used for the steel structure's foundation. If time permits the foundations will be evaluated to account for this larger base shear.

Appendix N: Seismic Loads

Building Weight (k)						
Level	Floor (k)	Columns (k)	MEP (k)	SDL (k)	Walls (k)	Total (k)
Ground	4924.75	368.00	196.99	590.97	55.07	6135.78
2	3483.00	368.00	139.32	417.96	119.32	4527.60
3	3643.88	368.00	145.76	437.27	112.86	4707.75
4	3812.00	368.00	152.48	457.44	169.57	4959.49
5	2866.38	368.00	114.66	343.97	205.15	3898.15
6	2866.38	368.00	114.66	343.97	205.15	3898.15
7	2866.38	368.00	114.66	343.97	205.15	3898.15
8	2866.38	368.00	114.66	343.97	205.15	3898.15
9	2866.38	368.00	114.66	343.97	205.15	3898.15
10	2866.38	368.00	114.66	343.97	205.15	3898.15
Roof	3268.38	512.00	115.43	692.58	486.40	5074.79
				Total Building Weight		**48,794.30**

Seismic Forces N-S							
Level	Story Height, h_x (ft)	Story Weight, w_x (k)	$w_x h_x^k$	C_{vx}	Story Force, F_x (k)	Story Shear (k)	Overturning Moment (k-ft)
Ground	0	6136	0	0.00	0.00	1898.00	0.00
2nd	13	4528	148194.24	0.01	19.87	1898.00	258.26
3rd	26	4708	395528.29	0.03	53.02	1878.13	1378.59
4th	39	4959	723243.63	0.05	96.95	1825.11	3781.24
5th	51	3898	818754.42	0.06	109.76	1728.16	5597.69
6th	63	3898	1091343.25	0.08	146.30	1618.40	9216.95
7th	75	3898	1383380.14	0.10	185.45	1472.10	13908.75
8th	87	3898	1692795.14	0.12	226.93	1286.65	19742.81
9th	99	3898	2018004.28	0.14	270.52	1059.72	26781.97
10th	111	3898	2357748.46	0.17	316.07	789.19	35083.73
Roof	123	5075	3529301.02	0.25	473.12	473.12	58194.12
Sum		**48794**	**14,158,292.87**	**1.00**	**1898.00**		**173,944.13**

Seismic Forces N-S							
Level	Story Height, h_x (ft)	Story Weight, w_x (k)	$w_x h_x^k$	C_{vx}	Story Force, F_x (k)	Story Shear (k)	Overturning Moment (k-ft)
Ground	0	6136	0	0.00	0.00	1898.00	0.00
2nd	13	4528	148194.24	0.01	19.87	1898.00	258.26
3rd	26	4708	395528.29	0.03	53.02	1878.13	1378.59
4th	39	4959	723243.63	0.05	96.95	1825.11	3781.24
5th	51	3898	818754.42	0.06	109.76	1728.16	5597.69
6th	63	3898	1091343.25	0.08	146.30	1618.40	9216.95
7th	75	3898	1383380.14	0.10	185.45	1472.10	13908.75
8th	87	3898	1692795.14	0.12	226.93	1286.65	19742.81
9th	99	3898	2018004.28	0.14	270.52	1059.72	26781.97
10th	111	3898	2357748.46	0.17	316.07	789.19	35083.73
Roof	123	5075	3529301.02	0.25	473.12	473.12	58194.12
Sum		**48794**	**14,158,292.87**	**1.00**	**1898.00**		**173,944.13**

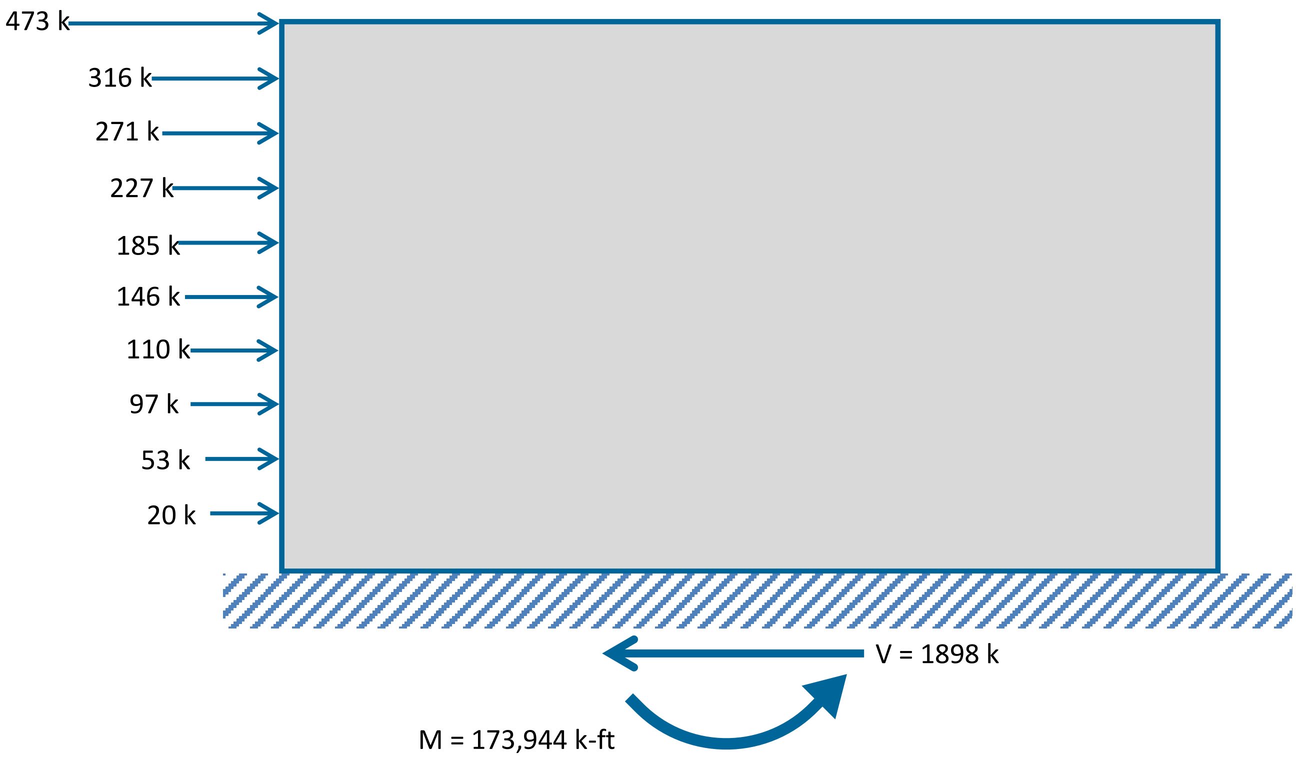


Figure 44: N-S Seismic loads

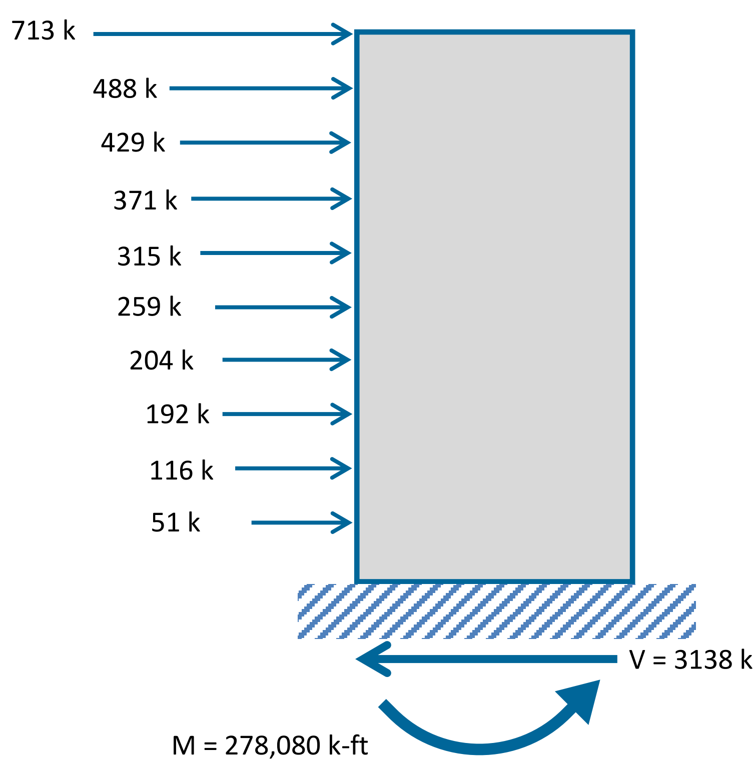


Figure 45: E-W Seismic loads

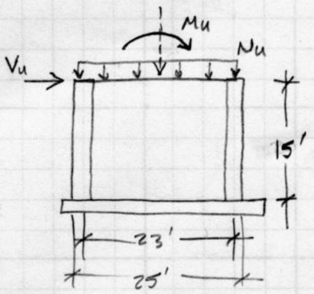
Appendix O: Seismic Drift

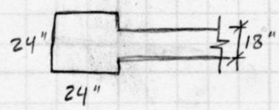
Drift N-S (x - direction)										
	E_X			$E_X + E_{XT}$ ($+e_y$)			$E_X + E_{XT}$ ($-e_y$)			
Level	δ_{xe}	$C_d\delta_{xe}/I$	Δ_x	δ_{xe}	$C_d\delta_{xe}/I$	Δ_x	δ_{xe}	$C_d\delta_{xe}/I$	Δ_x	Δ_{allow}
Roof	6.108	10.179	0.434	6.122	10.203	0.435	6.093	10.155	0.432	1.44
10	5.847	9.745	0.595	5.861	9.768	0.597	5.834	9.723	0.593	1.44
9	5.490	9.150	0.775	5.503	9.171	0.777	5.478	9.130	0.773	1.44
8	5.025	8.375	0.934	5.036	8.394	0.936	5.014	8.357	0.932	1.44
7	4.465	7.442	1.066	4.475	7.458	1.069	4.455	7.425	1.064	1.44
6	3.825	6.375	1.171	3.834	6.389	1.173	3.817	6.361	1.168	1.44
5	3.123	5.205	1.248	3.130	5.216	1.251	3.116	5.193	1.246	1.44
4	2.374	3.957	1.458	2.380	3.966	1.466	2.369	3.948	1.451	1.56
3	1.499	2.499	1.391	1.500	2.500	1.392	1.498	2.497	1.390	1.56
2	0.665	1.108	1.108	0.665	1.108	1.108	0.665	1.108	1.108	1.56
Ground	0	0	0	0	0	0	0	0	0	0

Drift E-W (y - direction)										
	E_Y			$E_Y + E_{YT}$ ($+e_x$)			$E_Y + E_{YT}$ ($-e_x$)			
Level	δ_{ye}	$C_d\delta_{ye}/I$	Δ_y	δ_{ye}	$C_d\delta_{ye}/I$	Δ_y	δ_{ye}	$C_d\delta_{ye}/I$	Δ_y	Δ_{allow}
Roof	3.706	9.883	1.034	3.761	10.029	0.970	3.652	9.738	1.098	1.44
10	3.319	8.849	1.098	3.397	9.059	1.123	3.240	8.640	1.074	1.44
9	2.907	7.751	1.105	2.976	7.935	1.131	2.837	7.566	1.080	1.44
8	2.492	6.646	1.101	2.552	6.805	1.126	2.433	6.487	1.075	1.44
7	2.079	5.545	1.078	2.129	5.678	1.104	2.030	5.412	1.052	1.44
6	1.675	4.467	1.033	1.715	4.574	1.059	1.635	4.360	1.008	1.44
5	1.288	3.434	0.961	1.318	3.516	0.985	1.257	3.352	0.937	1.44
4	0.927	2.473	0.926	0.949	2.531	0.894	0.906	2.415	0.958	1.56
3	0.580	1.547	0.775	0.614	1.637	0.821	0.546	1.456	0.729	1.56
2	0.290	0.772	0.772	0.306	0.817	0.817	0.273	0.727	0.727	1.56
Ground	0	0	0	0	0	0	0	0	0	0

Appendix P: Shear Wall Design

Shear Wall Design | Final Report | Andrew Voorhees | 1





Self wt of walls above

$= [(24 \times 24 \times 2) + (18 \times 23 \times 12)] \div 144 \times 150 \times 123'$

$= 784.125^k$

$V_u = 1076^k$

$M_u = 52{,}236.2^{k\text{-}ft}$

$N_u = 2888.66^k$

W_t of slabs + SDL

$= 11 \times [(29.5' + 23') \times 30'] \times (125 + 15)$

11 floors

$= 2425.5^k$

Total DL $= 3209.63^k$

$N_u = 0.9(3209.63) = 2888.66^k$

Shear Capacity

ACI 318-11 § 11.9.6 Minimum of :

$V_c = 3.3\lambda\sqrt{f'_c}\,hd + \frac{N_u d}{4 l_w}$ — $d = 0.8\,l_w = 0.8 \times 25' \times 12'' = 240''$

$= 3.3\sqrt{6000}(18)(240) + \frac{2888.66(240)}{4(25 \times 12)} \times 1000 = 1682.00$

$V_c = \left[0.6\lambda\sqrt{f'_c} + \frac{l_w\left(1.25\lambda\sqrt{f'_c} + \frac{0.2 N_u}{l_w h}\right)}{\frac{M_u}{V_u} - \frac{l_w}{2}}\right] hd$

$= \left[0.6\sqrt{6000} + \frac{(25 \times 12)\left(1.25\sqrt{6000} + \frac{0.2(2888.66) \times 1000}{(25 \times 12 \times 18)}\right)}{\frac{52{,}236.2 \times 12}{2888.66} - \frac{25 \times 12}{2}}\right] \times 240 \times 18$

$= 67.0$

$= 4143.17^k$

$\therefore V_c = 1682^k$

$V_u > 0.5\phi V_c$ ∴ Reinf shall be provided by 11.9.9

Shear Wall Design | Final Report | Andrew Voorhees | 2

Horizontal Reinforcement

$V_u \geq 0.5(0.75)(1682) = 630.75^k$

but $V_u > 0.75(1682) = 1261.5^k$

∴ Reinf. provided based on $A_{v,min}$

$\rho_t \geq 0.0025 = \frac{A_v}{sh}$ $\qquad s \leq \begin{cases} l_w/5 = 60'' \\ 3h = 54'' \\ 18'' \leftarrow \text{controls} \end{cases}$

$0.0025 = \frac{A_v}{18''(18'')}$

$A_v \geq 0.81 \div 2 = 0.405\ in^2$ per curtain

$\#6 \quad A_b = 0.44\ in^2$ $\qquad \rho = \frac{0.88\ in^2}{18(18)} = 0.0027$ ✓ok

∴ use 2 curtains of #6 @ 18" o.c.

Vertical Reinforcement

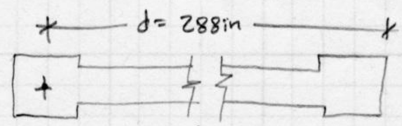
$\rho_l \geq \begin{cases} 0.0025 \\ 0.0025 + 0.5\left(2.5 - \frac{15}{25}\right)(0.0027 - 0.0025) \end{cases} = 0.00269$

∴ use 2 curtains of #6 @ 18" o.c. $\qquad \rho_l = 0.0027$

Flexural Design

$T = A_s F_y$

$C = 0.85 f'_c b a$



$a = \frac{T + N_u}{0.85 f'_c b} = \frac{A_s F_y + N_u}{0.85 f'_c b}$

$\phi M_n = \phi\left[T\left(d - \frac{a}{2}\right) + N_u\left(\frac{l_w - a}{2}\right)\right]$

substitute for a, solve for A_s

$\phi M_n = \phi\left[A_s F_y\left(d - \left(\frac{A_s F_y + N_u}{0.85 f'_c b(2)}\right)\right) + \frac{N_u}{2}\left(l_w - \left(\frac{A_s F_y + N_u}{0.85 f'_c b}\right)\right)\right]$

$\phi M_n \geq M_u$

Shear Wall Design | Final Report | Andrew Voorhees | 3

$$\frac{M_u}{\phi} = A_s F_y \left(d - \frac{N_u}{0.85 f'_c b (2)} - \frac{A_s F_y}{0.85 f'_c b (2)} \right) + \frac{N_u}{2} \left(l_w - \frac{N_u}{0.85 f'_c b} - \frac{A_s F_y}{0.85 f'_c b} \right)$$

$$\frac{52{,}236.2 \times 12}{0.9} = 60 A_s \left(288 - \frac{2888.66}{0.85(6)(18)(2)} - \frac{60 A_s}{0.85(6)(18)(2)} \right) +$$

$$+ \frac{2888.66}{2} \left(25 \times 12 - \frac{2888.66}{0.85(6)(18)} - \frac{60 A_s}{0.85(6)(18)} \right)$$

$$696{,}482.67 = 16{,}335.99 A_s - 19.61 A_s^2 + 387{,}850.43 - 944.01 A_s$$

$$0 = -19.61 A_s^2 + 15391.98 A_s - 308{,}632.24$$

$$A_s = 20.59 \text{ in}^2$$

#10's = 16.2 bars ≈ 18 bars
#11's = 13.2 bars ≈ 14 bars

$$A_s = 14(1.56) = 21.84 \text{ in}^2$$

∴ use (14) #11's

$$T = A_s F_y = 14(1.56)(60) = 1310.4^k$$

$$a = \frac{T + N_u}{0.85 f'_c b} = \frac{1310.4 + 2888.66}{0.85(6)(18)} = 45.74''$$

$$\phi M_n = 0.9 \left[1310 \left(288 - \frac{45.74}{2} \right) + 2888.66 \left(\frac{300 - 45.74}{2} \right) \right]$$

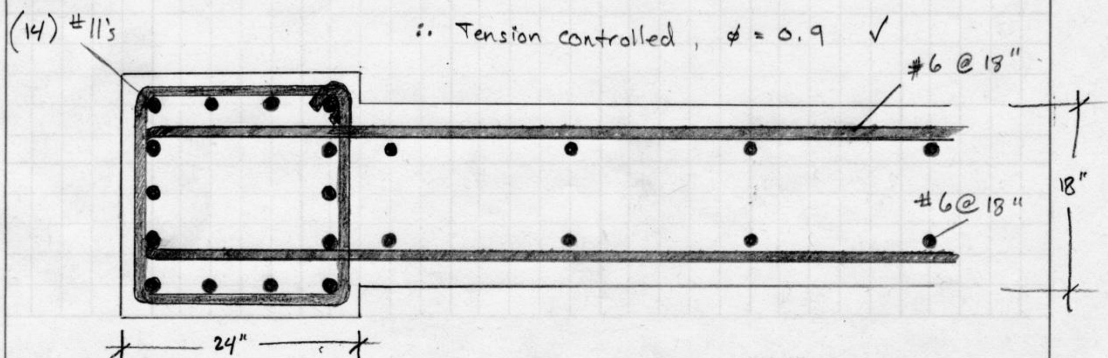
$$= 643{,}100 \text{ "k} = 53{,}591.67 \text{ kft}$$

$\phi M_n \geq M_u$ ✓ OK

Tension controlled ?

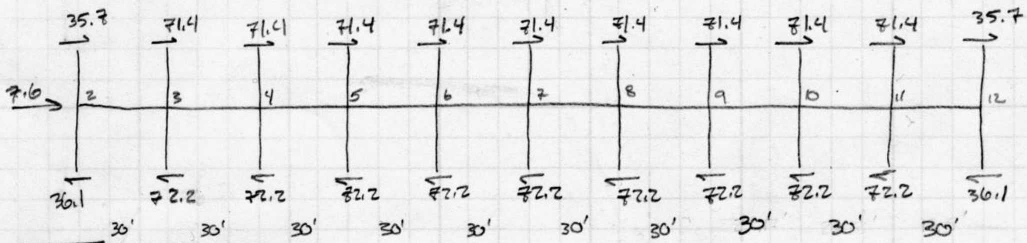
$$c = a/\beta_1 = 45.74/0.75 = 60.99'' < 0.375d = 108''$$

∴ Tension controlled, $\phi = 0.9$ ✓



Appendix Q: Moment Frame Design

Moment Frame Calcs | Final Report | Andrew Voorhees | 1



Exterior Frame

Story shear @ second story = 1878 k

Frame takes 38% ⟹ 714 k

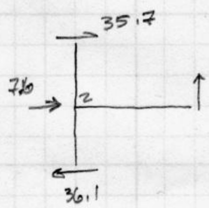
Story Force @ second story = 19.87 k

38% ⟹ 7.6 k

Shear in ground columns = (714 + 7.6) ÷ 10 = 72.2 k

Compare to etabs output: shear = 60.51 k ✓ ok
Frame B ↗

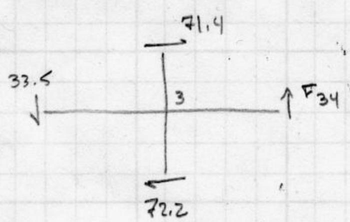
Etabs distributed forces to other frames ie. lobby. More conservative to use hand calcs.



$\Sigma M_2 = 35.7 \times 7' + 36.1 \times 7' - F_{23} \times 15'$

$F_{23} = 33.5^k$

$M_{23} = 33.5 \times 15' = 502.6$ ft k



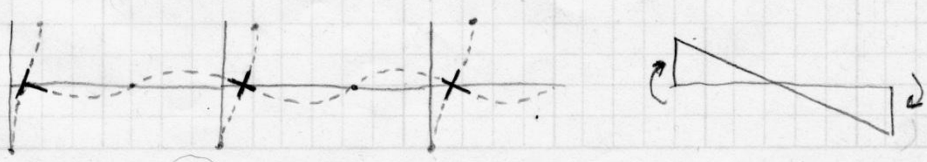
$\Sigma M_3 = 71.4 \times 7' + 72.2 \times 7' - 33.5 \times 15' - F_{34} \times 15'$

$F_{34} = 33.5^k$

M = 502.7 ✓ ok   should be the same

Compare with etabs output

Frame E: M = 277.0 ft k → Moment is lower b/c shear is lower



Moment Frame Calcs | Final Report | Andrew Voorhees | 2

Moments from DDM :

Live = 80 psf
MEP = 5 psf
SDL = 10 psf
S.wt = 125 psf

EQ. $M = 502.6^{ftk}$

Load Combos :

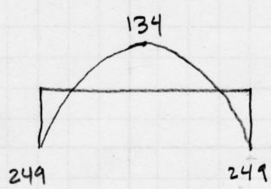
1.2D + 1.0E + L + 0.2S ←
0.9D + 1.0E + 1.6H

$q_u = 1.0(80\ psf) + 1.2(15 + 125) = 0.248\ ksf$

$M_o = \frac{q_u l_2 l_n^2}{8} = \frac{0.248(15.75')(28)^2}{8} =$ $M_o = 382.8^{kft}$

$M_u^+ = 0.35 M_o$ $\quad M_u^- = 0.65 M_o$

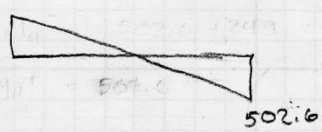
$= 134^{kft}$ $\quad = 249^{kft}$



Distribute to Beam

$M_u^- = 38\% = 94.62^{ftk}$

$M_u^+ = 38\% = 50.92^{ftk}$



$M_u^- = 502.6 + 50.92 = 553.52^{ftk}$

Reversible ∴ M = 553.52 at Top and Bottom

shear : $0.248 \times 15.75' = 3.91\ klf$

$V_{max} = \frac{3.91 \times 28}{2} = 54.7\ k$

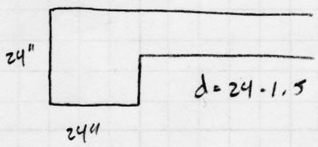
$V_{from\ EQ} = 33.5^k$

$V_{max} = 88.2^k$

Moment Frame Calcs | Final Report | Andrew Voorhees | 3

Design Edge Beams

$M = 553.52$ ftk



$A_s = \frac{M_u}{4d} = \frac{553.52}{4(22.5)} = 6.15$

Try #10's $A_s = 1.27$ → Need 5 bars
$A_s = 6.35\ in^2$
Top + Bottom

$a = \frac{A_s F_y}{0.85 f'_c b} = \frac{6.35(60)}{0.85(4)(24)} = 4.67$ in

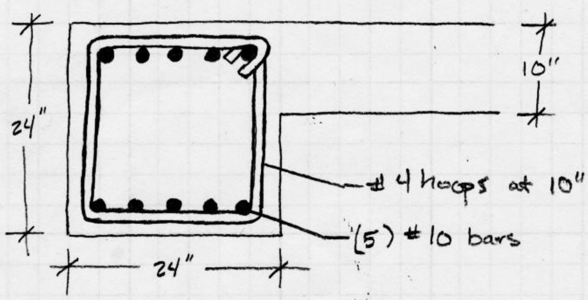
$c = \frac{4.67}{0.85} = 5.5''$

$d = 22.5 - 0.635 = 21.865''$

$\varepsilon_s = \frac{0.003}{5.5}(22.5 - 5.5) = 0.0092 > 0.005 \therefore \phi = 0.9$

$\phi M_n = 0.9(6.35)(21.865 - \frac{4.67}{2})(\frac{60}{12}) = 558.1$ ftk $> M_u$ ✓ok

∴ use (5) #10 bars Top and Bottom



Shear reinf.

$s = \frac{A_v f_y d}{V_s}$

$V_c = 2\lambda\sqrt{f'_c}\, b_w d$
$= 2\sqrt{4000}(24)(21.865) = 66.37$

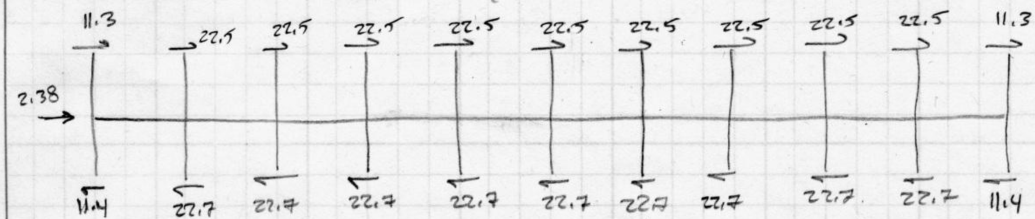
$V_s = \frac{V_u}{\phi} - V_c = \frac{88.2}{0.75} - 66.37 = 51.23^k$

try #4 hoops

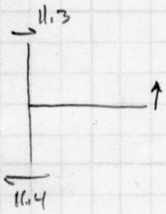
$s = \frac{(0.20 \times 2)60(21.865)}{51.23} = 10.24''$

∴ use #4 hoops at 10"

Moment Frame (Int.) | Final ~~Report~~ | Andrew Voorhees | 4



Interior Frame



$11.3 \times 7' + 11.4 \times 7' - F_{23} \times 15' = 0$

$F_{23} = 10.59^k$

$M = 158.9^{ftk}$

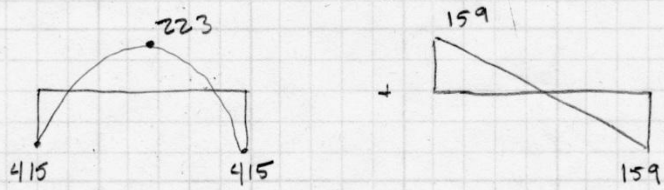
Moments from DDM:

$q_u = 0.248$ ksf Load Combo $1.2D + 1.0E + L$

$M_o = \frac{0.248(28)^2(26.25)}{8} = 638.0^{ftk}$

$M_u^- = 0.65 M_o$

$M_u^+ = 0.35 M_o$



$M_u^- = 415 + 159 = 574^{ftk}$

$M_u^+ = 223^{ftk}$

Distribute to Col. and Middle strips

M_u^- to Col. $= 0.75(574) = 430.5^{ftk}$

M_u^- to Mid $= 0.25(574) = 143.5^{ftk}$ → half to each

M_u^+ to Col $= 0.60(223) = 133.8^{ftk}$

M_u^+ to Mid $= 0.40(223) = 89.2^{ftk}$ → half to each

Reinf designed with excel spreadsheet

Neg. Reinf @ Col. = 41 bars Pos. Reinf. @ Col. strip = 12 bars
@ Mid = 13 bars @ Mid Strip = 18 bars

Check Col shear due to Lateral Loads — Andrew Voorhees

Check Column B-7 (Part of Moment Frame)

ties → #4's @ 18" oc.

V_u from lateral Load = 72.2^k, $N_u = 1428^k$

$V_c = 2\left(1 + \frac{N_u}{2000A_g}\right)\lambda\sqrt{f'c}\, b_w d$ (Eqn. 11-4)

$2\left(1 + \frac{1428 \times 1000}{2000(24 \times 24)}\right)(1)\sqrt{6000}(24)(21.5) = 179.03^k$

$V_u \le 0.5\,\phi\,V_c$?

$= 0.5(0.75)(179.03) = 67.14^k$

$V_u \ge 67.14^k$ ∴ Must satisfy § 11.4.5.1

spacing $\le d/2 = 10.75$ ⇒ use 10"

§ 11.4.6.3 $A_{v\,min} = 0.75\sqrt{f'c}\,\frac{b_w s}{f_{yt}}$

$= 0.75\sqrt{6000}\,\frac{24(10)}{60000} = 0.23 \text{ in}^2$ ← controls

and $\ge \frac{50 b_w s}{f_{yt}} = \frac{50(24)(10)}{60{,}000} = 0.2$

2 legs of a #4

$A_v = 0.20 \times 2 = 0.40 \text{ in}^2$ ✓ ok

∴ use #4 hoops @ 10" oc.

Appendix R: Krueger Diffuser Specifications

KRUEGER
Excellence in Air Distribution

LINEAR SLOT DIFFUSERS E1

DesignFlo® | Architectural Linear Slot Diffuser

DFL Performance Data: Vertical Throw

IP/METRIC DATA: DFL, CONTINUOUS SLOT (VT BLADES)

		IP Data				Metric Data			Octave Band, dB					
		Air Flow	Press Ps	Perpendicular Throw	NC	Air Flow	Press Ps	Perpendicular Throw						
		CFM/ft	"WG	ft		L/s/m	Pa	m	2	3	4	5	6	7
1.0" Slot Width	1 Slot	20	0.003	2 - 3 - 6	-	31	0.8	0.5 - 0.9 - 1.8	-	11	-	-	-	-
		80	0.054	8 - 12 - 19	19	124	13.3	2.5 - 3.7 - 5.7	41	42	34	30	22	13
		110	0.101	11 - 16 - 22	27	171	25.2	3.4 - 4.7 - 6.7	49	49	42	38	31	23
		140	0.164	14 - 18 - 25	33	217	40.8	4.3 - 5.3 - 7.6	55	54	47	44	38	31
		200	0.335	17 - 21 - 30	42	310	83.3	5.2 - 6.4 - 9.0	65	62	56	52	49	42
	2 Slots	50	0.005	4 - 5 - 11	-	78	1.3	1.1 - 1.6 - 3.3	14	19	-	-	-	-
		150	0.047	11 - 16 - 26	20	233	11.7	3.3 - 4.9 - 7.8	42	43	36	31	23	14
		200	0.084	14 - 21 - 30	28	310	20.8	4.3 - 6.4 - 9.0	50	50	42	38	32	23
		250	0.131	18 - 23 - 33	34	388	32.5	5.4 - 7.1 - 10.1	56	54	48	44	38	30
		350	0.256	23 - 28 - 39	42	543	63.8	6.9 - 8.4 - 11.9	64	62	56	52	48	41
1.5" Slot Width	1 Slot	30	0.006	2 - 4 - 7	-	47	1.4	0.7 - 1.1 - 2.3	13	-	-	-	-	-
		100	0.063	8 - 12 - 21	14	155	15.7	2.5 - 3.8 - 6.4	42	37	31	25	17	-
		135	0.115	11 - 17 - 24	23	210	28.6	3.4 - 5.1 - 7.4	49	44	39	34	30	22
		170	0.182	14 - 19 - 27	30	264	45.3	4.3 - 5.9 - 8.3	55	50	45	42	40	33
		240	0.363	19 - 23 - 33	44	373	90.3	5.7 - 7.0 - 9.9	63	58	54	52	55	51
	2 Slots	40	0.003	1 - 3 - 7	-	62	0.6	0.4 - 0.9 - 2.1	-	-	-	-	-	-
		160	0.040	9 - 14 - 27	11	248	10.0	2.8 - 4.3 - 8.1	39	34	28	21	11	-
		220	0.076	13 - 19 - 31	20	342	19.0	3.9 - 5.8 - 9.5	47	42	37	31	24	14
		280	0.123	16 - 24 - 35	27	435	30.7	5.0 - 7.4 - 10.7	53	48	43	38	35	27
		400	0.252	23 - 30 - 42	39	621	62.7	7.1 - 9.0 - 12.8	62	57	52	50	50	45
2.0" Slot Width	1 Slot	20	0.002	1 - 1 - 4	-	31	0.4	0.2 - 0.4 - 1.3	30	25	-	-	-	-
		100	0.044	7 - 11 - 21	20	155	10.9	2.2 - 3.3 - 6.4	45	43	32	15	-	-
		140	0.086	10 - 15 - 25	24	217	21.3	3.0 - 4.6 - 7.6	48	47	39	25	17	-
		180	0.141	13 - 19 - 28	28	279	35.2	3.9 - 5.9 - 8.6	51	49	44	33	27	16
		260	0.295	19 - 24 - 34	37	404	73.5	5.6 - 7.3 - 10.3	54	54	52	44	43	32
	2 Slots	40	0.002	1 - 2 - 6	-	62	0.4	0.3 - 0.6 - 1.8	33	28	-	-	-	-
		180	0.035	9 - 14 - 27	22	279	8.8	2.8 - 4.1 - 8.3	47	45	33	15	-	-
		250	0.068	13 - 19 - 33	26	388	17.0	3.8 - 5.8 - 10.1	50	48	39	25	15	-
		320	0.112	16 - 24 - 38	30	497	27.8	4.9 - 7.4 - 11.4	53	51	44	32	25	13
		460	0.231	23 - 32 - 45	37	714	57.5	7.1 - 9.7 - 13.7	56	55	52	44	40	30
2.5" Slot Width	1 Slot	20	0.001	0 - 1 - 4	-	31	0.3	0.1 - 0.3 - 1.2	-	-	-	-	-	-
		120	0.049	8 - 11 - 23	11	186	12.2	2.3 - 3.5 - 7.0	38	34	28	13	-	-
		170	0.098	11 - 16 - 27	19	264	24.5	3.3 - 4.9 - 8.3	44	41	35	24	21	-
		220	0.165	14 - 21 - 31	25	342	41.0	4.3 - 6.4 - 9.5	49	46	40	32	30	19
		320	0.348	20 - 27 - 38	33	497	86.7	6.2 - 8.1 - 11.4	55	54	48	44	43	38
	2 Slots	40	0.001	1 - 1 - 5	-	62	0.3	0.2 - 0.4 - 1.6	-	-	-	-	-	-
		220	0.041	10 - 15 - 30	13	342	10.2	3.0 - 4.5 - 9.1	40	35	29	13	-	-
		310	0.082	14 - 21 - 37	20	481	20.3	4.3 - 6.4 - 11.2	46	42	36	24	21	-
		400	0.136	18 - 27 - 42	26	621	33.9	5.5 - 8.2 - 12.8	50	47	41	32	30	17
		580	0.286	26 - 36 - 51	34	900	71.2	8.0 - 10.9 - 15.4	56	55	49	44	43	36
3.0" Slot Width	1 Slot	20	0.001	0 - 1 - 3	-	31	0.3	0.1 - 0.2 - 0.9	-	-	-	-	-	-
		140	0.051	8 - 12 - 24	-	217	12.6	2.5 - 3.7 - 7.4	40	31	22	14	-	-
		200	0.104	12 - 17 - 30	16	310	25.8	3.5 - 5.3 - 9.0	47	39	31	24	21	-
		260	0.175	15 - 23 - 34	23	404	43.6	4.6 - 6.9 - 10.3	51	45	38	31	29	19
		380	0.374	22 - 29 - 41	33	590	93.1	6.7 - 8.8 - 12.4	59	54	47	41	41	34
	2 Slots	50	0.002	1 - 2 - 6	-	78	0.4	0.2 - 0.5 - 1.9	-	-	-	-	-	-
		250	0.040	10 - 15 - 31	-	388	10.1	3.1 - 4.7 - 9.4	41	32	23	14	-	-
		350	0.079	14 - 22 - 39	16	543	19.8	4.4 - 6.6 - 11.9	47	39	31	23	20	-
		450	0.131	19 - 28 - 45	23	699	32.7	5.6 - 8.5 - 13.5	52	45	37	30	28	16
		650	0.274	27 - 38 - 54	33	1009	68.1	8.1 - 11.5 - 16.3	59	54	46	40	39	31

NOTES: Throw values are given for terminal velocities of 150, 100, and 50 FPM (0.75, 0.50, and 0.25 m/s). NC values are based on octave band 2 - 7 sound power levels minus a room absorption of 10dB, re 10^{-12} Watts. Dash in space denotes a NC or dB value of less than 10. Data was obtained from tests conducted in accordance with ANSI/ASHRAE Standard 70, ISO Standard 5219, and ISO Standard 3741. 2-Way, 1-Slot throw is split throw. Refer to page E1-4 and E1-5 for directional airflow descriptions. Pressures are for diffuser section only. Plenums will add to sound level and pressure drop. Keep inlet velocities below 800 FPM to reduce plenum generated sound level and pressure drop. See correction factors on page E1-14. See selection software for performance data not shown, including octave band data.

LINEAR SLOT DIFFUSERS

DESIGNFLO

Appendix S: Steel Cost Estimate

Steel Deck - 05 31 13.50 (5400)						
Level	SF	Material	Labor	Equipment	Total	Tot Incl O&P
		2.34	0.47	0.04	2.85	3.45
Ground	39398	92191.32	18517.06	1575.92	112284.3	135923.1
2nd	27864	65201.76	13096.08	1114.56	79412.4	96130.8
3rd	29151	68213.34	13700.97	1166.04	83080.35	100570.95
4th	30496	71360.64	14333.12	1219.84	86913.6	105211.2
5th	22931	53658.54	10777.57	917.24	65353.35	79111.95
6th	22931	53658.54	10777.57	917.24	65353.35	79111.95
7th	22931	53658.54	10777.57	917.24	65353.35	79111.95
8th	22931	53658.54	10777.57	917.24	65353.35	79111.95
9th	22931	53658.54	10777.57	917.24	65353.35	79111.95
10th	22931	53658.54	10777.57	917.24	65353.35	79111.95
Roof	23086	54021.24	10850.42	923.44	65795.1	79646.7
Total	**287581**	**$672,939.54**	**$135,163.07**	**$11,503.24**	**$819,605.85**	**$ 992,154.45**

Applied Fireproofing - Steel Deck - 07 81 16.10 (0500)						
Level	SF	Material	Labor	Equipment	Total	Tot Incl O&P
		0.79	0.71	0.1	1.6	2.05
Ground	39398	31124.42	27972.58	3939.8	63036.8	80765.9
2nd	27864	22012.56	19783.44	2786.4	44582.4	57121.2
3rd	29151	23029.29	20697.21	2915.1	46641.6	59759.55
4th	30496	24091.84	21652.16	3049.6	48793.6	62516.8
5th	22931	18115.49	16281.01	2293.1	36689.6	47008.55
6th	22931	18115.49	16281.01	2293.1	36689.6	47008.55
7th	22931	18115.49	16281.01	2293.1	36689.6	47008.55
8th	22931	18115.49	16281.01	2293.1	36689.6	47008.55
9th	22931	18115.49	16281.01	2293.1	36689.6	47008.55
10th	22931	18115.49	16281.01	2293.1	36689.6	47008.55
Roof	23086	18237.94	16391.06	2308.6	36937.6	47326.3
Total	**287581**	**$227,188.99**	**$204,182.51**	**$28,758.10**	**$460,129.60**	**$ 589,541.05**

Placing Concrete - 03 31 05.70 (1400)						
Level	**C.Y.**	**Material**	**Labor**	**Equipment**	**Total**	**Tot Incl O&P**
		0	**17.25**	**5.5**	**22.75**	**32.5**
Ground	395.20	0	6817.13	2173.58	8990.71	12843.87
2nd	279.50	0	4821.38	1537.25	6358.63	9083.75
3rd	292.41	0	5044.07	1608.25	6652.32	9503.32
4th	305.90	0	5276.80	1682.46	6959.25	9941.79
5th	230.02	0	3967.81	1265.10	5232.90	7475.58
6th	230.02	0	3967.81	1265.10	5232.90	7475.58
7th	230.02	0	3967.81	1265.10	5232.90	7475.58
8th	230.02	0	3967.81	1265.10	5232.90	7475.58
9th	230.02	0	3967.81	1265.10	5232.90	7475.58
10th	230.02	0	3967.81	1265.10	5232.90	7475.58
Roof	231.57	0	3994.63	1273.65	5268.28	7526.11
Total	**2884.69**	**$ -**	**$ 49,760.83**	**$15,865.77**	**$ 65,626.61**	**$ 93,752.29**

Finishing Concrete - 03 35 29.30 (0250)						
Level	**SF**	**Material**	**Labor**	**Equipment**	**Total**	**Tot Incl O&P**
		0	**0.56**	**0.03**	**0.49**	**0.86**
Ground	39398	0	22062.88	1181.94	19305.02	33882.28
2nd	27864	0	15603.84	835.92	13653.36	23963.04
3rd	29151	0	16324.56	874.53	14283.99	25069.86
4th	30496	0	17077.76	914.88	14943.04	26226.56
5th	22931	0	12841.36	687.93	11236.19	19720.66
6th	22931	0	12841.36	687.93	11236.19	19720.66
7th	22931	0	12841.36	687.93	11236.19	19720.66
8th	22931	0	12841.36	687.93	11236.19	19720.66
9th	22931	0	12841.36	687.93	11236.19	19720.66
10th	22931	0	12841.36	687.93	11236.19	19720.66
Roof	23086	0	12928.16	692.58	11312.14	19853.96
Total	**2884.685957**	**$ -**	**$161,045.36**	**$ 8,627.43**	**$140,914.69**	**$ 247,319.66**

Concrete Topping - 03 30 53.40 (3300)						
Level	SF	Material	Labor	Equipment	Total	Tot Incl O&P
		1.16	0.95	0.31	2.42	3.06
Ground	39398	45701.68	37428.1	12213.38	95343.16	120557.88
2nd	27864	32322.24	26470.8	8637.84	67430.88	85263.84
3rd	29151	33815.16	27693.45	9036.81	70545.42	89202.06
4th	30496	35375.36	28971.2	9453.76	73800.32	93317.76
5th	22931	26599.96	21784.45	7108.61	55493.02	70168.86
6th	22931	26599.96	21784.45	7108.61	55493.02	70168.86
7th	22931	26599.96	21784.45	7108.61	55493.02	70168.86
8th	22931	26599.96	21784.45	7108.61	55493.02	70168.86
9th	22931	26599.96	21784.45	7108.61	55493.02	70168.86
10th	22931	26599.96	21784.45	7108.61	55493.02	70168.86
Roof	23086	26779.76	21931.7	7156.66	55868.12	70643.16
Total	**287581**	**$ 333,593.96**	**$ 273,201.95**	**$ 89,150.11**	**$ 695,946.02**	**$ 879,997.86**

Structural Steel - Beams & Girders (6th Floor) 05 12 23.77 (0900)												
Member				#	Length	L.F.	Tons	Material	Labor	Equipment	Total	Tot Incl O&P
								2600	440	126	3166	3750
W	12	x	14	10	10.0	100.0	0.70	1820.00	308.00	88.20	2216.20	2625.00
W	12	x	16	1	19.5	19.5	0.16	405.60	68.64	19.66	493.90	585.00
W	12	x	19	1	23.0	23.0	0.22	568.10	96.14	27.53	691.77	819.38
W	12	x	19	1	11.7	11.7	0.11	288.25	48.78	13.97	351.00	415.74
W	12	x	30	2	11.7	23.3	0.35	910.26	154.04	44.11	1108.42	1312.88
W	14	x	22	1	29.5	29.5	0.32	843.70	142.78	40.89	1027.37	1216.88
W	14	x	22	2	11.7	23.3	0.26	667.52	112.97	32.35	812.84	962.78
W	14	x	22	19	23.0	437.0	4.81	12498.20	2115.08	605.68	15218.96	18026.25
W	14	x	34	1	20.3	20.3	0.35	898.59	152.07	43.55	1094.20	1296.04
W	14	x	38	1	23.0	23.0	0.44	1136.20	192.28	55.06	1383.54	1638.75
W	16	x	26	4	23.0	92.0	1.20	3109.60	526.24	150.70	3786.54	4485.00
W	16	x	26	52	29.5	1534.0	19.94	51849.20	8774.48	2512.69	63136.37	74782.50
W	16	x	26	1	20.3	20.3	0.26	687.15	116.29	33.30	836.74	991.09
W	16	x	31	4	29.5	118.0	1.83	4755.40	804.76	230.45	5790.61	6858.75
W	16	x	31	4	23.0	92.0	1.43	3707.60	627.44	179.68	4514.72	5347.50
W	18	x	35	1	29.5	29.5	0.52	1342.25	227.15	65.05	1634.45	1935.94
W	18	x	35	3	20.3	61.0	1.07	2775.05	469.62	134.48	3379.15	4002.47
W	18	x	35	2	19.5	39.0	0.68	1774.50	300.30	86.00	2160.80	2559.38
W	18	x	40	2	29.5	59.0	1.18	3068.00	519.20	148.68	3735.88	4425.00
W	18	x	40	1	20.3	20.3	0.41	1057.16	178.90	51.23	1287.30	1524.75
W	21	x	44	2	19.5	39.0	0.86	2230.80	377.52	108.11	2716.43	3217.50
W	21	x	50	1	29.5	29.5	0.74	1917.50	324.50	92.93	2334.93	2765.63
W	24	x	62	1	29.5	29.5	0.91	2377.70	402.38	115.23	2895.31	3429.38
W	24	x	62	1	30.0	30.0	0.93	2418.00	409.20	117.18	2944.38	3487.50
W	24	x	84	1	30.0	30.0	1.26	3276.00	554.40	158.76	3989.16	4725.00
W	24	x	76	2	30.0	60.0	2.28	5928.00	1003.20	287.28	7218.48	8550.00
W	24	x	55	27	30.0	810.0	22.28	57915.00	9801.00	2806.65	70522.65	83531.25
W	24	x	68	2	29.2	58.3	1.98	5156.73	872.68	249.90	6279.31	7437.59
HSS	10x6x1/2			2	23.0	46.0	1.12	2921.23	494.36	141.57	3557.16	4213.31
HSS	10x6x1/2			1	20.3	20.3	0.50	1291.06	218.49	62.57	1572.11	1862.10
HSS	6x6x3/8			4	11.5	46.0	0.63	1643.30	278.10	79.64	2001.04	2370.15
HSS	12x12x1/2			1	30.0	30.0	1.14	2966.73	502.06	143.77	3612.56	4278.94
Total							**70.85**	**$ 184,204.37**	**$ 31,173.05**	**$ 8,926.83**	**$ 224,304.25**	**$ 265,679.39**

Columns 05 12 23.77 (0900)													
Member				#	Length	LF	Tons	Material	Labor	Equipment	Total	Tot Incl O&P
								2600	440	126	3166	3750
W	14	x	43	2	58	116	2.49	6484.40	1097.36	314.24	7896.00	9352.50
W	14	x	43	1	50	50	1.08	2795.00	473.00	135.45	3403.45	4031.25
W	14	x	61	4	58	232	7.08	18397.60	3113.44	891.58	22402.62	26535.00
W	14	x	61	4	52	208	6.34	16494.40	2791.36	799.34	20085.10	23790.00
W	14	x	61	4	50	200	6.10	15860.00	2684.00	768.60	19312.60	22875.00
W	14	x	68	2	52	104	3.54	9193.60	1555.84	445.54	11194.98	13260.00
W	14	x	74	5	52	260	9.62	25012.00	4232.80	1212.12	30456.92	36075.00
W	14	x	82	1	42	42	1.72	4477.20	757.68	216.97	5451.85	6457.50
W	14	x	82	1	52	52	2.13	5543.20	938.08	268.63	6749.91	7995.00
W	14	x	90	6	28	168	7.56	19656.00	3326.40	952.56	23934.96	28350.00
W	14	x	90	6	39	234	10.53	27378.00	4633.20	1326.78	33337.98	39487.50
W	14	x	90	2	42	84	3.78	9828.00	1663.20	476.28	11967.48	14175.00
W	14	x	90	4	50	200	9.00	23400.00	3960.00	1134.00	28494.00	33750.00
W	14	x	90	11	52	572	25.74	66924.00	11325.60	3243.24	81492.84	96525.00
W	14	x	90	12	58	696	31.32	81432.00	13780.80	3946.32	99159.12	117450.00
W	14	x	99	3	58	174	8.61	22393.80	3789.72	1085.24	27268.76	32298.75
W	14	x	99	5	52	260	12.87	33462.00	5662.80	1621.62	40746.42	48262.50
W	14	x	109	1	52	52	2.83	7368.40	1246.96	357.08	8972.44	10627.50
W	14	x	109	1	42	42	2.29	5951.40	1007.16	288.41	7246.97	8583.75
W	14	x	120	6	52	312	18.72	48672.00	8236.80	2358.72	59267.52	70200.00
W	14	x	132	1	55	55	3.63	9438.00	1597.20	457.38	11492.58	13612.50
W	14	x	132	4	56	224	14.78	38438.40	6504.96	1862.78	46806.14	55440.00
W	14	x	145	2	56	112	8.12	21112.00	3572.80	1023.12	25707.92	30450.00
W	14	x	145	2	52	104	7.54	19604.00	3317.60	950.04	23871.64	28275.00
W	14	x	159	1	62	62	4.93	12815.40	2168.76	621.05	15605.21	18483.75
W	14	x	159	7	52	364	28.94	75238.80	12732.72	3646.19	91617.71	108517.50
W	14	x	176	2	52	104	9.15	23795.20	4026.88	1153.15	28975.23	34320.00
W	14	x	176	1	75	75	6.60	17160.00	2904.00	831.60	20895.60	24750.00
W	14	x	176	4	56	224	19.71	51251.20	8673.28	2483.71	62408.19	73920.00
W	14	x	176	1	62	62	5.46	14185.60	2400.64	687.46	17273.70	20460.00
W	14	x	193	2	56	112	10.81	28100.80	4755.52	1361.81	34218.13	40530.00
W	14	x	193	2	62	124	11.97	31111.60	5265.04	1507.72	37884.36	44872.50
W	14	x	193	2	52	104	10.04	26093.60	4415.84	1264.54	31773.98	37635.00
W	14	x	211	1	52	52	5.49	14263.60	2413.84	691.24	17368.68	20572.50
W	14	x	211	3	56	168	17.72	46082.40	7798.56	2233.22	56114.18	66465.00
W	14	x	211	1	62	62	6.54	17006.60	2878.04	824.17	20708.81	24528.75
W	12	x	230	6	13	78	8.97	23322.00	3946.80	1130.22	28399.02	33637.50
W	14	x	233	4	52	208	24.23	63003.20	10662.08	3053.23	76718.51	90870.00
W	14	x	233	1	62	62	7.22	18779.80	3178.12	910.10	22868.02	27086.25
W	14	x	233	2	42	84	9.79	25443.60	4305.84	1233.04	30982.48	36697.50
W	14	x	233	4	69	276	32.15	83600.40	14147.76	4051.40	101799.56	120577.50
W	14	x	257	2	56	112	14.39	37419.20	6332.48	1813.39	45565.07	53970.00
W	14	x	257	2	42	84	10.79	28064.40	4749.36	1360.04	34173.80	40477.50
W	14	x	257	2	52	104	13.36	34746.40	5880.16	1683.86	42310.42	50115.00
W	14	x	342	5	56	280	47.88	124488.00	21067.20	6032.88	151588.08	179550.00
W	14	x	370	1	56	56	10.36	26936.00	4558.40	1305.36	32799.76	38850.00
W	14	x	426	2	56	112	23.86	62025.60	10496.64	3005.86	75528.10	89460.00
Total							**547.79**	**$1,424,248.80**	**$241,026.72**	**$69,021.29**	**$1,734,296.81**	**$2,054,205.00**

Sturcural Steel - Braced Frames - 05 12 23.77 (0900)											
Member			#	L.F.	lb/ft	Tons	Material	Labor	Equipment	Total	Tot Incl O&P
							2600	440	126	3166	3750
Column Line E	HSS	10x10x1/2	2	22.4	62.46	1.40	3637.67	615.61	176.29	4429.56	5246.64
	HSS	10x10x3/8	2	17.5	47.9	0.84	2179.45	368.83	105.62	2653.90	3143.44
	HSS	10x10x5/16	4	17.5	40.35	1.41	3671.85	621.39	177.94	4471.18	5295.94
	HSS	10x10x5/16	4	16.5	40.35	1.33	3462.03	585.88	167.78	4215.69	4993.31
	HSS	8x8x5/16	6	16.5	31.84	1.58	4097.81	693.48	198.59	4989.87	5910.30
	HSS	6x6x5/16	6	16.5	23.34	1.16	3003.86	508.35	145.57	3657.77	4332.49
	HSS	10x10x5/16	1	36	40.35	0.73	1888.38	319.57	91.51	2299.47	2723.63
	HSS	12x12x3/8	2	36	58.1	2.09	5438.16	920.30	263.54	6622.01	7843.50
	HSS	12x12x1/2	2	20.5	76.07	1.56	4054.53	686.15	196.49	4937.17	5847.88
	HSS	10x10x1/2	4	20.5	62.46	2.56	6658.24	1126.78	322.67	8107.68	9603.23
	HSS	10x10x1/2	4	19.8	62.46	2.47	6430.88	1088.30	311.65	7830.84	9275.31
	HSS	10x10x3/8	2	19.8	47.9	0.95	2465.89	417.30	119.50	3002.70	3556.58
	HSS	10x10x5/16	2	19.8	40.35	0.80	2077.22	351.53	100.67	2529.41	2995.99
	HSS	8x8x5/16	6	19.8	31.84	1.89	4917.37	832.17	238.30	5987.84	7092.36
Column Line B	HSS	12x12x1/2	2	20.5	76.07	1.56	4054.53	686.15	196.49	4937.17	5847.88
	HSS	12x12x3/8	4	20.5	58.1	2.38	6193.46	1048.12	300.14	7541.73	8932.88
	HSS	10x10x1/2	2	19.8	62.46	1.24	3215.44	544.15	155.83	3915.42	4637.66
	HSS	10x10x3/8	6	19.8	47.9	2.85	7397.68	1251.91	358.50	9008.09	10669.73
	HSS	8x8x5/16	4	19.8	31.84	1.26	3278.25	554.78	158.87	3991.90	4728.24
	HSS	6x6x5/16	2	19.8	23.34	0.46	1201.54	203.34	58.23	1463.11	1733.00
	HSS	10x10x5/16	1	22.8	40.35	0.46	1195.97	202.40	57.96	1456.33	1724.96
	HSS	10x10x5/16	1	27.6	40.35	0.56	1447.76	245.01	70.16	1762.92	2088.11
	HSS	12x12x3/8	3	33.1	58.1	2.88	7500.13	1269.25	363.47	9132.85	10817.49
	HSS	12x12x3/8	3	32.7	58.1	2.85	7409.49	1253.91	359.08	9022.48	10686.77
	HSS	10x10x1/2	2	32.7	62.46	2.04	5310.35	898.67	257.35	6466.37	7659.16
	HSS	10x10x5/16	2	32.7	40.35	1.32	3430.56	580.56	166.25	4177.36	4947.92
	HSS	6x6x5/16	1	32.7	23.34	0.38	992.18	167.91	48.08	1208.17	1431.03
Column Line 12	HSS	10x10x1/2	4	18.1	62.46	2.26	5878.74	994.86	284.89	7158.49	8478.95
	HSS	10x10x5/16	2	18.1	40.35	0.73	1898.87	321.35	92.02	2312.24	2738.76
	HSS	10x10x5/16	10	17.3	40.35	3.49	9074.72	1535.72	439.77	11050.21	13088.53
	HSS	8x8x5/16	4	17.3	31.84	1.10	2864.33	484.73	138.81	3487.87	4131.24
	HSS	6x6x5/16	2	29.4	23.34	0.69	1784.11	301.93	86.46	2172.50	2573.24
Column Line 8	HSS	10x10x3/8	2	23.1	47.9	1.11	2876.87	486.86	139.42	3503.15	4149.34
	HSS	10x10x1/2	4	18.1	62.46	2.26	5878.74	994.86	284.89	7158.49	8478.95
	HSS	10x10x3/8	2	18.1	47.9	0.87	2254.17	381.48	109.24	2744.89	3251.21
	HSS	10x10x3/8	2	17.3	47.9	0.83	2154.54	364.61	104.41	2623.57	3107.51
	HSS	10x10x5/16	8	17.3	40.35	2.79	7259.77	1228.58	351.82	8840.17	10470.83
	HSS	8x8x5/16	4	17.3	31.84	1.10	2864.33	484.73	138.81	3487.87	4131.24
Column Line 7	HSS	10x10x1/2	2	23.1	62.46	1.44	3751.35	634.84	181.80	4567.99	5410.60
	HSS	10x10x1/2	6	18.1	62.46	3.39	8818.10	1492.29	427.34	10737.74	12718.42
	HSS	10x10x1/2	2	17.3	62.46	1.08	2809.45	475.45	136.15	3421.05	4052.09
	HSS	10x10x3/8	4	17.3	47.9	1.66	4309.08	729.23	208.82	5247.14	6215.03
	HSS	10x10x5/16	4	17.3	40.35	1.40	3629.89	614.29	175.91	4420.08	5235.41
	HSS	8x8x5/16	4	17.3	31.84	1.10	2864.33	484.73	138.81	3487.87	4131.24
Column Line 4	HSS	12x12x5/8	2	23.1	93.34	2.16	5606.00	948.71	271.68	6826.38	8085.58
	HSS	12x12x1/2	2	18.1	76.07	1.38	3579.85	605.82	173.49	4359.16	5163.25
	HSS	12x12x3/8	2	18.1	58.1	1.05	2734.19	462.71	132.50	3329.40	3943.54
	HSS	12x12x1/2	2	18.1	76.07	1.38	3579.85	605.82	173.49	4359.16	5163.25
	HSS	12x12x1/2	2	17.3	76.07	1.32	3421.63	579.04	165.82	4166.49	4935.04
	HSS	12x12x3/8	4	17.3	58.1	2.01	5226.68	884.51	253.29	6364.48	7538.48
	HSS	10x10x3/8	2	17.3	47.9	0.83	2154.54	364.61	104.41	2623.57	3107.51
	HSS	10x10x5/16	2	17.3	40.35	0.70	1814.94	307.14	87.95	2210.04	2617.71
	HSS	8x8x5/16	4	17.3	31.84	1.10	2864.33	484.73	138.81	3487.87	4131.24
Total						80.22	$ 208,564.06	$ 35,295.46	$10,107.34	$ 253,966.86	$ 300,813.56

Appendix T: Concrete Cost Estimate

Formwork - Columns - 03 11 13.25 (6500)									
Level	Height	Dim.	#	S.F.C.A.	Material	Labor	Equipment	Total	Tot Incl O&P
					2.57	7.05	0	9.62	13.65
Basement	15	24"x24"	38	4560	11719.2	32148	0	43867.2	62244
Ground	13	24"x24"	44	4576	11760.32	32260.8	0	44021.12	62462.4
2nd	13	24"x24"	44	4576	11760.32	32260.8	0	44021.12	62462.4
3rd	13	24"x24"	44	4576	11760.32	32260.8	0	44021.12	62462.4
4th	12	24"x24"	44	4224	10855.68	29779.2	0	40634.88	57657.6
5th	12	24"x24"	44	4224	10855.68	29779.2	0	40634.88	57657.6
6th	12	24"x24"	44	4224	10855.68	29779.2	0	40634.88	57657.6
7th	12	24"x24"	44	4224	10855.68	29779.2	0	40634.88	57657.6
8th	12	24"x24"	44	4224	10855.68	29779.2	0	40634.88	57657.6
9th	12	24"x24"	44	4224	10855.68	29779.2	0	40634.88	57657.6
10th	12	24"x24"	44	4224	10855.68	29779.2	0	40634.88	57657.6
Total				47856	122989.92	$337,384.80	$ -	$460,374.72	$ 653,234.40

Formwork - Exterior Beams - 03 11 13.20 (1500)								
Level	Dim.	L.F.	S.F.C.A.	Material	Labor	Equipment	Total	Tot Incl O&P
				2	7.8	0	9.8	14.15
Ground	24"x18"	0	0	0	0	0	0	0
2nd	24"x18"	722	3610	7220	28158	0	35378	51081.5
3rd	24"x18"	722	3610	7220	28158	0	35378	51081.5
4th	24"x18"	722	3610	7220	28158	0	35378	51081.5
5th	24"x18"	722	3610	7220	28158	0	35378	51081.5
6th	24"x18"	722	3610	7220	28158	0	35378	51081.5
7th	24"x18"	722	3610	7220	28158	0	35378	51081.5
8th	24"x18"	722	3610	7220	28158	0	35378	51081.5
9th	24"x18"	722	3610	7220	28158	0	35378	51081.5
10th	24"x18"	722	3610	7220	28158	0	35378	51081.5
Roof	24"x18"	722	3610	7220	28158	0	35378	51081.5
Total		7220	36100	$ 72,200.00	$281,580.00	$ -	$353,780.00	$ 510,815.00

Formwork - Interior Beams - 03 11 13.20 (2000)								
Level	Dim.	L.F.	S.F.C.A.	Material	Labor	Equipment	Total	Tot Incl O&P
				3.03	6.85		9.88	13.9
Ground	12"x18"	289	676.26	2049.0678	4632.381	0	6681.4488	9400.014
2nd	12"x18"	289	676.26	2049.0678	4632.381	0	6681.4488	9400.014
3rd	12"x18"	289	676.26	2049.0678	4632.381	0	6681.4488	9400.014
4th	12"x18"	331	774.54	2346.8562	5305.599	0	7652.4552	10766.106
5th	12"x18"	331	774.54	2346.8562	5305.599	0	7652.4552	10766.106
6th	12"x18"	331	774.54	2346.8562	5305.599	0	7652.4552	10766.106
7th	12"x18"	331	774.54	2346.8562	5305.599	0	7652.4552	10766.106
8th	12"x18"	331	774.54	2346.8562	5305.599	0	7652.4552	10766.106
9th	12"x18"	331	774.54	2346.8562	5305.599	0	7652.4552	10766.106
10th	12"x18"	331	774.54	2346.8562	5305.599	0	7652.4552	10766.106
Roof	12"x18"	331	774.54	2346.8562	5305.599	0	7652.4552	10766.106
Total		**3515**	**8225.1**	**$ 24,922.05**	**$ 56,341.94**	**$ -**	**$ 81,263.99**	**$ 114,328.89**

Formwork - Shear Walls - 03 11 13.85 (2400)								
Level	Height	Wall Length	S.F.C.A.	Material	Labor	Equipment	Total	Tot Incl O&P
				2.4	7.35	0	9.75	13.95
Ground	15	21	1890	4536	13891.5	0	18427.5	26365.5
2nd	13	21	1638	3931.2	12039.3	0	15970.5	22850.1
3rd	13	21	1638	3931.2	12039.3	0	15970.5	22850.1
4th	13	21	1638	3931.2	12039.3	0	15970.5	22850.1
5th	12	21	1512	3628.8	11113.2	0	14742	21092.4
6th	12	21	1512	3628.8	11113.2	0	14742	21092.4
7th	12	21	1512	3628.8	11113.2	0	14742	21092.4
8th	12	21	1512	3628.8	11113.2	0	14742	21092.4
9th	12	21	1512	3628.8	11113.2	0	14742	21092.4
10th	12	21	1512	3628.8	11113.2	0	14742	21092.4
Roof	12	21	1512	3628.8	11113.2	0	14742	21092.4
Total			**17388**	**$ 41,731.20**	**$127,801.80**	**$ -**	**$169,533.00**	**$242,562.60**

Structural Concrete - Columns - 03 31 05.35 (0411)										
Level	Height	Dim.	#	f'c	C.Y.	Material	Labor	Equipment	Total	Tot Incl O&P
						124	0	0	124	136
Basement	15	24"x24"	38	6000	84.44	10471.11	0	0	10471.11	11484.44
Ground	13	24"x24"	44	6000	84.74	10507.85	0	0	10507.85	11524.74
2nd	13	24"x24"	44	6000	84.74	10507.85	0	0	10507.85	11524.74
Structural Concrete - Columns - 03 31 05.35 (0300)										
Level	**Height**	**Dim.**	**#**	**f'c**	**C.Y.**	**Material**	**Labor**	**Equipment**	**Total**	**Tot Incl O&P**
						103	0	0	103	113
3rd	13	24"x24"	44	4000	84.74	8728.30	0	0	8728.30	9575.70
4th	12	24"x24"	44	4000	78.22	8056.89	0	0	8056.89	8839.11
5th	12	24"x24"	44	4000	78.22	8056.89	0	0	8056.89	8839.11
6th	12	24"x24"	44	4000	78.22	8056.89	0	0	8056.89	8839.11
7th	12	24"x24"	44	4000	78.22	8056.89	0	0	8056.89	8839.11
8th	12	24"x24"	44	4000	78.22	8056.89	0	0	8056.89	8839.11
9th	12	24"x24"	44	4000	78.22	8056.89	0	0	8056.89	8839.11
10th	12	24"x24"	44	4000	78.22	8056.89	0	0	8056.89	8839.11
Total					**886.22**	**$ 96,613.33**	**$ -**	**$ -**	**$ 96,613.33**	**$ 105,983.41**

Structural Concrete - Slabs and Drop Panels - 03 31 05.35 (0300)											
Level	S.F.	Slab Thickness	Drop Thickness	Drop Dimensions	# of Drops	C.Y.	Material	Labor	Equipment	Total	Tot Incl O&P
							103	0	0	103	113
Ground	39398	10	2.5	10'x10'	39	1246.08	128346.27	0	0	128346.27	140807.07
2nd	27864	10	2.5	10'x10'	27	880.83	90725.83	0	0	90725.83	99534.17
3rd	29151	10	5	10'x10'	27	941.39	96963.06	0	0	96963.06	106376.94
4th	30496	10	2.5	10'x10'	27	962.07	99092.99	0	0	99092.99	108713.67
5th	22931	10	2.5	10'x10'	27	728.58	75043.77	0	0	75043.77	82329.57
6th	22931	10	2.5	10'x10'	27	728.58	75043.77	0	0	75043.77	82329.57
7th	22931	10	2.5	10'x10'	27	728.58	75043.77	0	0	75043.77	82329.57
8th	22931	10	2.5	10'x10'	27	728.58	75043.77	0	0	75043.77	82329.57
9th	22931	10	2.5	10'x10'	27	728.58	75043.77	0	0	75043.77	82329.57
10th	22931	10	2.5	10'x10'	27	728.58	75043.77	0	0	75043.77	82329.57
Roof	23086	10	2.5	10'x10'	27	733.36	75536.51	0	0	75536.51	82870.15
Total						**9135.22**	**$ 940,927.25**	**$ -**	**$ -**	**$ 940,927.25**	**$ 1,032,279.41**

Structural Concrete - Beams - 03 31 05.35 (0300)										
Level	L.F. Int Beams	Dim Int Beams	L.F. Ext Beams	Dim Ext Beams	C.Y.	Material	Labor	Equipment	Total	Tot Incl O&P
						103	0	0	103	113
Ground	289	12"x18"	0	24"x18"	7.14	734.99	0	0	734.99	806.35
2nd	289	12"x18"	722	24"x18"	42.79	4407.38	0	0	4407.38	4835.28
3rd	289	12"x18"	722	24"x18"	42.79	4407.38	0	0	4407.38	4835.28
4th	331	12"x18"	722	24"x18"	43.83	4514.20	0	0	4514.20	4952.47
5th	331	12"x18"	722	24"x18"	43.83	4514.20	0	0	4514.20	4952.47
6th	331	12"x18"	722	24"x18"	43.83	4514.20	0	0	4514.20	4952.47
7th	331	12"x18"	722	24"x18"	43.83	4514.20	0	0	4514.20	4952.47
8th	331	12"x18"	722	24"x18"	43.83	4514.20	0	0	4514.20	4952.47
9th	331	12"x18"	722	24"x18"	43.83	4514.20	0	0	4514.20	4952.47
10th	331	12"x18"	722	24"x18"	43.83	4514.20	0	0	4514.20	4952.47
Roof	331	12"x18"	722	24"x18"	43.83	4514.20	0	0	4514.20	4952.47
Total					**443.33**	**$ 45,663.33**	**$ -**	**$ -**	**$ 45,663.33**	**$ 50,096.67**

Structural Concrete - Shear Walls - 03 31 05.35 (0411)									
Level	Height	Wall Length	Wall Width	C.Y. (3 Walls)	Material	Labor	Equipment	Total	Tot Incl O&P
					124	0	0	124	136
Basement	15	21	1.5	52.50	6510	0	0	6510.00	7140.00
Ground	13	21	1.5	45.50	5642	0	0	5642.00	6188.00
2nd	13	21	1.5	45.50	5642	0	0	5642.00	6188.00
3rd	13	21	1.5	45.50	5642	0	0	5642.00	6188.00
4th	12	21	1.5	42.00	5208	0	0	5208.00	5712.00
5th	12	21	1.5	42.00	5208	0	0	5208.00	5712.00
6th	12	21	1.5	42.00	5208	0	0	5208.00	5712.00
7th	12	21	1.5	42.00	5208	0	0	5208.00	5712.00
8th	12	21	1.5	42.00	5208	0	0	5208.00	5712.00
9th	12	21	1.5	42.00	5208	0	0	5208.00	5712.00
10th	12	21	1.5	42.00	5208	0	0	5208.00	5712.00
Total				483.00	$ 59,892.00	$ -	$ -	$ 59,892.00	$ 65,688.00

Placing Concrete - Slabs and Drop Panels - 03 31 05.70 (1500)											
Level	S.F.	Slab Thickness	Drop Thickness	Drop Dimensions	# of Drops	C.Y.	Material	Labor	Equipment	Total	Tot Incl O&P
							0	15.1	4.82	19.92	28.5
Ground	39398	10	2.5	10'x10'	39	1246.08	0	18815.81	6006.11	24821.92	35513.29
2nd	27864	10	2.5	10'x10'	27	880.83	0	13300.58	4245.62	17546.20	25103.75
3rd	29151	10	5	10'x10'	27	941.39	0	14214.97	4537.49	18752.47	26829.58
4th	30496	10	2.5	10'x10'	27	962.07	0	14527.23	4637.17	19164.39	27418.94
5th	22931	10	2.5	10'x10'	27	728.58	0	11001.56	3511.76	14513.32	20764.54
6th	22931	10	2.5	10'x10'	27	728.58	0	11001.56	3511.76	14513.32	20764.54
7th	22931	10	2.5	10'x10'	27	728.58	0	11001.56	3511.76	14513.32	20764.54
Placing Concrete - Slabs and Drop Panels - 03 31 05.70 (1550)											
Level	S.F.	Slab Thickness	Drop Thickness	Drop Dimensions	# of Drops	C.Y.	Material	Labor	Equipment	Total	Tot Incl O&P
							0	25	10.7	35.7	50
8th	22931	10	2.5	10'x10'	27	728.58	0	18214.51	7795.81	26010.31	36429.01
9th	22931	10	2.5	10'x10'	27	728.58	0	18214.51	7795.81	26010.31	36429.01
10th	22931	10	2.5	10'x10'	27	728.58	0	18214.51	7795.81	26010.31	36429.01
Roof	23086	10	2.5	10'x10'	27	733.36	0	18334.10	7847.00	26181.10	36668.21
Total						9135.22	$ -	$ 166,840.90	$61,196.08	$ 228,036.98	$ 323,114.41

Placing Concrete - Beams - 03 31 05.70 (0050)										
Level	L.F. Int Beams	Dim Int Beams	L.F. Ext Beams	Dim Ext Beams	C.Y.	Material	Labor	Equipment	Total	Tot Incl O&P
						0	40	12.85	52.85	75.5
Ground	289	12"x18"	0	24"x18"	7.14	0	285.43	91.70	377.13	538.75
2nd	289	12"x18"	722	24"x18"	42.79	0	1711.60	549.85	2261.46	3230.65
3rd	289	12"x18"	722	24"x18"	42.79	0	1711.60	549.85	2261.46	3230.65
4th	331	12"x18"	722	24"x18"	43.83	0	1753.09	563.18	2316.27	3308.95
5th	331	12"x18"	722	24"x18"	43.83	0	1753.09	563.18	2316.27	3308.95
6th	331	12"x18"	722	24"x18"	43.83	0	1753.09	563.18	2316.27	3308.95
7th	331	12"x18"	722	24"x18"	43.83	0	1753.09	563.18	2316.27	3308.95
Placing Concrete - Beams - 03 31 05.70 (0100)										
Level	L.F. Int Beams	Dim Int Beams	L.F. Ext Beams	Dim Ext Beams	C.Y.	Material	Labor	Equipment	Total	Tot Incl O&P
						0	61	26	87	122
8th	331	12"x18"	722	24"x18"	43.83	0	2673.46	1139.51	3812.96	5346.91
9th	331	12"x18"	722	24"x18"	43.83	0	2673.46	1139.51	3812.96	5346.91
10th	331	12"x18"	722	24"x18"	43.83	0	2673.46	1139.51	3812.96	5346.91
Roof	331	12"x18"	722	24"x18"	43.83	0	2673.46	1139.51	3812.96	5346.91
Total					443.33	0	$ 21,414.81	$ 8,002.14	$ 29,416.96	$ 41,623.52

Placing Concrete - Shear Walls - 03 31 05.70 (5350)									
Level	Height	Wall Length	Wall Width	C.Y. (3 Walls)	Material	Labor	Equipment	Total	Tot Incl O&P
					0	20	6.4	26.4	37.5
Basement	15	21	1.5	52.50	0	1050.00	336.00	1386.00	1968.75
Ground	13	21	1.5	45.50	0	910.00	291.20	1201.20	1706.25
2nd	13	21	1.5	45.50	0	910.00	291.20	1201.20	1706.25
3rd	13	21	1.5	45.50	0	910.00	291.20	1201.20	1706.25
4th	12	21	1.5	42.00	0	840.00	268.80	1108.80	1575.00
5th	12	21	1.5	42.00	0	840.00	268.80	1108.80	1575.00
6th	12	21	1.5	42.00	0	840.00	268.80	1108.80	1575.00
Placing Concrete - Shear Walls - 03 31 05.70 (5400)									
Level	Height	Wall Length	Wall Width	C.Y. (3 Walls)	Material	Labor	Equipment	Total	Tot Incl O&P
					0	29	12.4	41.4	57.5
7th	12	21	1.5	42.00	0	1218.00	520.80	1738.80	2415.00
8th	12	21	1.5	42.00	0	1218.00	520.80	1738.80	2415.00
9th	12	21	1.5	42.00	0	1218.00	520.80	1738.80	2415.00
10th	12	21	1.5	42.00	0	1218.00	520.80	1738.80	2415.00
Total				**483.00**	**$ -**	**$ 11,172.00**	**$ 4,099.20**	**$ 15,271.20**	**$ 21,472.50**

Placing Concrete - Columns - 03 31 05.70 (0800)									
Level	Height	Dim.	#	C.Y.	Material	Labor	Equipment	Total	Tot Incl O&P
					0	26	8.4	34.4	49
Basement	15	24"x24"	38	84.44	0	2195.56	709.33	2904.89	4137.78
Ground	13	24"x24"	44	84.74	0	2203.26	711.82	2915.08	4152.30
2nd	13	24"x24"	44	84.74	0	2203.26	711.82	2915.08	4152.30
3rd	13	24"x24"	44	84.74	0	2203.26	711.82	2915.08	4152.30
4th	12	24"x24"	44	78.22	0	2033.78	657.07	2690.84	3832.89
5th	12	24"x24"	44	78.22	0	2033.78	657.07	2690.84	3832.89
6th	12	24"x24"	44	78.22	0	2033.78	657.07	2690.84	3832.89
Placing Concrete - Columns - 03 31 05.70 (0850)									
Level	Height	Dim.	#	C.Y.	Material	Labor	Equipment	Total	Tot Incl O&P
					0	39	16.8	55.8	78
7th	12	24"x24"	44	78.22	0	3050.67	1314.13	4364.80	6101.33
8th	12	24"x24"	44	78.22	0	3050.67	1314.13	4364.80	6101.33
9th	12	24"x24"	44	78.22	0	3050.67	1314.13	4364.80	6101.33
10th	12	24"x24"	44	78.22	0	3050.67	1314.13	4364.80	6101.33
Total				**886.22**	**$ -**	**$ 27,109.33**	**$ 10,072.53**	**$ 37,181.87**	**$ 52,498.67**

Concrete Finishing - Slabs - 03 35 29.30 (0200)						
Level	S.F.	Material	Labor	Equipment	Total	Tot Incl O&P
		0	0.76	0	0.76	1.13
Ground	39398	0	29942.48	0	29942.48	44519.74
2nd	27864	0	21176.64	0	21176.64	31486.32
3rd	29151	0	22154.76	0	22154.76	32940.63
4th	30496	0	23176.96	0	23176.96	34460.48
5th	22931	0	17427.56	0	17427.56	25912.03
6th	22931	0	17427.56	0	17427.56	25912.03
7th	22931	0	17427.56	0	17427.56	25912.03
8th	22931	0	17427.56	0	17427.56	25912.03
9th	22931	0	17427.56	0	17427.56	25912.03
10th	22931	0	17427.56	0	17427.56	25912.03
Roof	23086	0	17545.36	0	17545.36	26087.18
Total		$ -	$218,561.56	$ -	$218,561.56	$324,966.53

Concrete Finishing - Walls & Columns - 03 35 29.60 (0020)										
Level	Height	Wall Length	S.F. (2 Sides)	SFCA (Cols)	SF Total	Material	Labor	Equipment	Total	Tot Incl O&P
						0.03	0.63	0	0.66	0.96
Basement	15	21	630	4560	5190	156	3269.70	0	3425.40	4982.40
Ground	13	21	546	4576	5122	154	3226.86	0	3380.52	4917.12
2nd	13	21	546	4576	5122	154	3226.86	0	3380.52	4917.12
3rd	13	21	546	4576	5122	154	3226.86	0	3380.52	4917.12
4th	12	21	504	4224	4728	142	2978.64	0	3120.48	4538.88
5th	12	21	504	4224	4728	142	2978.64	0	3120.48	4538.88
6th	12	21	504	4224	4728	142	2978.64	0	3120.48	4538.88
7th	12	21	504	4224	4728	142	2978.64	0	3120.48	4538.88
8th	12	21	504	4224	4728	142	2978.64	0	3120.48	4538.88
9th	12	21	504	4224	4728	142	2978.64	0	3120.48	4538.88
10th	12	21	504	4224	4728	142	2978.64	0	3120.48	4538.88
Total					53652	$ 1,609.56	$ 33,800.76	$ -	$ 35,410.32	$ 51,505.92

Reinforcement Bars - Slabs - 03 21 10.60 (0400)						
Level	**Tons**	**Material**	**Labor**	**Equipment**	**Total**	**Tot Incl O&P**
		1050	**540**	**0**	**1590**	**2025**
Ground	101.02	106074	54552.37	0	160626.43	204571.40
2nd	71.66	75239	38694.13	0	113932.70	145102.97
3rd	77.17	81026	41670.60	0	122696.76	156264.74
4th	45.18	47439	24397.30	0	71836.51	91489.89
5th	45.18	47439	24397.30	0	71836.51	91489.89
6th	45.18	47439	24397.30	0	71836.51	91489.89
7th	45.18	47439	24397.30	0	71836.51	91489.89
8th	45.18	47439	24397.30	0	71836.51	91489.89
9th	45.18	47439	24397.30	0	71836.51	91489.89
10th	45.18	47439	24397.30	0	71836.51	91489.89
Roof	45.18	47439	24397.30	0	71836.51	91489.89
Total (+10%)	**672.42**	**$ 706,037.67**	**$ 363,105.09**	**$ -**	**$ 1,069,142.76**	**$ 1,361,644.08**

Reinforcement Bars - Columns - 03 21 10.60 (0250)								
Level	**Height**	**#**	**Tons**	**Material**	**Labor**	**Equipment**	**Total**	**Tot Incl O&P**
				980	**685**	**0**	**1665**	**2175**
Basement	15	38	18.17	17807	12446.77	0	30253.82	39520.75
Ground	13	44	12.31	12060	8430.01	0	20490.46	26766.81
2nd	13	44	7.78	7624	5328.75	0	12952.37	16919.76
3rd	13	44	14.77	14473	10116.01	0	24588.55	32120.17
4th	12	44	7.18	7037	4918.85	0	11956.03	15618.24
5th	12	44	7.18	7037	4918.85	0	11956.03	15618.24
6th	12	44	5.64	5526	3862.74	0	9389.00	12264.91
7th	12	44	5.64	5526	3862.74	0	9389.00	12264.91
8th	12	44	5.64	5526	3862.74	0	9389.00	12264.91
9th	12	44	5.64	5526	3862.74	0	9389.00	12264.91
10th	12	44	5.64	5526	3862.74	0	9389.00	12264.91
Total (+10%)			**105.14**	**$103,036.25**	**$ 72,020.24**	**$ -**	**$175,056.48**	**$228,677.39**

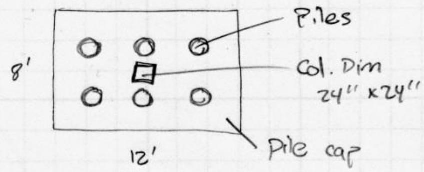
Reinforcement Bars - Walls - 03 21 10.60 (0750)								
Level	**Height**	**Length**	**Tons**	**Material**	**Labor**	**Equipment**	**Total**	**Tot Incl O&P**
			(3 Walls)	**930**	**525**	**0**	**1455**	**1850**
Basement	15	21	3.36	3129	1766.21	0	4894.91	6223.77
Ground	13	21	2.92	2712	1530.71	0	4242.26	5393.93
2nd	13	21	2.92	2712	1530.71	0	4242.26	5393.93
3rd	13	21	2.92	2712	1530.71	0	4242.26	5393.93
4th	12	21	2.69	2503	1412.96	0	3915.93	4979.02
5th	12	21	2.69	2503	1412.96	0	3915.93	4979.02
6th	12	21	2.69	2503	1412.96	0	3915.93	4979.02
7th	12	21	2.69	2503	1412.96	0	3915.93	4979.02
8th	12	21	2.69	2503	1412.96	0	3915.93	4979.02
9th	12	21	2.69	2503	1412.96	0	3915.93	4979.02
10th	12	21	2.69	2503	1412.96	0	3915.93	4979.02
Total (+10%)			**34.05**	**$ 31,662.50**	**$ 17,873.99**	**$ -**	**$ 49,536.50**	**$ 62,984.55**

Appendix U: Foundation Checks

Foundation Check — Andrew Voorhees — 1

Check Existing Footing — Column C-6

$P_u = 2200^k$



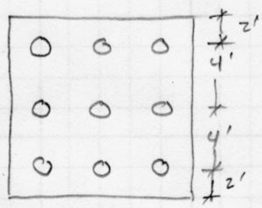
Pile Cap Dimensions 8' × 12' × 4'-6"

Long Dir: Top = (19) #8
Bot = (21) #8

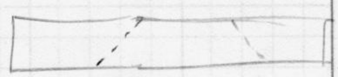
Short Dir: Top = (19) #8
Bot (19) #8

Piles 16" φ, Capacity = 120 Tons
= 240 kips

$\# \text{ of Piles} = \frac{2200}{240} = 9.16 \rightarrow$ use 9



12 × 12 pile cap



$b_o = 512"$

$9 \text{ piles} = \frac{2160^k}{144\,ft} = 15{,}000\,psf = g$

Check punching shear

$$d^2(4v_c + g) + d(2v_c + g)(b+c) = g(BL - cb)$$

$$v_c \le \begin{cases} \frac{4}{\beta_c} + 2 = \frac{4}{1} + 2 = 6 \\ \frac{\alpha_s d}{b_o} = \frac{40(52)}{512} = 4.06 \\ 4 = 4 \leftarrow \text{control} \end{cases}$$

d = 52"

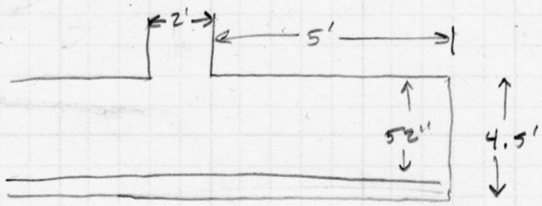
$$V_c = 4(\sqrt{4000}) \times 512 \times 52 = 6735.4 \text{ kips}$$

$$P = \frac{1}{144 \times 144}\left[2(52")(6735.4^k)(24"+52") + 2(52)(6735.4)(24+52) + 15(24+52)(24+52)\right]$$

$= 5138.8^k$ to punch $> 2200^k$ ∴ punching OK

2

Check Flexure



$q_u = 15$ ksf

$M_u = \frac{15(1')(5')^2}{2} = 187.5'^k$

$a = \frac{A_s F_y}{0.85 f'_c b} = \frac{60(A_s)}{0.85(4)(12'')} = 1.47 A_s$

$M_u \le \phi M_n = \phi A_s F_y (d - a/2)$

$187.5'^k (12) = 0.9 A_s (60)(52'' - \frac{1.47 A_s}{2})$

$2250^{k\,in} = 2808 A_s - 39.69 A_s^2$

$A_s \geq 0.81\ in^2/ft$

Try (1) #9 / ft = $A_s = 1\ in^2/ft$

$\rho_{min} = \frac{1\ in^2/ft}{54''(12'')} = 0.0015 < 0.0018$ ← use this

$0.0018(54)(12) = A_s = 1.16$ ∴ use #10 @ 12" $A_s = 1.27\ in^2/ft$

$\varepsilon = \frac{0.003}{c} = \frac{\varepsilon_s}{(d-c)} \Rightarrow \frac{0.003}{2.2}(52 - 2.2)$

$= 0.07 > 0.005$ ∴ $\phi = 0.9$

$a = 1.47(1.27) = 1.87$

$c = \frac{1.87}{0.85} = 2.2$

∴ use (12) #10's in each direction

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