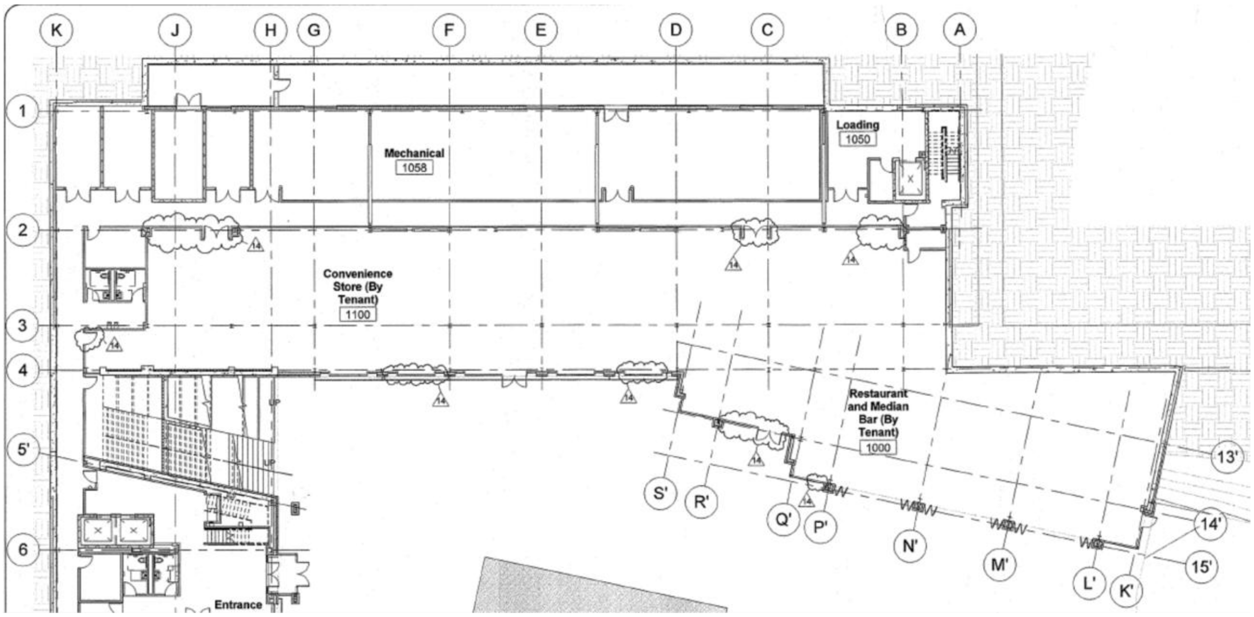
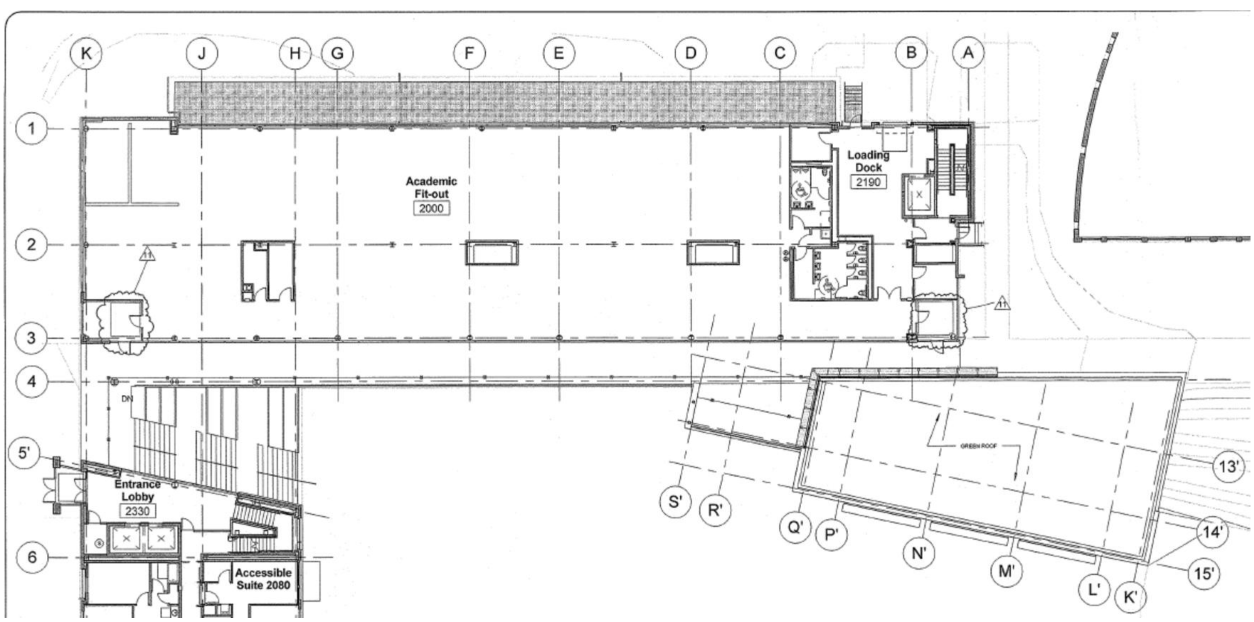
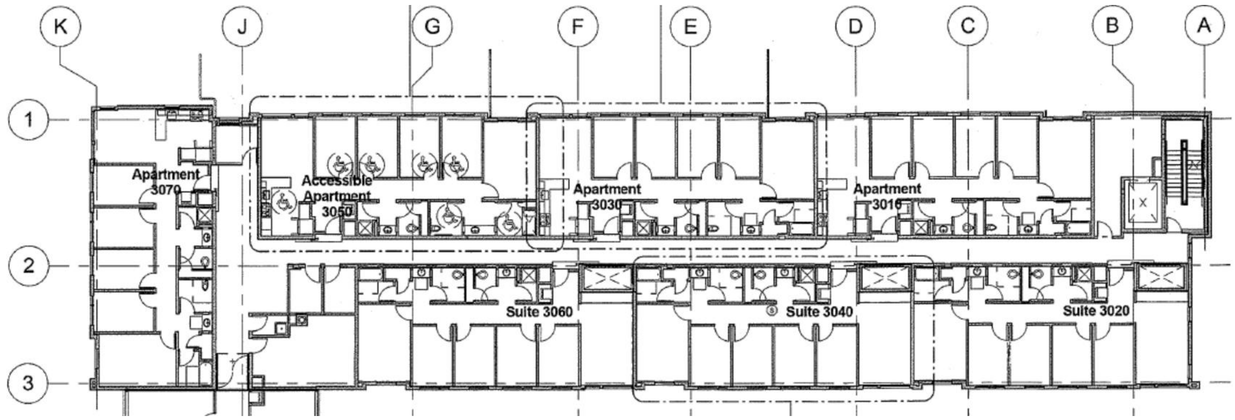
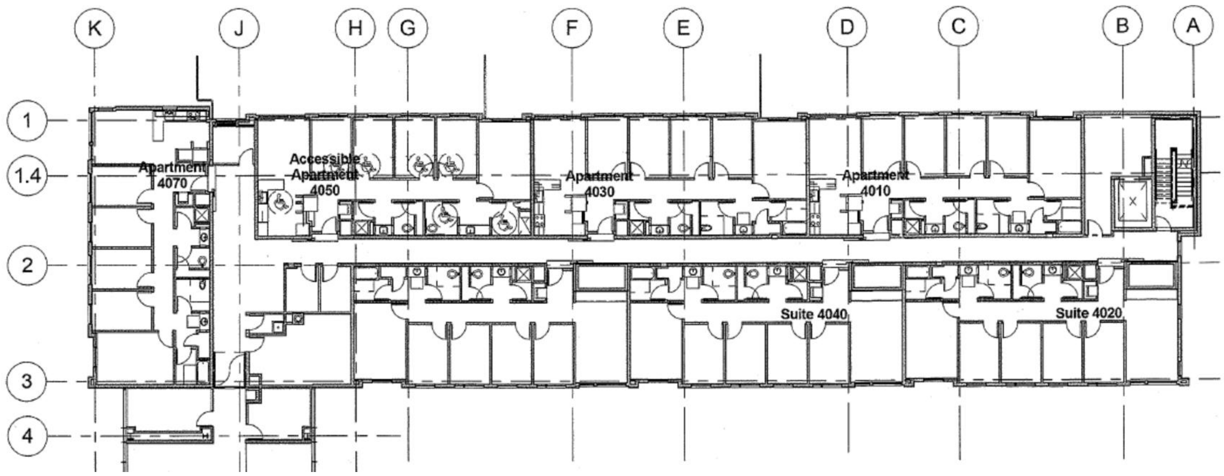
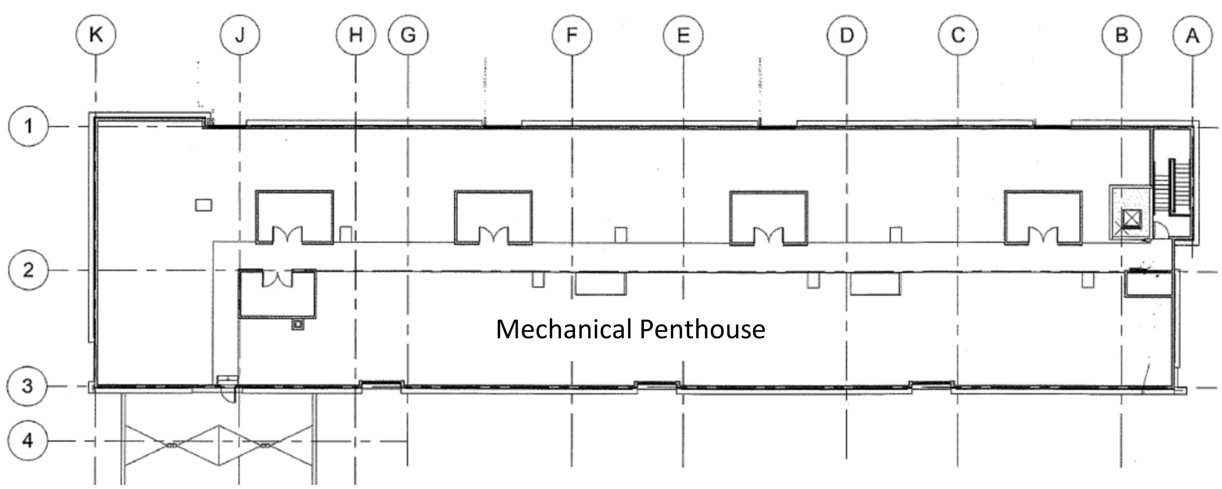
Appendix A: Typical Plans and Details

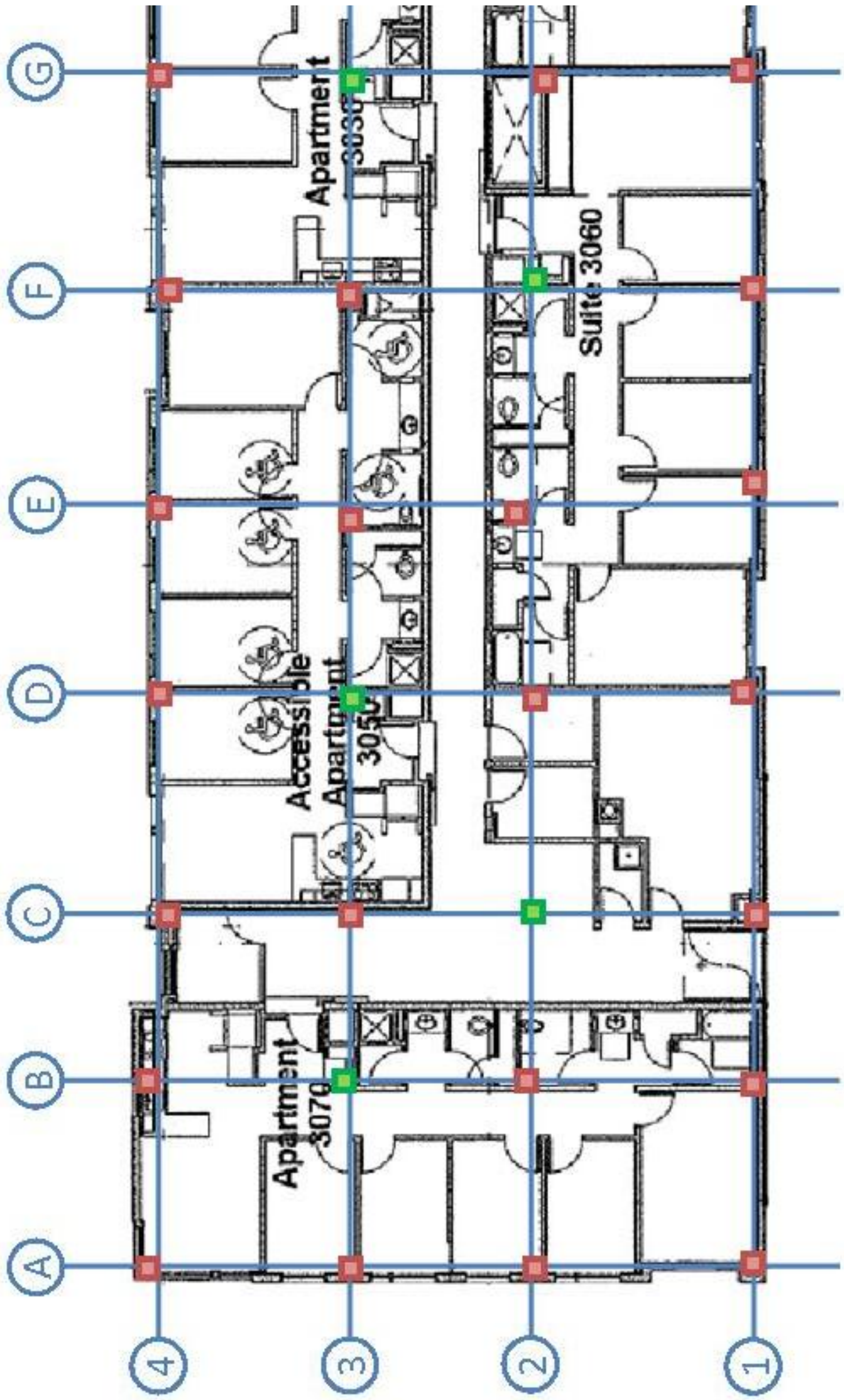


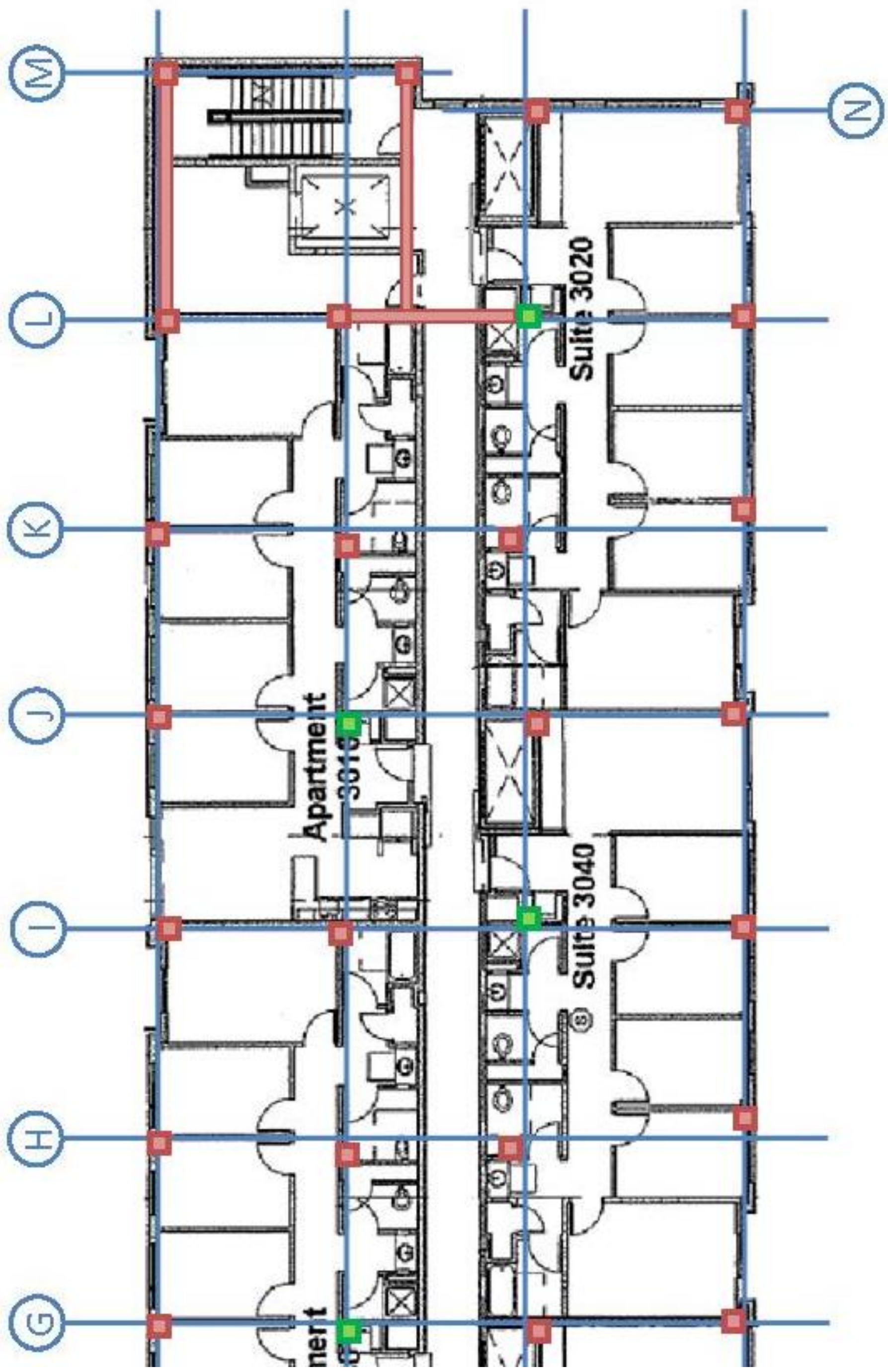



Apartment 3070
Accessible Apartment 3050
Apartment 3030
Apartment 3010
Suite 3060
Suite 3040
Suite 3020


Apartment 4070
Accessible Apartment 4050
Apartment 4030
Apartment 4010
Suite 4040
Suite 4020

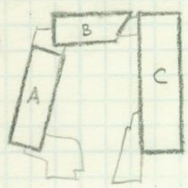

Mechanical Penthouse


G
F
E
D
C
B
A
4
3
2
1
Apartment
Suite 3060
Accessible Apartment 3050
Apartment 3070


M
L
K
J
I
H
G
N
Suite 3020
Apartment
Suite 3040

Appendix B: Wind Load Calculations

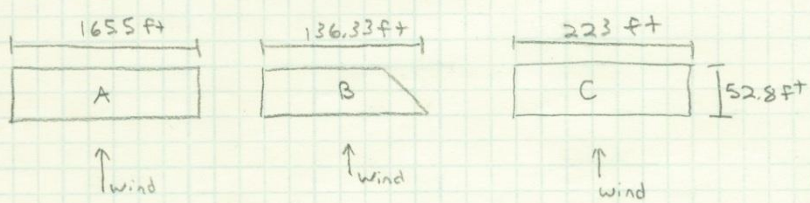
Total: 23 | Chris Vandelogt | Tech 1 | Wind Analysis | 1



- Thick outline represents the tallest height of each section of the structure
- To simplify, analyze the structure as 3 different buildings (outlined and labeled a, b, and c)

→ Dimensions

- Building A
  - Length: 165.5 ft
  - Width: 52.8 ft
  - Height: 51.83 ft
- Building B
  - Length: 136.33 ft
  - Width: 52.8 ft
  - Height: 62.5 ft
- Building C
  - Length: 223 ft
  - Width: 52.8 ft
  - Height: 62.5 ft



Total: 24 | Chris Vandelogt | Tech 1 | Wind Analysis | 2

→ Basic Wind Speed: From Figure 26.5-1B ASCE 7-10

$V = 120$ mph

→ Wind Directionality Factor: From Table 26.6-1

$K_d = .85$

→ Occupancy Category III

→ Exposure Category: C From Section 26.7.3

→ Topography Factor: From Section 26.8.2

$K_{zt} = 1.0$

→ Frequency: From Sect 26.9.2.1

$$L_{eff} = \frac{\Sigma h_i L_i}{\Sigma h_i} = 52.8$$

$h = 62.5 < 4(52.8)$ ← Allowed to use approx Freq

$$n_a = \frac{75}{h} \quad \text{(Equation 26.9-4)}$$

$$= \frac{75}{62.5} \quad \text{or} \quad \frac{75}{50}$$

$= 1.2$ or $1.5 > 1.0$ ∴ Rigid

→ Gust Factor: From Sect 26.9

$$G = .925\left(\frac{1 + 1.7 g_Q I_{\bar{z}} Q}{1 + 1.7 g_v I_{\bar{z}}}\right)$$

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

- $\bar{z} = .6h > z_{min} = 15'$ (Table 26.9-1) ✓ok
- $c = .2$ (Table 26.9-1)

g_Q and $g_v = 3.4$

* See spreadsheet for calculations

Total: 25 | Chris Vandelogt | Tech 1 | Wind Analysis | 3

$$Q = \sqrt{\frac{1}{1+.63\left(\frac{B+h}{L_{\bar{z}}}\right)^{.63}}}$$

- $L_{\bar{z}} = \ell\left(\frac{\bar{z}}{33}\right)^{\bar{\varepsilon}}$
  - $\ell = 500$
  - $\bar{\varepsilon} = 1/5$

→ *Note: Ignore internal pressure since net addition is zero and no large openings are located in the building

→ Velocity Pressure Exposure: From Table 27.3-1

k_z @ 14' = .85 | k_z @ 37.33' = 1.024
k_z @ 26.66' = .953 | k_z @ 51.83' = 1.097
k_z @ 48' = 1.08 | k_z @ 62.5 = 1.14

→ Velocity Pressure: From Sect 27.3.2

$q_z = .00256\, K_z K_{zt} K_d V^2$

* See spreadsheet for Calculations

→ Wind Loads: From Section 27.4.1

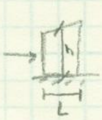
$p = qGC_p$

q_z for windward, q_h for sides and leeward

where $C_p = \begin{cases} .8 & \text{windward} \\ -.5 & \text{leeward} \\ -.7 & \text{sides} \end{cases}$ From Fig 27.4-1

$L/B < 1.0$

since roofs are monoslope:



use $h/L \geq 1.0$

$\theta < 10°$

$C_p = \begin{cases} 0 \text{ to } h/2 : & -1.3,\ -.18 \\ > h/2 : & -.7,\ -.18 \end{cases}$ (worst cases: -1.3, -.7)

↳ From Fig 27.4-1

* See spreadsheet for Calculations

Total: 26 Chris Vandelogt Tech 1 Wind Analysis 4

Wind Analysis -Wind Normal to Long Dimension (Length)

Building Dimensions				Gust Factor Calculations				
Building	Length (ft)	Width (ft)	Height (ft)	z_{bar}	I_{zbar}	L_{zbar}	Q	G
A	165.500	52.800	51.830	31.098	0.202	494.099	0.853	0.852
B	136.330	52.800	62.500	37.500	0.196	512.948	0.862	0.857
C	223.000	52.800	62.500	37.500	0.196	512.948	0.835	0.844

Constants					
V (mph) =	120.000	$C_{p,windward}$ =	0.800	$C_{p,roof<h/2}$ =	-1.300
k_d =	0.850	$C_{p,leeward}$ =	-0.500	$C_{p,roof>h/2}$ =	-0.700
k_{zt} =	1.000	$C_{p,sides}$ =	-0.700		

Building A

Floor	Height	k_z	q_z (lb/ft^2)	p_{wind} (lb/ft^2)	p_{lee} (lb/ft^2)	p_{side} (lb/ft^2)	$p_{roof<h/2}$ (lb/ft^2)	$p_{roof>h/2}$ (lb/ft^2)
2nd	14.000	0.850	26.634	18.145	-14.636	-20.490		
3rd	26.660	0.953	29.862	20.344	-14.636	-20.490		
Penthouse	37.330	1.024	32.086	21.859	-14.636	-20.490		
Roof	51.830	1.097	34.374	23.418	-14.636	-20.490	-38.054	-20.490

Building B

Floor	Height	k_z	q_z (lb/ft^2)	p_{wind} (lb/ft^2)	p_{lee} (lb/ft^2)	p_{side} (lb/ft^2)	$p_{roof<h/2}$ (lb/ft^2)	$p_{roof>h/2}$ (lb/ft^2)
2nd	14.000	0.850	26.634	18.262	-15.308	-21.431		
3rd	26.660	0.953	29.862	20.475	-15.308	-21.431		
4th	37.330	1.024	32.086	22.001	-15.308	-21.431		
Penthouse	48.000	1.080	33.841	23.204	-15.308	-21.431		
Roof	62.500	1.140	35.721	24.493	-15.308	-21.431	-39.801	-21.431

Building C

Floor	Height	k_z	q_z (lb/ft^2)	p_{wind} (lb/ft^2)	p_{lee} (lb/ft^2)	p_{side} (lb/ft^2)	$p_{roof<h/2}$ (lb/ft^2)	$p_{roof>h/2}$ (lb/ft^2)
2nd	14.000	0.850	26.634	17.979	-15.071	-21.099		
3rd	26.660	0.953	29.862	20.158	-15.071	-21.099		
4th	37.330	1.024	32.086	21.659	-15.071	-21.099		
Penthouse	48.000	1.080	33.841	22.844	-15.071	-21.099		
Roof	62.500	1.140	35.721	24.113	-15.071	-21.099	-39.184	-21.099

Total: 27 Chris Vandelogt Tech 1 Wind Analysis 5

Wind Analysis -Wind Normal to Short Dimension (Width)

Building Dimensions				Gust Factor Calculations				
Building	Width (ft)	Length (ft)	Height (ft)	z_{bar}	I_{zbar}	L_{zbar}	Q	G
A	52.800	165.500	51.830	31.098	0.202	494.099	0.899	0.875
B	52.800	136.330	62.500	37.500	0.196	512.948	0.896	0.874
C	52.800	223.000	62.500	37.500	0.196	512.948	0.896	0.874

Constants					
V (mph) =	120.000	$C_{p,windward}$ =	0.800	$C_{p,roof<h/2}$ =	-1.300
k_d =	0.850	$C_{p,leeward}$ =	-0.500	$C_{p,roof>h/2}$ =	-0.700
k_{zt} =	1.000	$C_{p,sides}$ =	-0.700		

Building A

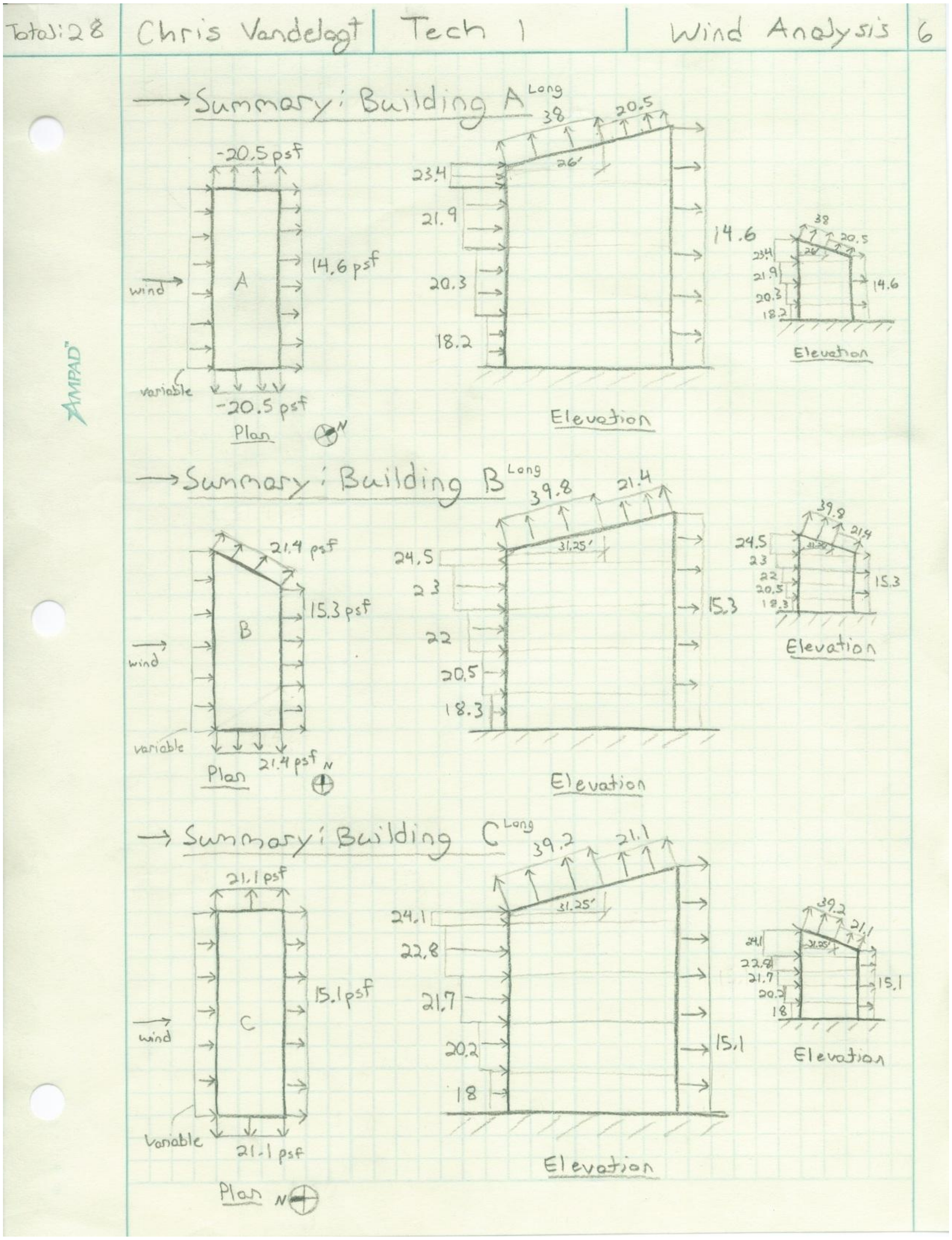
Floor	Height	k_z	q_z (lb/ft^2)	p_{wind} (lb/ft^2)	p_{lee} (lb/ft^2)	p_{side} (lb/ft^2)
2nd	14.000	0.850	26.634	18.639	-15.034	-21.048
3rd	26.660	0.953	29.862	20.897	-15.034	-21.048
Penthouse	37.330	1.024	32.086	22.454	-15.034	-21.048
Roof	51.830	1.097	34.374	24.055	-15.034	-21.048

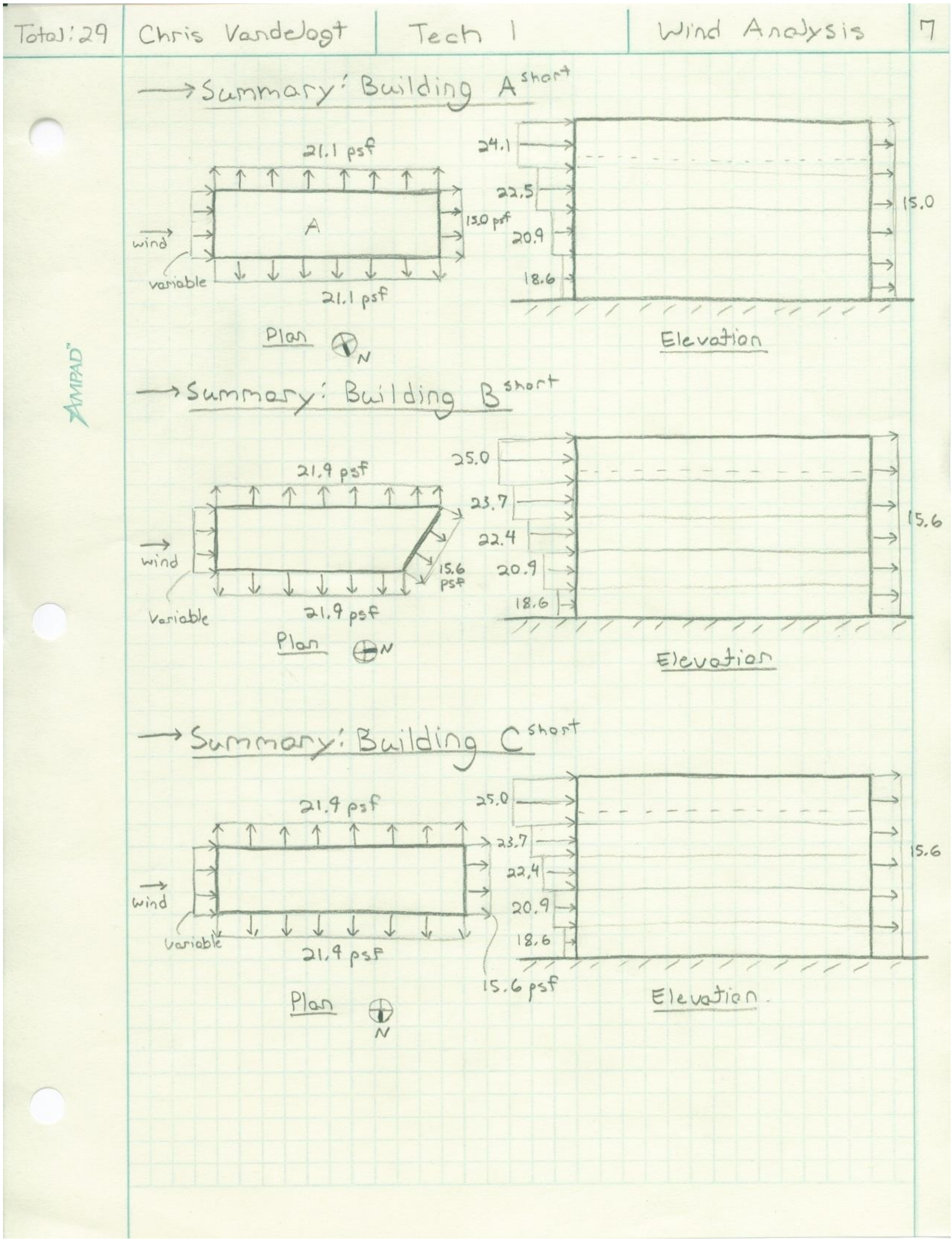
Building B

Floor	Height	k_z	q_z (lb/ft^2)	p_{wind} (lb/ft^2)	p_{lee} (lb/ft^2)	p_{side} (lb/ft^2)
2nd	14.000	0.850	26.634	18.620	-15.608	-21.851
3rd	26.660	0.953	29.862	20.876	-15.608	-21.851
4th	37.330	1.024	32.086	22.431	-15.608	-21.851
Penthouse	48.000	1.080	33.841	23.658	-15.608	-21.851
Roof	62.500	1.140	35.721	24.972	-15.608	-21.851

Building C

Floor	Height	k_z	q_z (lb/ft^2)	p_{wind} (lb/ft^2)	p_{lee} (lb/ft^2)	p_{side} (lb/ft^2)
2nd	14.000	0.850	26.634	18.620	-15.608	-21.851
3rd	26.660	0.953	29.862	20.876	-15.608	-21.851
4th	37.330	1.024	32.086	22.431	-15.608	-21.851
Penthouse	48.000	1.080	33.841	23.658	-15.608	-21.851
Roof	62.500	1.140	35.721	24.972	-15.608	-21.851


Total: 28
Chris Vandelogt
Tech 1
Wind Analysis
6
Summary: Building A Long
-20.5 psf
14.6 psf
A
wind
variable
-20.5 psf
Plan
Elevation
Summary: Building B Long
21.4 psf
15.3 psf
B
wind
variable
21.4 psf
Plan
Elevation
Summary: Building C Long
21.1 psf
15.1 psf
C
wind
Variable
21.1 psf
Plan
Elevation



Total: 29
Chris Vandelogt
Tech 1
Wind Analysis
7
Summary: Building A short
21.1 psf
A
wind
variable
13.0 psf
21.1 psf
Plan
N
24.1
22.5
20.9
18.6
15.0
Elevation
Summary: Building B short
21.9 psf
wind
Variable
15.6 psf
21.9 psf
Plan
N
25.0
23.7
22.4
20.9
18.6
15.6
Elevation
Summary: Building C short
21.4 psf
wind
variable
21.4 psf
15.6 psf
Plan
N
25.0
23.7
22.4
20.9
18.6
15.6
Elevation

Appendix C: Seismic Load Calculations

Variable	Value	Reference
I_e=	1.25	Table 1.5-2
S_s=	0.21	USGS
S_1=	0.06	USGS
Site Class:	C	Geotech Report
F_a=	1.2	Table 11.4-1
F_v=	1.7	Table 11.4-2
S_{ms}=	0.252	
S_{m1}=	0.102	
S_{DS}=	0.168	
S_{D1}=	0.068	
Category:	B	Table 11.6-1,2
R=	3	Table 12.2-1: Ordinary RC Moment Frame
T_L=	6 sec	Fig 22-12

Equivalent Lateral Force Procedure			
C_t=	0.02		Table 12.8-2: Other Structures
x=	0.75		
h_n=	62.5	ft	
T_a=	0.445	sec	
C_u=	1.7		Table 12.8-1
T=	0.756	sec	
k=	1.128		
C_S=	0.070		
$C_{S,max}$=	0.037		
$C_{S,min}$=	0.010		
Use C_S=	0.037		

Weight of Floors

1st Floor:			2nd Floor:			3rd Floor:		
SDL=	5	psf	SDL=	5	psf	SDL=	5	psf
MEP=	10	psf	MEP=	10	psf	MEP=	10	psf
Partitions=	15	psf	Partitions=	15	psf	Partitions=	15	psf
Slab=	106.3	psf	Ceiling=	5	psf	Ceiling=	5	psf
MEP Equip=	150	psf	Slab=	106.3	psf	Slab=	106.3	psf
A_{Mech}=	4314	ft^2	A_{Total}=	12456	ft^2	A_{Total}=	12456	ft^2
A_{Other}=	12456	ft^2						
Weight:	2345	kips	Weight:	1760	kips	Weight:	1760	kips

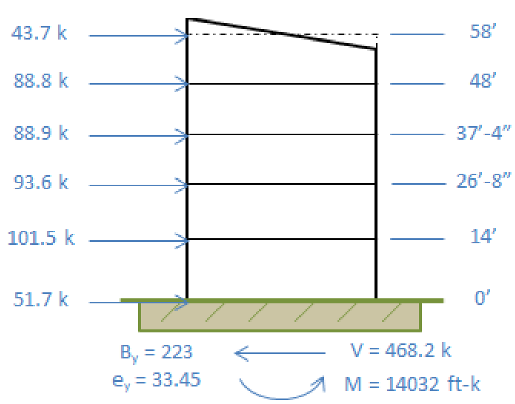
4th Floor:			Penthouse:			Roof:		
SDL=	5	psf	SDL=	5	psf	SDL=	5	psf
MEP=	10	psf	MEP=	10	psf	Framing=	15	psf
Partitions=	15	psf	Partitions=	20	psf	Insulation=	3	psf
Ceiling=	0	psf	Ceiling=	0	psf	20% Snow=	6.16	psf
Slab=	106.3	psf	Slab=	106.3	psf			
			MEP Equip=	150	psf			
A_{Total}=	12456	ft^2	A_{Mech}=	744	ft^2	A_{Total}=	11487	ft^2
			A_{Other}=	11487	ft^2			
Weight:	1698	kips	Weight:	1735	kips	Weight:	335	kips

Seismic Forces

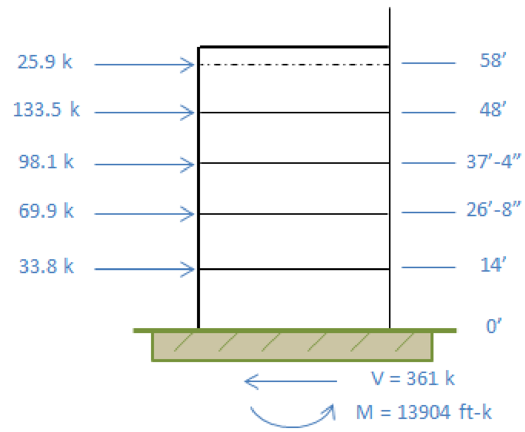
Building C							
Floor	Floor Weight, w_x (k)	Story Height, h_x (ft)	$w_x h_x^k$	C_{vx}	Story Force (k)	Story Shear (k)	Overturning Moment (k-ft)
Ground	2345	0.0	0.00	0.00	0.0	361.1	0.0
2nd	1760	14.0	89799.12	0.09	33.8	361.1	473.2
3rd	1760	26.7	185685.30	0.19	69.9	327.3	1863.3
4th	1698	37.3	260630.10	0.27	98.1	257.4	3662.1
Pent	1735	48.0	354584.69	0.37	133.5	159.3	6406.4
Roof	335	58.0	68682.22	0.07	25.9	25.9	1499.4
Sum:	9632		959381.4	1.00	361.1		
				√ ok	√ ok		
	Base Shear ($V=C_sW$) =		361	**Total Overturning Moment =**			13904

Appendix D: Story Loads

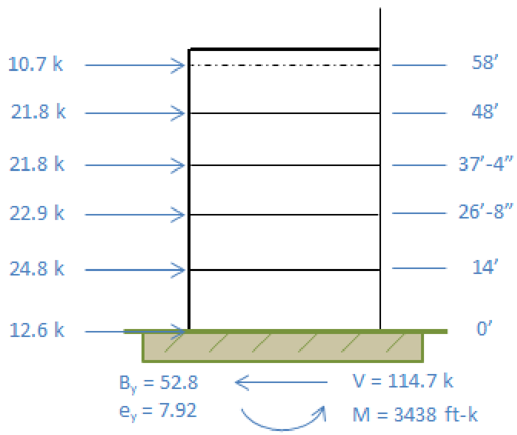
Wind: Y-Axis Loads



Seismic Loads



Wind: X-Axis Loads



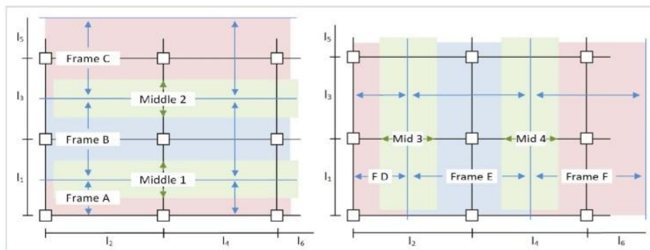
Appendix E: Column Calculations

Flat Plate With No Edge Beams (By Direct Design Method)

$l_{max,int}$=	20	ft
$l_{max,ext}$=	20	ft
f'_c=	4000	psi
f_y=	60000	psi
w_{SD}=	35	psf
w_L=	100	psf
$t_{col,1dir}$=	20	in
$t_{col,2dir}$=	20	in
$l_{n,1}$=	17.50	ft
$l_{n,2}$=	15.17	ft
$l_{n,3}$=	15.33	ft
$l_{n,4}$=	17.33	ft
$l_{n,5}$=	15.00	ft
$l_{n,6}$=	18.33	ft

l_1=	19.163	ft
l_3=	17	ft
l_5=	16.67	ft
l_2=	16.833	ft
l_4=	19	ft
l_6=	20	ft
$Width_{FA}$=	9.5815	ft
$Width_{FB}$=	18.0815	ft
$Width_{FC}$=	16.835	ft
$Width_{FD}$=	8.4165	ft
$Width_{FE}$=	17.9165	ft
$Width_{FF}$=	19.5	ft

Need to change orientation so l2 > l1



Note: Make sure $l_2 > l_1$

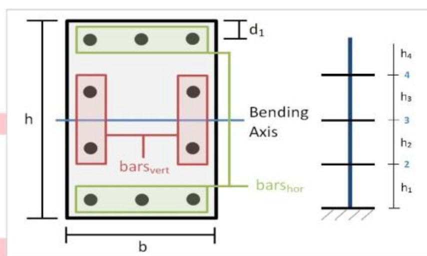
Column Design of Ground Floor Columns

Trial Column			
b=		20	in
h=		20	in
Use	#	10	bars
d_1=		2.5	in
$bars_{vert}$=		2	
$bars_{hor}$=		6	
Floors=		5	

Note: Includes roof but not ground

h_5=	10	ft
h_4=	10.67	ft
h_3=	10.67	ft
h_2=	12.66	ft
h_1=	14	ft

Roof Slope=	2	/	12
$w_{SD,roof}$=	23	psf	
$w_{L,roof}$=	20	psf	
w_{snow}=	30.8	psf	
$w_{SD,5}$=	35	psf	
$w_{L,5}$=	150	psf	Non-Reducible
$w_{SD,4}$=	30	psf	
$w_{L,4}$=	40	psf	
$w_{SD,3}$=	35	psf	
$w_{L,3}$=	40	psf	
$w_{SD,2}$=	35	psf	
$w_{L,2}$=	100	psf	Non-Reducible
$w_{SD,ground}$=	N/A	psf	
$w_{L,ground}$=	N/A	psf	



Column Strength / Strength Interaction Curve

Pure Compression		
P_o=	1915.7	kips
ϕP_o=	1245.2	kips

Pure Tension		
T_o=	-589.0	kips
ϕT_o=	-530.1	kips

Pure Bending (Solve by Hand)

Balanced-Strain Strength									
ε_y=	0.00207					β_1=	0.85	
c=	10.36	in	<	h	OK	A_s=	1.227	in²
d_1=	2.50	in				f_{s1}=	60.00	ksi
d_2=	10.00	in				f_{s2}=	3.00	ksi
d_3=	17.50	in				f_{s3}=	-60.00	ksi
d_4=		in				f_{s4}=		ksi
d_5=		in				f_{s5}=		ksi
d_6=		in				f_{s6}=		ksi
d_7=		in				f_{s7}=		ksi
d_8=		in				f_{s8}=		ksi
P_b=	606.0	kips				M_b=	555.4	ft-k
ϕP_b=	393.9	kips				ϕM_b=	361.0	ft-k

Column BD		
$t_{col,1dir}$=	20	in
$t_{col,2dir}$=	20	in
A_T=	608.731779	ft^2
$A_{T,roof}$=	152.182945	ft^2
$K_{LL}A_T$=	2434.92712	ft^2
$K_{LL}A_T$ >	$400ft^2$	OK
α=	0.55	
α_{roof}=	1.00	

Column BE		
$t_{col,1dir}$=	20	in
$t_{col,2dir}$=	20	in
A_T=	1295.82878	ft^2
$A_{T,roof}$=	323.957195	ft^2
$K_{LL}A_T$=	5183.31512	ft^2
$K_{LL}A_T$ >	$400ft^2$	OK
α=	0.46	
α_{roof}=	0.88	

Column BF		
$t_{col,1dir}$=	20	in
$t_{col,2dir}$=	20	in
A_T=	1410.357	ft^2
$A_{T,roof}$=	352.58925	ft^2
$K_{LL}A_T$=	5641.428	ft^2
$K_{LL}A_T$ >	$400ft^2$	OK
α=	0.45	
α_{roof}=	0.85	

Column BD		
$M_{ETABS,long}$=	96	ft-k
$M_{ETABS,short}$=	68	ft-k
$M_{unb,long}$=	31.7	ft-k
$M_{unb,short}$=	13.3	ft-k
P_L=	44.8	kips
P_D=	105.9	kips
$P_{S,Lr}$=	7.7	kips
$M_{u,long}$=	127.7	ft-k
$M_{u,short}$=	81.3	ft-k
P_T=	202.6	kips

Column BE		
$M_{ETABS,long}$=	96	ft-k
$M_{ETABS,short}$=	68	ft-k
$M_{unb,long}$=	27.3	ft-k
$M_{unb,short}$=	27.5	ft-k
P_L=	92.9	kips
P_D=	206.0	kips
$P_{S,Lr}$=	15.7	kips
$M_{u,long}$=	123.3	ft-k
$M_{u,short}$=	95.5	ft-k
P_T=	403.6	kips

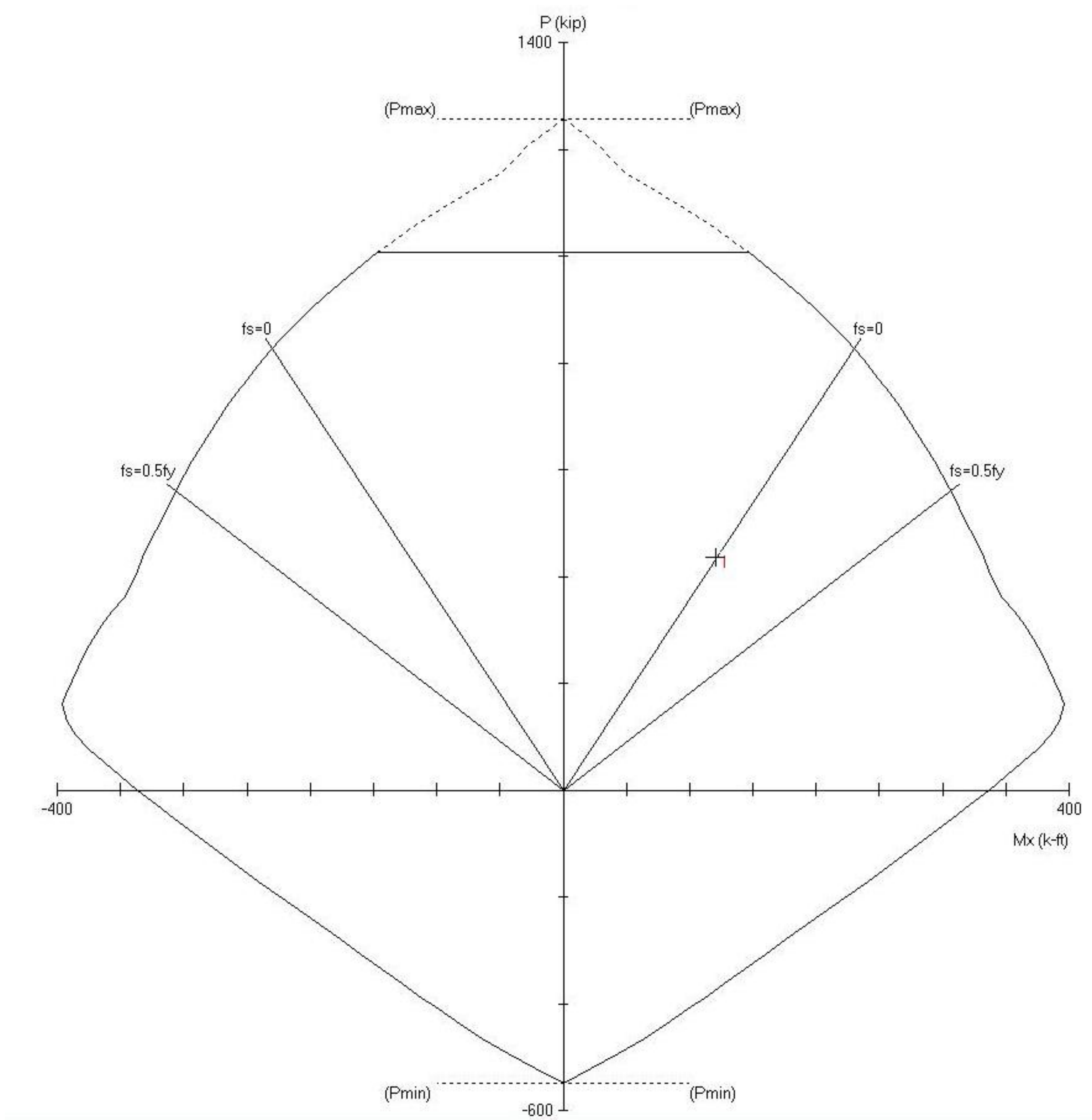
Column BF		
$M_{ETABS,long}$=	96	ft-k
$M_{ETABS,short}$=	68	ft-k
$M_{unb,long}$=	25.0	ft-k
$M_{unb,short}$=	29.9	ft-k
P_L=	100.8	kips
P_D=	222.7	kips
$P_{S,Lr}$=	16.8	kips
$M_{u,long}$=	121.0	ft-k
$M_{u,short}$=	97.9	ft-k
P_T=	437.0	kips

Interior Column BF (Reinforcement Needed)

$t_{col,1dir}$=	20	in	b_o=	108.50	in
$t_{col,2dir}$=	20	in	b_1=	27.13	in
$M_{u,long}$=	41.7	ft-k	b_2=	27.13	in
$M_{u,short}$=	49.9	ft-k	$V_{c,1}$=	195.6	kips
			$V_{c,2}$=	293.4	kips
			$V_{c,3}$=	226.2	kips
V_u=	116.2	kips	ϕV_c=	146.7	kips

Transferred by Eccentricity of Shear

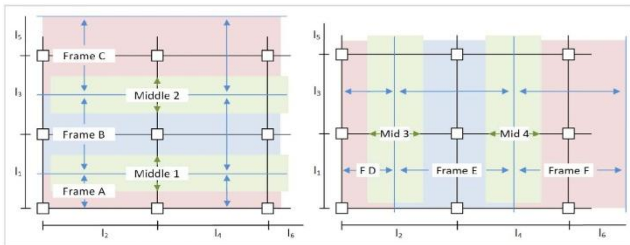
V_u=	116.2	kips				V_u=	116.2	kips			
$M_{uv,long}$=	16.7	ft-k				$M_{uv,short}$=	19.9	ft-k			
Centroid=	13.56	in				Centroid=	13.56	in			
J_c=	96434	in^4				J_c=	96434	in^4			
A_c=	773	in^2				A_c=	773	in^2			
ν_l=	122	psi				ν_l=	117	psi			
ν_r=	178	psi				ν_r=	184	psi			
ν_u=	178	psi				ν_u=	184	psi			
$\phi\nu_n$=	190	psi	>	ν_u	OK	$\phi\nu_n$=	190	psi	>	ν_u	OK


P (kip)
1400
(Pmax)
(Pmax)
fs=0
fs=0
fs=0.5fy
fs=0.5fy
1
-400
400
Mx (k-ft)
(Pmin)
(Pmin)
-600

Appendix F: Slab Thickness Calculations

Flat Plate With No Edge Beams (By Direct Design Method)

$l_{max,int}$=	20	ft	l_1=	19.163	ft
$l_{max,ext}$=	20	ft	l_3=	17	ft
f'_c=	4000	psi	l_5=	16.67	ft
f_y=	60000	psi	l_2=	19	ft
w_{SD}=	35	psf	l_4=	20	ft
w_L=	100	psf	l_6=	16.833	ft
$t_{col,1dir}$=	20	in	$Width_{FA}$=	9.5815	ft
$t_{col,2dir}$=	20	in	$Width_{FB}$=	18.0815	ft
$l_{n,1}$=	17.50	ft	$Width_{FC}$=	16.835	ft
$l_{n,2}$=	17.33	ft	$Width_{FD}$=	9.5	ft
$l_{n,3}$=	15.33	ft	$Width_{FE}$=	19.5	ft
$l_{n,4}$=	18.33	ft	$Width_{FF}$=	18.4165	ft
$l_{n,5}$=	15.00	ft	Need to change orientation so l2 > l1		
$l_{n,6}$=	15.17	ft			



Note: Make sure $l_2 > l_1$

Slab Thickness

t_{input}=	0.00	in			
$t_{min,int}$=	6.67	in			
$t_{min,ext}$=	8.07	in			
Use t_{slab}=	8.50	in	>	5"	OK

Wide Beam Action

$l_{max,FB}$=	18.1	ft	$l_{max,1dir}$=	19.2	ft
$l_{max,2dir}$=	20	ft	$l_{max,FE}$=	19.5	ft
d_{avg}=	7.13	in			
w_u=	329.5	psf			

Note: Dimensions from Same Bay

Long Direction

V_u=	51.1	kips			
ϕV_c=	146.8	kips	>	V_u	OK

Short Direction

V_u=	52.5	kips			
ϕV_c=	158.2	kips	>	V_u	OK

Punching Shear

$l_{max,FB}$=	18.1	ft			
$l_{max,FE}$=	19.5	ft			
V_u=	114.6	kips			
b_o=	108.5	in			
$V_{c,1}$=	195.6	kips			
$V_{c,2}$=	293.4	kips			
$V_{c,3}$=	226.2	kips			
ϕV_c=	146.7	kips	>	V_u	OK

Take Minimum Value

Deflection Check

Assume:	25	% of w_L is sustained
	90	% of immediate deflection due to dead load occurs before partitions are installed
	x	Check if: Nonstructural attached elements will be damaged by excessive deflection

Interior Panel l_3 - l_4

Column Strip			Middle Strip		
$I_{g,col}$=	5552	in^4	$I_{g,mid}$=	7062	in^4
w_D=	1.724	k/ft	w_D=	0.918	k/ft
w_L=	1.221	k/ft	w_L=	0.650	k/ft
$\Delta_{D,max}$=	0.062	in	$\Delta_{D,max}$=	0.014	in
$\Delta_{L,max}$=	0.081	in	$\Delta_{L,max}$=	0.018	in
$\Delta_{long-term}$=	0.246	in	$\Delta_{long-term}$=	0.054	in

Check Live Load Deflection

Δ_L=	0.099	in	
ACI Limit=	0.667	in	OK

Check Total Load Deflection

Δ_T=	0.406	in	
ACI Limit=	0.500	in	OK

Exterior Panel l_1 - l_2

Column Strip			Middle Strip		
$I_{g,col}$=	5552	in^4	$I_{g,mid}$=	5834	in^4
w_D=	1.724	k/ft	w_D=	0.872	k/ft
w_L=	1.221	k/ft	w_L=	0.618	k/ft
$\Delta_{D,max}$=	0.050	in	$\Delta_{D,max}$=	0.025	in
$\Delta_{L,max}$=	0.066	in	$\Delta_{L,max}$=	0.033	in
$\Delta_{long-term}$=	0.201	in	$\Delta_{long-term}$=	0.100	in

Check Live Load Deflection

Δ_L=	0.099	in	
ACI Limit=	0.633	in	OK

Check Total Load Deflection

Δ_T=	0.407	in	
ACI Limit=	0.475	in	OK

Exterior Panel l_3 - l_2

Column Strip			Middle Strip		
$I_{g,col}$=	5552	in^4	$I_{g,mid}$=	6448	in^4
w_D=	1.724	k/ft	w_D=	0.872	k/ft
w_L=	1.221	k/ft	w_L=	0.618	k/ft
$\Delta_{D,max}$=	0.050	in	$\Delta_{D,max}$=	0.014	in
$\Delta_{L,max}$=	0.066	in	$\Delta_{L,max}$=	0.026	in
$\Delta_{long-term}$=	0.201	in	$\Delta_{long-term}$=	0.062	in

Check Live Load Deflection

Δ_L=	0.092	in	
ACI Limit=	0.633	in	OK

Check Total Load Deflection

Δ_T=	0.361	in	
ACI Limit=	0.475	in	OK

Exterior Panel l_1 - l_4

Column Strip			Middle Strip		
$I_{g,col}$=	5859	in^4	$I_{g,mid}$=	5884	in^4
w_D=	1.859	k/ft	w_D=	0.880	k/ft
w_L=	1.316	k/ft	w_L=	0.623	k/ft
$\Delta_{D,max}$=	0.053	in	$\Delta_{D,max}$=	0.030	in
$\Delta_{L,max}$=	0.070	in	$\Delta_{L,max}$=	0.039	in
$\Delta_{long-term}$=	0.212	in	$\Delta_{long-term}$=	0.119	in

Check Live Load Deflection

Δ_L=	0.109	in	
ACI Limit=	0.667	in	OK

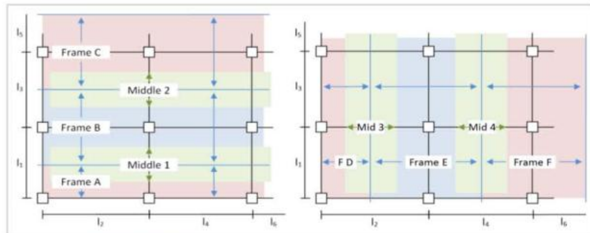
Check Total Load Deflection

Δ_T=	0.448	in	
ACI Limit=	0.500	in	OK

Appendix G: 2nd Floor Reinf Calcs

Flat Plate With No Edge Beams (By Direct Design Method)

$l_{max,int}$=	20	ft	l_1=	16.833	ft
$l_{max,ext}$=	20	ft	l_3=	15.166	ft
f'_c=	4000	psi	l_5=	20	ft
f_y=	60000	psi	l_2=	19.163	ft
w_{SD}=	35	psf	l_4=	17	ft
w_L=	100	psf	l_6=	16.67	ft
$t_{col,1dir}$=	20	in	$Width_{FA}$=	8.4165	ft
$t_{col,2dir}$=	20	in	$Width_{FB}$=	15.9995	ft
$l_{n,1}$=	15.17	ft	$Width_{FC}$=	17.583	ft
$l_{n,2}$=	17.50	ft	$Width_{FD}$=	9.5815	ft
$l_{n,3}$=	13.50	ft	$Width_{FE}$=	18.0815	ft
$l_{n,4}$=	15.33	ft	$Width_{FF}$=	16.835	ft
$l_{n,5}$=	18.33	ft			
$l_{n,6}$=	15.00	ft			



Note: Make sure $l_2 > l_1$

Slab Thickness

t_{input}=	0.00	in			
$t_{min,int}$=	6.67	in			
$t_{min,ext}$=	8.07	in			
Use t_{slab}=	8.50	in	>	5"	OK

Wide Beam Action

$l_{max,FB}$=	18.1	ft	$l_{max,1dir}$=	19.2	ft
$l_{max,2dir}$=	20	ft	$l_{max,FE}$=	19.5	ft
d_{avg}=	7.13	in			
w_u=	329.5	psf			

Long Direction

V_u=	51.1	kips			
ϕV_c=	146.8	kips	>	V_u	OK

Short Direction

V_u=	52.5	kips			
ϕV_c=	158.2	kips	>	V_u	OK

Note: Dimensions from Same Bay

Punching Shear

$l_{max,FB}$=	18.1	ft			
$l_{max,FE}$=	19.5	ft			
V_u=	114.6	kips			
b_o=	108.5	in			
V_{c1}=	195.6	kips			
V_{c2}=	293.4	kips			
V_{c3}=	226.2	kips			
ϕV_c=	146.7	kips	>	V_u	OK

Take Minimum Value

Deflection Check

Assume:

25	% of w_L is sustained
90	% of immediate deflection due to dead load occurs before partitions are installed
x	Check if: Nonstructural attached elements will be damaged by excessive deflection

Interior Panel l_3 - l_4

Column Strip			Middle Strip		
$I_{g,col}$=	5399	in^4	$I_{g,mid}$=	5783	in^4
w_D=	1.676	k/ft	w_D=	0.780	k/ft
w_L=	1.187	k/ft	w_L=	0.553	k/ft
$\Delta_{D,max}$=	0.032	in	$\Delta_{D,max}$=	0.009	in
$\Delta_{L,max}$=	0.042	in	$\Delta_{L,max}$=	0.012	in
$\Delta_{long-term}$=	0.129	in	$\Delta_{long-term}$=	0.035	in

Check Live Load Deflection

Δ_L=	0.054	in	
ACI Limit=	0.567	in	OK

Check Total Load Deflection

Δ_T=	0.222	in	
ACI Limit=	0.425	in	OK

Exterior Panel l_1 - l_2

Column Strip			Middle Strip		
$I_{g,col}$=	4913	in^4	$I_{g,mid}$=	6600	in^4
w_D=	1.525	k/ft	w_D=	0.880	k/ft
w_L=	1.080	k/ft	w_L=	0.623	k/ft
$\Delta_{D,max}$=	0.052	in	$\Delta_{D,max}$=	0.013	in
$\Delta_{L,max}$=	0.068	in	$\Delta_{L,max}$=	0.017	in
$\Delta_{long-term}$=	0.208	in	$\Delta_{long-term}$=	0.053	in

Check Live Load Deflection

Δ_L=	0.086	in	
ACI Limit=	0.639	in	OK

Check Total Load Deflection

Δ_T=	0.353	in	
ACI Limit=	0.479	in	OK

Exterior Panel $l_3 \cdot l_2$

Column Strip			Middle Strip		
$I_{g,col}$=	5399	in^4	$I_{g,mid}$=	7112	in^4
w_D=	1.676	k/ft	w_D=	0.880	k/ft
w_L=	1.187	k/ft	w_L=	0.623	k/ft
$\Delta_{D,max}$=	0.052	in	$\Delta_{D,max}$=	0.008	in
$\Delta_{L,max}$=	0.068	in	$\Delta_{L,max}$=	0.015	in
$\Delta_{long\text{-}term}$=	0.208	in	$\Delta_{long\text{-}term}$=	0.036	in

Check Live Load Deflection

Δ_L=	0.083	in	
ACI Limit=	0.639	in	OK

Check Total Load Deflection

Δ_T=	0.333	in	
ACI Limit=	0.479	in	OK

Exterior Panel $l_1 \cdot l_4$

Column Strip			Middle Strip		
$I_{g,col}$=	5169	in^4	$I_{g,mid}$=	5169	in^4
w_D=	1.724	k/ft	w_D=	0.773	k/ft
w_L=	1.221	k/ft	w_L=	0.547	k/ft
$\Delta_{D,max}$=	0.033	in	$\Delta_{D,max}$=	0.016	in
$\Delta_{L,max}$=	0.044	in	$\Delta_{L,max}$=	0.020	in
$\Delta_{long\text{-}term}$=	0.133	in	$\Delta_{long\text{-}term}$=	0.062	in

Check Live Load Deflection

Δ_L=	0.064	in	
ACI Limit=	0.567	in	OK

Check Total Load Deflection

Δ_T=	0.264	in	
ACI Limit=	0.425	in	OK

Total Static Moment

w_u=	329.5	psf		
	l_1 / l_2		l_3 / l_4	
$M_{0,A}$=	106.1	ft-k	81.5	ft-k
$M_{0,B}$=	201.7	ft-k	154.9	ft-k
$M_{0,C}$=	221.7	ft-k	170.3	ft-k
$M_{0,D}$=	90.8	ft-k	71.9	ft-k
$M_{0,E}$=	171.3	ft-k	135.7	ft-k
$M_{0,F}$=	159.5	ft-k	126.4	ft-k

Longitudinal Moments (ft-k)

	Span 1 (−)	Span 1 (+)	Span 1 (−)	Span 2 (−)	Span 2 (+)	Span 2 (−)
Frame A:	-26.5	55.2	-74.3	-53.0	28.5	-53.0
Frame B:	-50.4	104.9	-141.2	-100.7	54.2	-100.7
Frame C:	-55.4	115.3	-155.2	-110.7	59.6	-110.7
Frame D:	-22.7	47.2	-63.5	-46.7	25.2	-46.7
Frame E:	-42.8	89.1	-119.9	-88.2	47.5	-88.2
Frame F:	-39.9	82.9	-111.6	-82.1	44.2	-82.1

α=	0		Since flat plate (no beams)			
$C_{A,B,C}$=	2998.0	in^4		$C_{D,E,F}$=	2998.0	in^4
$I_{s,A}$=	5169	in^4		$I_{s,D}$=	5884	in^4
$I_{s,B}$=	9826	in^4		$I_{s,E}$=	11104	in^4
$I_{s,C}$=	10798	in^4		$I_{s,F}$=	10339	in^4
$\beta_{t,A}$=	0.2900	< 2.5 so	Use % col strip value below			
$\beta_{t,B}$=	0.1526	< 2.5 so	Use % col strip value below			
$\beta_{t,C}$=	0.1388	< 2.5 so	Use % col strip value below			
$\beta_{t,D}$=	0.2547	< 2.5 so	Use % col strip value below			
$\beta_{t,E}$=	0.1350	< 2.5 so	Use % col strip value below			
$\beta_{t,F}$=	0.1450	< 2.5 so	Use % col strip value below			

Frame A	Ext	Col Strip=	97.1	%
		Mid Strip=	2.9	%
	Pos	Col Strip=	60.0	%
		Mid Strip=	40.0	%
	Int	Col Strip=	75.0	%
		Mid Strip=	25.0	%
Frame B	Ext	Col Strip=	98.5	%
		Mid Strip=	1.5	%
	Pos	Col Strip=	60.0	%
		Mid Strip=	40.0	%
	Int	Col Strip=	75.0	%
		Mid Strip=	25.0	%

Summary of Moments (ft-k)

Frame A:	Col Strip:	4.2	ft	Col Strip:	4.2	ft
	Mid Strip:	4.2	ft	Mid Strip:	4.2	ft
M_{tot}=	-26.5	55.2	-74.3	-53.0	28.5	-53.0
M_{col}=	-25.8	33.1	-55.7	-39.7	17.1	-39.7
M_{mid}=	-0.8	22.1	-18.6	-13.2	11.4	-13.2
Frame B:	Col Strip:	8.0	ft	Col Strip:	8.0	ft
	Mid Strip:	8.0	ft	Mid Strip:	8.0	ft
M_{tot}=	-50.4	104.9	-141.2	-100.7	54.2	-100.7
M_{col}=	-49.7	62.9	-105.9	-75.5	32.5	-75.5
M_{mid}=	-0.8	42.0	-35.3	-25.2	21.7	-25.2
Frame C:	Col Strip:	8.8	ft	Col Strip:	8.8	ft
	Mid Strip:	8.8	ft	Mid Strip:	8.8	ft
M_{tot}=	-55.4	115.3	-155.2	-110.7	59.6	-110.7
M_{col}=	-54.7	69.2	-116.4	-83.0	35.8	-83.0
M_{mid}=	-0.8	46.1	-38.8	-27.7	23.8	-27.7
Frame D:	Col Strip:	4.2	ft	Col Strip:	3.8	ft
	Mid Strip:	5.4	ft	Mid Strip:	5.8	ft
M_{tot}=	-22.7	47.2	-63.5	-46.7	25.2	-46.7
M_{col}=	-22.1	28.3	-47.7	-35.1	15.1	-35.1
M_{mid}=	-0.6	18.9	-15.9	-11.7	10.1	-11.7

Frame C	Ext	Col Strip=	98.6	%
		Mid Strip=	1.4	%
	Pos	Col Strip=	60.0	%
		Mid Strip=	40.0	%
	Int	Col Strip=	75.0	%
		Mid Strip=	25.0	%
Frame D	Ext	Col Strip=	97.5	%
		Mid Strip=	2.5	%
	Pos	Col Strip=	60.0	%
		Mid Strip=	40.0	%
	Int	Col Strip=	75.0	%
		Mid Strip=	25.0	%
Frame E	Ext	Col Strip=	98.7	%
		Mid Strip=	1.3	%
	Pos	Col Strip=	60.0	%
		Mid Strip=	40.0	%
	Int	Col Strip=	75.0	%
		Mid Strip=	25.0	%
Frame F	Ext	Col Strip=	98.6	%
		Mid Strip=	1.4	%
	Pos	Col Strip=	60.0	%
		Mid Strip=	40.0	%
	Int	Col Strip=	75.0	%
		Mid Strip=	25.0	%

Frame E: Col Strip: 8.4 ft; Mid Strip: 9.7 ft | Col Strip: 7.6 ft; Mid Strip: 10.5 ft

M_{tot}=	-42.8	89.1	-119.9	-88.2	47.5	-88.2
M_{col}=	-42.2	53.4	-89.9	-66.2	28.5	-66.2
M_{mid}=	-0.6	35.6	-30.0	-22.1	19.0	-22.1

Frame F: Col Strip: 8.4 ft; Mid Strip: 8.5 ft | Col Strip: 7.6 ft; Mid Strip: 9.3 ft

M_{tot}=	-39.9	82.9	-111.6	-82.1	44.2	-82.1
M_{col}=	-39.3	49.8	-83.7	-61.6	26.5	-61.6
M_{mid}=	-0.6	33.2	-27.9	-20.5	17.7	-20.5

Assume:

#	5	bars

Interpolate Machine:

	ρ =	R =
Low	0.003	175
High	0.0035	204
Result	0.00329	192

Design of Slab Reinforcement for Frame A

Column Strip

Description	Exterior Span			Interior Span	
	M^-_{ext}	M^+	M^-_{int}	M^-	M^+
Moment: $M_{u,col}$	-25.8	33.1	-55.7	-39.7	17.1
Col. Strip Width: b	50.5	50.5	50.5	50.5	50.5
Effective Depth: d	7.44	7.44	7.44	7.44	7.44
M_u x 12/b	-6.1	7.9	-13.2	-9.4	4.1
$M_n = M_u/\phi$	-28.6	36.8	-61.9	-44.1	19.0
$R = M_n$ x $12000/bd^2$	123.0	158.0	265.9	189.6	81.7
ρ = See Table A.5a	0	0	0.00463	0	0
ρ_{min} = See Table A.4	←		0.0033	→	
ρ_{max} = See Table A.4	←		0.0206	→	
Check ρ_{min}	N.G.	N.G.	OK	N.G.	N.G.
Check ρ_{max}	OK	OK	OK	OK	OK
Use ρ	0.0033	0.0033	0.00463	0.0033	0.0033
A_s = ρbd	1.24	1.24	1.74	1.24	1.24
$A_{s,min}$ = .0018bt	0.77	0.77	0.77	0.77	0.77
Check $A_s > A_{s,min}$	OK	OK	OK	OK	OK
Use A_s	1.24	1.24	1.74	1.24	1.24
No. of Bars	5	5	6	5	5
Min No. of Bars	3	3	3	3	3
Use No. of Bars	5	5	6	5	5

Middle Strip

Description	Exterior Span			Interior Span	
	M^-_{ext}	M^+	M^-_{int}	M^-	M^+
Moment: $M_{u,col}$	-0.8	22.1	-18.6	-13.2	11.4
Col. Strip Width: b	50.5	50.5	50.5	50.5	50.5
Effective Depth: d	7.44	7.44	7.44	7.44	7.44
M_u x 12/b	-0.2	5.2	-4.4	-3.1	2.7
$M_n = M_u/\phi$	-0.9	24.5	-20.6	-14.7	12.7
$R = M_n$ x $12000/bd^2$	3.7	105.4	88.6	63.2	54.5
ρ = See Table A.5a	0	0	0	0	0
ρ_{min} = See Table A.4	←		0.0033	→	
ρ_{max} = See Table A.4	←		0.0206	→	
Check ρ_{min}	N.G.	N.G.	N.G.	N.G.	N.G.
Check ρ_{max}	OK	OK	OK	OK	OK
Use ρ	0.0033	0.0033	0.0033	0.0033	0.0033
A_s = ρbd	1.24	1.24	1.24	1.24	1.24
$A_{s,min}$ = .0018bt	0.77	0.77	0.77	0.77	0.77
Check $A_s > A_{s,min}$	OK	OK	OK	OK	OK
Use A_s	1.24	1.24	1.24	1.24	1.24
No. of Bars	5	5	5	5	5
Min No. of Bars	3	3	3	3	3
Use No. of Bars	5	5	5	5	5

Design of Slab Reinforcement for Frame B

Column Strip

Description	Exterior Span			Interior Span	
	M^-_{ext}	M^+	M^-_{int}	M^-	M^+
Moment: $M_{u,col}$	-49.7	62.9	-105.9	-75.5	32.5
Col. Strip Width: b	96.0	96.0	96.0	96.0	96.0
Effective Depth: d	7.44	7.44	7.44	7.44	7.44
M_u x 12/b	-6.2	7.9	-13.2	-9.4	4.1
$M_n = M_u/\phi$	-55.2	69.9	-117.7	-83.9	36.2
$R = M_n$ x $12000/bd^2$	124.7	158.0	265.9	189.6	81.7
ρ = See Table A.5a	0	0	0.00463	0	0
ρ_{min} = See Table A.4	←		0.0033	→	
ρ_{max} = See Table A.4	←		0.0206	→	
Check ρ_{min}	N.G.	N.G.	OK	N.G.	N.G.
Check ρ_{max}	OK	OK	OK	OK	OK
Use ρ	0.0033	0.0033	0.00463	0.0033	0.0033
A_s = ρbd	2.36	2.36	3.31	2.36	2.36
$A_{s,min}$ = .0018bt	1.47	1.47	1.47	1.47	1.47
Check $A_s > A_{s,min}$	OK	OK	OK	OK	OK
Use A_s	2.36	2.36	3.31	2.36	2.36
No. of Bars	8	8	11	8	8
Min No. of Bars	6	6	6	6	6
Use No. of Bars	8	8	11	8	8

Middle Strip

Description	Exterior Span			Interior Span	
	M^-_{ext}	M^+	M^-_{int}	M^-	M^+
Moment: $M_{u,col}$	-0.8	42.0	-35.3	-25.2	21.7
Col. Strip Width: b	96.0	96.0	96.0	96.0	96.0
Effective Depth: d	7.44	7.44	7.44	7.44	7.44
M_u x 12/b	-0.1	5.2	-4.4	-3.1	2.7
$M_n = M_u/\phi$	-0.9	46.6	-39.2	-28.0	24.1
$R = M_n$ x $12000/bd^2$	1.9	105.4	88.6	63.2	54.5
ρ = See Table A.5a	0	0	0	0	0
ρ_{min} = See Table A.4	←		0.0033	→	
ρ_{max} = See Table A.4	←		0.0206	→	
Check ρ_{min}	N.G.	N.G.	N.G.	N.G.	N.G.
Check ρ_{max}	OK	OK	OK	OK	OK
Use ρ	0.0033	0.0033	0.0033	0.0033	0.0033
A_s = ρbd	2.36	2.36	2.36	2.36	2.36
$A_{s,min}$ = .0018bt	1.47	1.47	1.47	1.47	1.47
Check $A_s > A_{s,min}$	OK	OK	OK	OK	OK
Use A_s	2.36	2.36	2.36	2.36	2.36
No. of Bars	8	8	8	8	8
Min No. of Bars	6	6	6	6	6
Use No. of Bars	8	8	8	8	8

Design of Slab Reinforcement for Frame C

Column Strip

Description	Exterior Span			Interior Span	
	M^-_{ext}	M^+	M^-_{int}	M^-	M^+
Moment: $M_{u,col}$	-54.7	69.2	-116.4	-83.0	35.8
Col. Strip Width: b	105.5	105.5	105.5	105.5	105.5
Effective Depth: d	7.44	7.44	7.44	7.44	7.44
M_u x 12/b	-6.2	7.9	-13.2	-9.4	4.1
$M_n = M_u/\phi$	-60.7	76.9	-129.3	-92.2	39.7
$R = M_n$ x $12000/bd^2$	124.9	158.0	265.9	189.6	81.7
ρ = See Table A.5a	0	0	0.00463	0	0
ρ_{min} = See Table A.4	←		0.0033	→	
ρ_{max} = See Table A.4	←		0.0206	→	
Check ρ_{min}	N.G.	N.G.	OK	N.G.	N.G.
Check ρ_{max}	OK	OK	OK	OK	OK
Use ρ	0.0033	0.0033	0.00463	0.0033	0.0033
A_s = ρbd	2.59	2.59	3.63	2.59	2.59
$A_{s,min}$ = .0018bt	1.61	1.61	1.61	1.61	1.61
Check $A_s > A_{s,min}$	OK	OK	OK	OK	OK
Use A_s	2.59	2.59	3.63	2.59	2.59
No. of Bars	9	9	12	9	9
Min No. of Bars	7	7	7	7	7
Use No. of Bars	9	9	12	9	9

Middle Strip

Description	Exterior Span			Interior Span	
	M^-_{ext}	M^+	M^-_{int}	M^-	M^+
Moment: $M_{u,col}$	-0.8	46.1	-38.8	-27.7	23.8
Col. Strip Width: b	105.5	105.5	105.5	105.5	105.5
Effective Depth: d	7.44	7.44	7.44	7.44	7.44
M_u x 12/b	-0.1	5.2	-4.4	-3.1	2.7
$M_n = M_u/\phi$	-0.9	51.2	-43.1	-30.7	26.5
$R = M_n$ x $12000/bd^2$	1.8	105.4	88.6	63.2	54.5
ρ = See Table A.5a	0	0	0	0	0
ρ_{min} = See Table A.4	←		0.0033	→	
ρ_{max} = See Table A.4	←		0.0206	→	
Check ρ_{min}	N.G.	N.G.	N.G.	N.G.	N.G.
Check ρ_{max}	OK	OK	OK	OK	OK
Use ρ	0.0033	0.0033	0.0033	0.0033	0.0033
A_s = ρbd	2.59	2.59	2.59	2.59	2.59
$A_{s,min}$ = .0018bt	1.61	1.61	1.61	1.61	1.61
Check $A_s > A_{s,min}$	OK	OK	OK	OK	OK
Use A_s	2.59	2.59	2.59	2.59	2.59
No. of Bars	9	9	9	9	9
Min No. of Bars	7	7	7	7	7
Use No. of Bars	9	9	9	9	9

Design of Slab Reinforcement for Frame D

Column Strip

Description	Exterior Span			Interior Span	
	M^-_{ext}	M^+	M^-_{int}	M^-	M^+
Moment: $M_{u,col}$	-22.1	28.3	-47.7	-35.1	15.1
Col. Strip Width: b	50.5	50.5	50.5	45.5	45.5
Effective Depth: d	6.81	6.81	6.81	6.81	6.81
M_u x 12/b	-5.3	6.7	-11.3	-9.2	4.0
$M_n = M_u/\phi$	-24.6	31.5	-53.0	-39.0	16.8
$R = M_n$ x $12000/bd^2$	125.8	161.1	271.1	221.4	95.4
ρ = See Table A.5a	0	0	0.00472	0.00381	0
ρ_{min} = See Table A.4	←		0.0033	→	

Middle Strip

Description	Exterior Span			Interior Span	
	M^-_{ext}	M^+	M^-_{int}	M^-	M^+
Moment: $M_{u,col}$	-0.6	18.9	-15.9	-11.7	10.1
Col. Strip Width: b	64.5	64.5	64.5	69.5	69.5
Effective Depth: d	6.81	6.81	6.81	6.81	6.81
M_u x 12/b	-0.1	3.5	-3.0	-2.0	1.7
$M_n = M_u/\phi$	-0.6	21.0	-17.7	-13.0	11.2
$R = M_n$ x $12000/bd^2$	2.6	84.1	70.8	48.3	41.6
ρ = See Table A.5a	0	0	0	0	0
ρ_{min} = See Table A.4	←		0.0033	→	

ρ_{max} = See Table A.4	←		0.0206	→	
Check ρ_{min}	N.G.	N.G.	OK	OK	N.G.
Check ρ_{max}	OK	OK	OK	OK	OK
Use ρ	0.0033	0.0033	0.00472	0.00381	0.0033
$A_s = \rho bd$	1.14	1.14	1.62	1.18	1.02
$A_{s,min}$ = .0018bt	0.77	0.77	0.77	0.70	0.70
Check $A_s > A_{s,min}$	OK	OK	OK	OK	OK
Use A_s	1.14	1.14	1.62	1.18	1.02
No. of Bars	4	4	6	4	4
Min No. of Bars	3	3	3	3	3
Use No. of Bars	4	4	6	4	4

ρ_{max} = See Table A.4	←		0.0206	→	
Check ρ_{min}	N.G.	N.G.	N.G.	N.G.	N.G.
Check ρ_{max}	OK	OK	OK	OK	OK
Use ρ	0.0033	0.0033	0.0033	0.0033	0.0033
$A_s = \rho bd$	1.45	1.45	1.45	1.56	1.56
$A_{s,min}$ = .0018bt	0.99	0.99	0.99	1.06	1.06
Check $A_s > A_{s,min}$	OK	OK	OK	OK	OK
Use A_s	1.45	1.45	1.45	1.56	1.56
No. of Bars	5	5	5	6	6
Min No. of Bars	4	4	4	5	5
Use No. of Bars	5	5	5	6	6

Design of Slab Reinforcement for Frame E

Column Strip

Description	Exterior Span			Interior Span	
	M^-_{ext}	M^+	M^-_{int}	M^-	M^+
Moment: $M_{u,col}$	-42.2	53.4	-89.9	-66.2	28.5
Col. Strip Width: b	101.0	101.0	101.0	91.0	91.0
Effective Depth: d	6.81	6.81	6.81	6.81	6.81
M_u x 12/b	-5.0	6.4	-10.7	-8.7	3.8
$M_n = M_u/\phi$	-46.9	59.4	-99.9	-73.5	31.7
$R = M_n$ x $12000/bd^2$	120.2	152.0	255.8	208.9	90.0
ρ = See Table A.5a	0	0	0.00444	0.00359	0
ρ_{min} = See Table A.4	←		0.0033	→	
ρ_{max} = See Table A.4	←		0.0206	→	
Check ρ_{min}	N.G.	N.G.	OK	OK	N.G.
Check ρ_{max}	OK	OK	OK	OK	OK
Use ρ	0.0033	0.0033	0.00444	0.00359	0.0033
$A_s = \rho bd$	2.27	2.27	3.05	2.23	2.05
$A_{s,min}$ = .0018bt	1.55	1.55	1.55	1.39	1.39
Check $A_s > A_{s,min}$	OK	OK	OK	OK	OK
Use A_s	2.27	2.27	3.05	2.23	2.05
No. of Bars	8	8	10	8	7
Min No. of Bars	6	6	6	6	6
Use No. of Bars	8	8	10	8	7

Middle Strip

Description	Exterior Span			Interior Span	
	M^-_{ext}	M^+	M^-_{int}	M^-	M^+
Moment: $M_{u,col}$	-0.6	35.6	-30.0	-22.1	19.0
Col. Strip Width: b	116.0	116.0	116.0	126.0	126.0
Effective Depth: d	6.81	6.81	6.81	6.81	6.81
M_u x 12/b	-0.1	3.7	-3.1	-2.1	1.8
$M_n = M_u/\phi$	-0.6	39.6	-33.3	-24.5	21.1
$R = M_n$ x $12000/bd^2$	1.4	88.3	74.3	50.3	43.3
ρ = See Table A.5a	0	0	0	0	0
ρ_{min} = See Table A.4	←		0.0033	→	
ρ_{max} = See Table A.4	←		0.0206	→	
Check ρ_{min}	N.G.	N.G.	N.G.	N.G.	N.G.
Check ρ_{max}	OK	OK	OK	OK	OK
Use ρ	0.0033	0.0033	0.0033	0.0033	0.0033
$A_s = \rho bd$	2.61	2.61	2.61	2.83	2.83
$A_{s,min}$ = .0018bt	1.77	1.77	1.77	1.93	1.93
Check $A_s > A_{s,min}$	OK	OK	OK	OK	OK
Use A_s	2.61	2.61	2.61	2.83	2.83
No. of Bars	9	9	9	10	10
Min No. of Bars	7	7	7	8	8
Use No. of Bars	9	9	9	10	10

Design of Slab Reinforcement for Frame F

Column Strip

Description	Exterior Span			Interior Span	
	M^-_{ext}	M^+	M^-_{int}	M^-	M^+
Moment: $M_{u,col}$	-39.3	49.8	-83.7	-61.6	26.5
Col. Strip Width: b	100.5	100.5	100.5	91.0	91.0
Effective Depth: d	6.81	6.81	6.81	6.81	6.81
M_u x 12/b	-4.7	5.9	-10.0	-8.1	3.5
$M_n = M_u/\phi$	-43.7	55.3	-93.0	-68.4	29.5
$R = M_n$ x $12000/bd^2$	112.3	142.2	239.3	194.5	83.8
ρ = See Table A.5a	0	0	0.00414	0.00334	0
ρ_{min} = See Table A.4	←		0.0033	→	
ρ_{max} = See Table A.4	←		0.0206	→	
Check ρ_{min}	N.G.	N.G.	OK	OK	N.G.
Check ρ_{max}	OK	OK	OK	OK	OK
Use ρ	0.0033	0.0033	0.00414	0.00334	0.0033
$A_s = \rho bd$	2.26	2.26	2.83	2.07	2.05
$A_{s,min}$ = .0018bt	1.54	1.54	1.54	1.39	1.39
Check $A_s > A_{s,min}$	OK	OK	OK	OK	OK
Use A_s	2.26	2.26	2.83	2.07	2.05
No. of Bars	8	8	10	7	7
Min No. of Bars	6	6	6	6	6
Use No. of Bars	8	8	10	7	7

Middle Strip

Description	Exterior Span			Interior Span	
	M^-_{ext}	M^+	M^-_{int}	M^-	M^+
Moment: $M_{u,col}$	-0.6	33.2	-27.9	-20.5	17.7
Col. Strip Width: b	101.5	101.5	101.5	111.0	111.0
Effective Depth: d	6.81	6.81	6.81	6.81	6.81
M_u x 12/b	-0.1	3.9	-3.3	-2.2	1.9
$M_n = M_u/\phi$	-0.6	36.9	-31.0	-22.8	19.7
$R = M_n$ x $12000/bd^2$	1.6	93.9	79.0	53.1	45.8
ρ = See Table A.5a	0	0	0	0	0
ρ_{min} = See Table A.4	←		0.0033	→	
ρ_{max} = See Table A.4	←		0.0206	→	
Check ρ_{min}	N.G.	N.G.	N.G.	N.G.	N.G.
Check ρ_{max}	OK	OK	OK	OK	OK
Use ρ	0.0033	0.0033	0.0033	0.0033	0.0033
$A_s = \rho bd$	2.28	2.28	2.28	2.50	2.50
$A_{s,min}$ = .0018bt	1.55	1.55	1.55	1.70	1.70
Check $A_s > A_{s,min}$	OK	OK	OK	OK	OK
Use A_s	2.28	2.28	2.28	2.50	2.50
No. of Bars	8	8	8	9	9
Min No. of Bars	6	6	6	7	7
Use No. of Bars	8	8	8	9	9

Slab Reinforcement for Middle Strip 1

Description	Exterior Span			Interior Span	
	M^-_{ext}	M^+	M^-_{int}	M^-	M^+
Frame A Width (ft)	4.2	4.2	4.2	4.2	4.2
Frame B Width (ft)	4.2	4.2	4.2	4.2	4.2
No. of Bars from Frame A	5	5	5	5	5
No. of Bars from Frame B	4	4	4	4	4
Use No. of Bars	10	10	10	10	10

Slab Reinforcement for Middle Strip 2

Description	Exterior Span			Interior Span	
	M^-_{ext}	M^+	M^-_{int}	M^-	M^+
Frame B Width (ft)	3.8	3.8	3.8	3.8	3.8
Frame C Width (ft)	3.8	3.8	3.8	3.8	3.8
No. of Bars from Frame B	4	4	4	4	4
No. of Bars from Frame C	4	4	4	4	4
Use No. of Bars	8	8	8	8	8

Slab Reinforcement for Middle Strip 3

Description	Exterior Span			Interior Span	
	M^-_{ext}	M^+	M^-_{int}	M^-	M^+
Frame D Width (ft)	5.4	5.4	5.4	5.8	5.8
Frame E Width (ft)	5.4	5.4	5.4	5.8	5.8
No. of Bars from Frame D	5	5	5	6	6
No. of Bars from Frame E	5	5	5	6	6
Use No. of Bars	11	11	11	12	12

Slab Reinforcement for Middle Strip 4

Description	Exterior Span			Interior Span	
	M^-_{ext}	M^+	M^-_{int}	M^-	M^+
Frame E Width (ft)	4.3	4.3	4.3	4.7	4.7
Frame F Width (ft)	4.3	4.3	4.3	4.7	4.7
No. of Bars from Frame E	4	4	4	4	4
No. of Bars from Frame F	4	4	4	5	5
Use No. of Bars	9	9	9	10	10

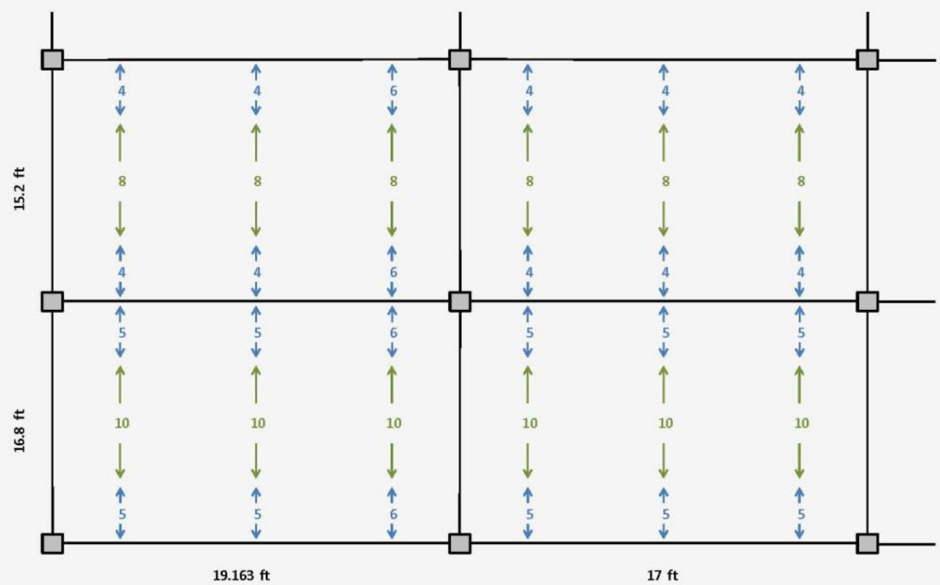
Summary of Required Reinforcement

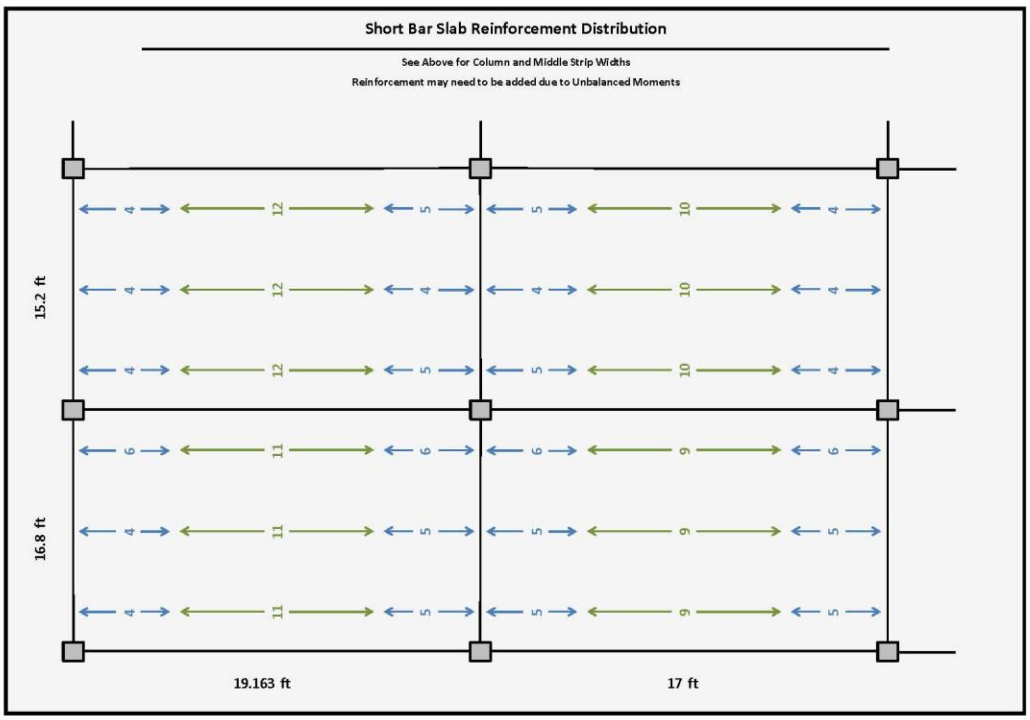
l_1:	16.833	ft	t_{slab}:	8.50	in
l_2:	19.163	ft	f'_c:	4000	psi
l_3:	15.166	ft	$t_{col,1\,dir}$:	20	in
l_4:	17	ft	$t_{col,2\,dir}$:	20	in

Long Bar Slab Reinforcement Distribution

See Above for Column and Middle Strip Widths

Note: Reinforcement may need to be added due to Unbalanced Moments

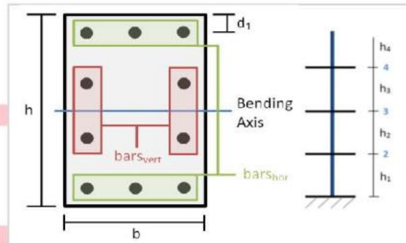



Short Bar Slab Reinforcement Distribution
See Above for Column and Middle Strip Widths
Reinforcement may need to be added due to Unbalanced Moments
15.2 ft
16.8 ft
19.163 ft
17 ft

Column Design of Ground Floor Columns

Trial Column		
b=	20	in
h=	20	in
Use #	9	bars
d_1=	2.5	in
$bars_{vert}$=	4	
$bars_{hor}$=	8	
Floors=	5	
Note: Includes roof but not ground		
h_5=	10	ft
h_4=	10.67	ft
h_3=	10.67	ft
h_2=	12.66	ft
h_1=	14	ft

Roof Slope=	2	/ 12	
$w_{SD,roof}$=	23	psf	
$w_{L,roof}$=	20	psf	
w_{snow}=	30.8	psf	
$w_{SD,5}$=	35	psf	
$w_{L,5}$=	150	psf	Non-Reducible
$w_{SD,4}$=	30	psf	
$w_{L,4}$=	40	psf	
$w_{SD,3}$=	35	psf	
$w_{L,3}$=	40	psf	
$w_{SD,2}$=	35	psf	
$w_{L,2}$=	100	psf	Non-Reducible
$w_{SD,ground}$=	N/A	psf	
$w_{L,ground}$=	N/A	psf	



Column Strength / Strength Interaction Curve

Pure Compression		
P_o=	2035.1	kips

Pure Tension		
T_o=	-715.7	kips

Pure Bending (Solve by Hand)

Balanced-Strain Strength							
ε_y=	0.00207				β_1=	0.85	
c=	10.36	in	< h	OK	A_s=	0.994	in^2
d_1=	2.50	in			f_{s1}=	60.00	ksi
d_2=	7.50	in			f_{s2}=	24.00	ksi
d_3=	12.50	in			f_{s3}=	-18.00	ksi
d_4=	17.50	in			f_{s4}=	-60.00	ksi
d_5=		in			f_{s5}=		ksi
d_6=		in			f_{s6}=		ksi
d_7=		in			f_{s7}=		ksi
d_8=		in			f_{s8}=		ksi
P_b=	610.6	kips			M_b=	594.9	ft-k

Live Load Reduction ($L = L_o \times \alpha$)

	Column CD			Column CE			Column CF	
$t_{col,1dir}$=	20	in	$t_{col,1dir}$=	20	in	$t_{col,1dir}$=	20	in
$t_{col,2dir}$=	20	in	$t_{col,2dir}$=	20	in	$t_{col,2dir}$=	20	in
A_T=	673.886058	ft^2	A_T=	1271.70806	ft^2	A_T=	1184.03922	ft^2
$A_{T,roof}$=	168.471515	ft^2	$A_{T,roof}$=	317.927015	ft^2	$A_{T,roof}$=	296.009805	ft^2
$K_{LL}A_T$=	2695.54423	ft^2	$K_{LL}A_T$=	5086.83223	ft^2	$K_{LL}A_T$=	4736.15688	ft^2
$K_{LL}A_T$ >	$400ft^2$	OK	$K_{LL}A_T$ >	$400ft^2$	OK	$K_{LL}A_T$ >	$400ft^2$	OK
α=	0.54		α=	0.46		α=	0.47	
α_{roof}=	1.00		α_{roof}=	0.88		α_{roof}=	0.90	

	Column BD			Column BE			Column BF	
$t_{col,1dir}$=	20	in	$t_{col,1dir}$=	20	in	$t_{col,1dir}$=	20	in
$t_{col,2dir}$=	20	in	$t_{col,2dir}$=	20	in	$t_{col,2dir}$=	20	in
A_T=	613.196837	ft^2	A_T=	1157.17984	ft^2	A_T=	1077.40633	ft^2
$A_{T,roof}$=	153.299209	ft^2	$A_{T,roof}$=	289.294959	ft^2	$A_{T,roof}$=	269.351583	ft^2
$K_{LL}A_T$=	2452.78735	ft^2	$K_{LL}A_T$=	4628.71935	ft^2	$K_{LL}A_T$=	4309.62532	ft^2
$K_{LL}A_T$ >	$400ft^2$	OK	$K_{LL}A_T$ >	$400ft^2$	OK	$K_{LL}A_T$ >	$400ft^2$	OK
α=	0.55		α=	0.47		α=	0.48	
α_{roof}=	1.00		α_{roof}=	0.91		α_{roof}=	0.93	

	Column AD			Column AE			Column AF	
$t_{col,1dir}$=	20	in	$t_{col,1dir}$=	20	in	$t_{col,1dir}$=	20	in
$t_{col,2dir}$=	20	in	$t_{col,2dir}$=	20	in	$t_{col,2dir}$=	20	in
A_T=	322.570779	ft^2	A_T=	608.731779	ft^2	A_T=	566.76711	ft^2
$A_{T,roof}$=	80.6426948	ft^2	$A_{T,roof}$=	152.182945	ft^2	$A_{T,roof}$=	141.691778	ft^2
$K_{LL}A_T$=	1290.28312	ft^2	$K_{LL}A_T$=	2434.92712	ft^2	$K_{LL}A_T$=	2267.06844	ft^2
$K_{LL}A_T$ >	$400ft^2$	OK	$K_{LL}A_T$ >	$400ft^2$	OK	$K_{LL}A_T$ >	$400ft^2$	OK
α=	0.67		α=	0.55		α=	0.57	
α_{roof}=	1.00		α_{roof}=	1.00		α_{roof}=	1.00	

Total Loads

Column CD		
$M_{ETABS,long}$=	68	ft-k
$M_{ETABS,short}$=	96	ft-k
$M_{unb,long}$=	41.0	ft-k
$M_{unb,short}$=	21.9	ft-k
P_L=	49.4	kips
P_D=	115.4	kips
$P_{S,Lr}$=	8.6	kips
$M_{u,long}$=	109.0	ft-k
$M_{u,short}$=	117.9	ft-k
P_T=	221.7	kips

Column CE		
$M_{ETABS,long}$=	68	ft-k
$M_{ETABS,short}$=	96	ft-k
$M_{unb,long}$=	27.0	ft-k
$M_{unb,short}$=	40.2	ft-k
P_L=	91.2	kips
P_D=	202.5	kips
$P_{S,Lr}$=	15.4	kips
$M_{u,long}$=	95.0	ft-k
$M_{u,short}$=	136.2	ft-k
P_T=	396.6	kips

Column CF		
$M_{ETABS,long}$=	68	ft-k
$M_{ETABS,short}$=	96	ft-k
$M_{unb,long}$=	15.1	ft-k
$M_{unb,short}$=	37.5	ft-k
P_L=	85.1	kips
P_D=	189.7	kips
$P_{S,Lr}$=	14.5	kips
$M_{u,long}$=	83.1	ft-k
$M_{u,short}$=	133.5	ft-k
P_T=	371.0	kips

Column BD		
$M_{ETABS,long}$=	68	ft-k
$M_{ETABS,short}$=	96	ft-k
$M_{unb,long}$=	37.3	ft-k
$M_{unb,short}$=	11.0	ft-k
P_L=	45.1	kips
P_D=	106.5	kips
$P_{S,Lr}$=	7.8	kips
$M_{u,long}$=	105.3	ft-k
$M_{u,short}$=	107.0	ft-k
P_T=	203.9	kips

Column BE		
$M_{ETABS,long}$=	68	ft-k
$M_{ETABS,short}$=	96	ft-k
$M_{unb,long}$=	24.5	ft-k
$M_{unb,short}$=	20.1	ft-k
P_L=	83.2	kips
P_D=	185.8	kips
$P_{S,Lr}$=	14.2	kips
$M_{u,long}$=	92.5	ft-k
$M_{u,short}$=	116.1	ft-k
P_T=	363.2	kips

Column BF		
$M_{ETABS,long}$=	68	ft-k
$M_{ETABS,short}$=	96	ft-k
$M_{unb,long}$=	13.8	ft-k
$M_{unb,short}$=	18.7	ft-k
P_L=	77.6	kips
P_D=	174.2	kips
$P_{S,Lr}$=	13.3	kips
$M_{u,long}$=	81.8	ft-k
$M_{u,short}$=	114.7	ft-k
P_T=	339.9	kips

Column AD		
$M_{ETABS,long}$=	68	ft-k
$M_{ETABS,short}$=	96	ft-k
$M_{unb,long}$=	19.1	ft-k
$M_{unb,short}$=	16.3	ft-k
P_L=	24.5	kips
P_D=	64.2	kips
$P_{S,Lr}$=	4.1	kips
$M_{u,long}$=	87.1	ft-k
$M_{u,short}$=	112.3	ft-k
P_T=	118.2	kips

Column AE		
$M_{ETABS,long}$=	68	ft-k
$M_{ETABS,short}$=	96	ft-k
$M_{unb,long}$=	12.5	ft-k
$M_{unb,short}$=	30.0	ft-k
P_L=	44.8	kips
P_D=	105.9	kips
$P_{S,Lr}$=	7.7	kips
$M_{u,long}$=	80.5	ft-k
$M_{u,short}$=	126.0	ft-k
P_T=	202.6	kips

Column AF		
$M_{ETABS,long}$=	68	ft-k
$M_{ETABS,short}$=	96	ft-k
$M_{unb,long}$=	7.0	ft-k
$M_{unb,short}$=	27.9	ft-k
P_L=	41.8	kips
P_D=	99.8	kips
$P_{S,Lr}$=	7.2	kips
$M_{u,long}$=	75.0	ft-k
$M_{u,short}$=	123.9	ft-k
P_T=	190.2	kips

Unbalanced Moments in Columns

		Check if: In accordance to ACI 13.5.3.3
#	5	bars
d=	7.13	in
w_u=	329.5	psf
w_D=	141.3	psf

Exterior Column CD (Reinforcement Needed)

$t_{col,1dir}$=	20	in	b_o=	74.25	in
$t_{col,2dir}$=	20	in	b_1=	23.56	in
$M_{o,long}$=	221.7	ft-k	b_2=	27.13	in
$M_{u,long}$=	66.5	ft-k	V_{c1}=	133.8	kips
$M_{u,short}$=	35.5	ft-k	V_{c2}=	200.8	kips
			V_{c3}=	163.2	kips
V_u=	55.5	kips	ϕV_c=	100.4	kips

Transferred by Flexure

γ_f=	0.617				
$M_{ub,long}$=	41.0	ft-k	$M_{ub,short}$=	21.9	ft-k
$M_{ub,totlong}$=	109.0	ft-k	$M_{ub,totshort}$=	117.9	ft-k
$M_{col,lright}$=	23.6	ft-k	$M_{col,sleft}$=	25.2	ft-k
M_{ub} < M_{col}	Need Reinforcement		M_{ub} < M_{col}	Need Reinforcement	

Description	Value
Moment: M_u	85.4
Strip Width: b	45.5
Effective Depth: d	7.13
M_u x 12/b	22.5
$M_n = M_u/\phi$	94.9
$R = M_n$ x $12000/bd^2$	493.2
ρ = See Table A.5a	0.00892
ρ_{min} = See Table A.4	0.0033
ρ_{max} = See Table A.4	0.0206
Check ρ_{min}	OK
Check ρ_{max}	OK
Use ρ	0.00892
$A_s = \rho bd$	2.89
$A_{s,min}$ = .0018bt	0.70
Check $A_s > A_{s,min}$	OK
Use A_s	2.89
No. of Bars	10
Min No. of Bars	3
Use No. of Bars	10

Description	Value
Moment: M_u	92.7
Strip Width: b	32.75
Effective Depth: d	7.13
M_u x 12/b	34.0
$M_n = M_u/\phi$	103.0
$R = M_n$ x $12000/bd^2$	743.2
ρ = See Table A.5a	0.01416
ρ_{min} = See Table A.4	0.0033
ρ_{max} = See Table A.4	0.0206
Check ρ_{min}	OK
Check ρ_{max}	OK
Use ρ	0.01416
$A_s = \rho bd$	3.30
$A_{s,min}$ = .0018bt	0.50
Check $A_s > A_{s,min}$	OK
Use A_s	3.30
No. of Bars	11
Min No. of Bars	2
Use No. of Bars	11

Transferred by Eccentricity of Shear

V_u=	55.5	kips	V_u=	55.5	kips
$M_{uv,long}$=	25.5	ft-k	$M_{uv,short}$=	13.6	ft-k
Centroid=	7.48	in	Centroid=	13.56	in
J_c=	33980	in^4	J_c=	87096	in^4
A_c=	529	in^2	A_c=	529	in^2
v_l=	-40	psi	v_l=	79	psi
v_r=	172	psi	v_r=	130	psi
v_u=	172	psi	v_u=	130	psi
ϕv_n=	190	psi	ϕv_n=	190	psi
ϕv_n > v_u	OK		ϕv_n > v_u	OK	

Exterior Column BD (Reinforcement Needed)

$t_{col,1dir}$=	20	in	b_o=	74.25	in
$t_{col,2dir}$=	20	in	b_1=	23.56	in
$M_{o,long}$=	201.7	ft-k	b_2=	27.13	in
$M_{u,long}$=	60.5	ft-k	V_{c1}=	133.8	kips
$M_{u,short}$=	17.8	ft-k	V_{c2}=	200.8	kips
			V_{c3}=	163.2	kips
V_u=	50.5	kips	ϕV_c=	100.4	kips

Transferred by Flexure

γ_f=	0.617				
$M_{ub,long}$=	37.3	ft-k	$M_{ub,short}$=	11.0	ft-k
$M_{ub,totlong}$=	105.3	ft-k	$M_{ub,totshort}$=	107.0	ft-k
$M_{col,lright}$=	23.5	ft-k	$M_{col,sleft}$=	34.3	ft-k
M_{ub} < M_{col}	Need Reinforcement		$M_{col,sright}$=	25.2	ft-k
			M_{ub} < M_{col}	Need Reinforcement	

Description	Value
Moment: M_u	81.8
Strip Width: b	45.5
Effective Depth: d	7.13
M_u x 12/b	21.6
$M_n = M_u/\phi$	90.9
$R = M_n$ x $12000/bd^2$	472.1
ρ = See Table A.5a	0.0085
ρ_{min} = See Table A.4	0.0033
ρ_{max} = See Table A.4	0.0206
Check ρ_{min}	OK
Check ρ_{max}	OK
Use ρ	0.0085
$A_s = \rho bd$	2.76
$A_{s,min}$ = .0018bt	0.70
Check $A_s > A_{s,min}$	OK
Use A_s	2.76
No. of Bars	9
Min No. of Bars	3
Use No. of Bars	9

Description	Left Side	Right Side
Moment: M_u	72.7	81.7
Strip Width: b	32.75	32.75
Effective Depth: d	7.13	7.13
M_u x 12/b	26.6	29.9
$M_n = M_u/\phi$	80.7	90.8
$R = M_n$ x $12000/bd^2$	582.7	655.4
ρ = See Table A.5a	0.01072	0.01225
ρ_{min} = See Table A.4	0.0033	0.0033
ρ_{max} = See Table A.4	0.0206	0.0206
Check ρ_{min}	OK	OK
Check ρ_{max}	OK	OK
Use ρ	0.01072	0.01225
$A_s = \rho bd$	2.50	2.86
$A_{s,min}$ = .0018bt	0.50	0.50
Check $A_s > A_{s,min}$	OK	OK
Use A_s	2.50	2.86
No. of Bars	9	10
Min No. of Bars	2	2
Use No. of Bars	9	10

Transferred by Eccentricity of Shear

V_u=	50.5	kips					V_u=	50.5	kips				
$M_{uv,long}$=	23.2	ft-k					$M_{uv,short}$=	6.8	ft-k				
Centroid=	7.48	in					Centroid=	13.56	in				
J_c=	33980	in^4					J_c=	87096	in^4				
A_c=	529	in^2					A_c=	529	in^2				
v_l=	-36	psi					v_l=	83	psi				
v_r=	157	psi					v_r=	108	psi				
v_u=	157	psi					v_u=	108	psi				
ϕv_n=	190	psi	>	v_u	OK		ϕv_n=	190	psi	>	v_u	OK	

Corner Column AD (Reinforcement Needed)

$t_{col,1dir}$=	20	in	b_o=	47.13	in
$t_{col,2dir}$=	20	in	b_1=	23.56	in
$M_{o,long}$=	106.1	ft-k	b_2=	23.56	in
$M_{u,long}$=	31.8	ft-k	V_{c1}=	84.9	kips
$M_{o,short}$=	90.8	ft-k	V_{c2}=	127.4	kips
$M_{u,short}$=	27.2	ft-k	V_{c3}=	106.7	kips
V_u=	26.6	kips	ϕV_c=	63.7	kips

Transferred by Flexure

γ_f=	0.600				
$M_{ub,long}$=	19.1	ft-k	$M_{ub,short}$=	16.3	ft-k
$M_{ub,totlong}$=	87.1	ft-k	$M_{ub,totshort}$=	112.3	ft-k
$M_{col,lright}$=	16.7	ft-k	$M_{col,sright}$=	14.3	ft-k
M_{ub} < M_{col}	Need Reinforcement		M_{ub} < M_{col}	Need Reinforcement	

Description	Value
Moment: M_u	70.4
Strip Width: b	32.75
Effective Depth: d	7.13
$M_u \times 12/b$	25.8
$M_n = M_u/\phi$	78.2
$R = M_n \times 12000/bd^2$	564.5
ρ = See Table A.5a	0.01035
ρ_{min} = See Table A.4	0.0033
ρ_{max} = See Table A.4	0.0206
Check ρ_{min}	OK
Check ρ_{max}	OK
Use ρ	0.01035
$A_s = \rho bd$	2.42
$A_{s,min}$ = .0018bt	0.50
Check $A_s > A_{s,min}$	OK
Use A_s	2.42
No. of Bars	8
Min No. of Bars	2
Use No. of Bars	8

Description	Value
Moment: M_u	98.0
Strip Width: b	32.75
Effective Depth: d	7.13
$M_u \times 12/b$	35.9
$M_n = M_u/\phi$	108.9
$R = M_n \times 12000/bd^2$	785.9
ρ = See Table A.5a	0.01511
ρ_{min} = See Table A.4	0.0033
ρ_{max} = See Table A.4	0.0206
Check ρ_{min}	OK
Check ρ_{max}	OK
Use ρ	0.01511
$A_s = \rho bd$	3.53
$A_{s,min}$ = .0018bt	0.50
Check $A_s > A_{s,min}$	OK
Use A_s	3.53
No. of Bars	12
Min No. of Bars	2
Use No. of Bars	12

Transferred by Eccentricity of Shear

V_u=	26.6	kips	V_u=	26.6	kips
$M_{uv,long}$=	12.7	ft-k	$M_{uv,short}$=	10.9	ft-k
Centroid=	7.85	in	Centroid=	7.85	in
J_c=	32489	in^4	J_c=	32489	in^4
A_c=	336	in^2	A_c=	336	in^2
v_l=	5	psi	v_l=	16	psi
v_r=	116	psi	v_r=	111	psi
v_u=	116	psi	v_u=	111	psi
ϕv_n=	190	psi	ϕv_n=	190	psi
$\phi v_n > v_u$	OK		$\phi v_n > v_u$	OK	

Interior Column CE (Reinforcement Needed)

$t_{col,1dir}$=	20	in	b_o=	108.50	in
$t_{col,2dir}$=	20	in	b_1=	27.13	in
$M_{u,long}$=	45.0	ft-k	b_2=	27.13	in
$M_{u,short}$=	67.0	ft-k	V_{c1}=	195.6	kips
			V_{c2}=	293.4	kips
			V_{c3}=	226.2	kips
V_u=	104.8	kips	ϕV_c=	146.7	kips

Transferred by Flexure

γ_f=	0.600				
$M_{ub,long}$=	27.0	ft-k	$M_{ub,short}$=	40.2	ft-k
$M_{ub,totlong}$=	95.0	ft-k	$M_{ub,totshort}$=	136.2	ft-k
$M_{col,lleft}$=	50.2	ft-k	$M_{col,sleft}$=	33.1	ft-k
$M_{col,lright}$=	35.8	ft-k	M_{ub} < M_{col}	Need Reinforcement	
M_{ub} < M_{col}	Need Reinforcement				

Description	Left Side	Right Side
Moment: M_u	44.8	59.2
Strip Width: b	45.5	45.5
Effective Depth: d	7.13	7.13
M_u x 12/b	11.8	15.6
$M_n = M_u/\phi$	49.8	65.7
$R = M_n$ x $12000/bd^2$	258.5	341.6
ρ = See Table A.5a	0.0045	0.006
ρ_{min} = See Table A.4	0.0033	0.0033
ρ_{max} = See Table A.4	0.0206	0.0206
Check ρ_{min}	OK	OK
Check ρ_{max}	OK	OK
Use ρ	0.0045	0.006
A_s = ρbd	1.46	1.95
$A_{s,min}$ = .0018bt	0.70	0.70
Check $A_s > A_{s,min}$	OK	OK
Use A_s	1.46	1.95
No. of Bars	5	7
Min No. of Bars	3	3
Use No. of Bars	5	7

Description	Left Side
Moment: M_u	103.1
Strip Width: b	45.5
Effective Depth: d	7.13
M_u x 12/b	27.2
$M_n = M_u/\phi$	114.6
$R = M_n$ x $12000/bd^2$	595.4
ρ = See Table A.5a	0.011
ρ_{min} = See Table A.4	0.0033
ρ_{max} = See Table A.4	0.0206
Check ρ_{min}	OK
Check ρ_{max}	OK
Use ρ	0.011
A_s = ρbd	3.57
$A_{s,min}$ = .0018bt	0.70
Check $A_s > A_{s,min}$	OK
Use A_s	3.57
No. of Bars	12
Min No. of Bars	3
Use No. of Bars	12

Transferred by Eccentricity of Shear

V_u=	104.8	kips		V_u=	104.8	kips	
$M_{uv,long}$=	18.0	ft-k		$M_{uv,short}$=	26.8	ft-k	
Centroid=	13.56	in		Centroid=	13.56	in	
J_c=	96434	in^4		J_c=	96434	in^4	
A_c=	773	in^2		A_c=	773	in^2	
ν_l=	105	psi		ν_l=	90	psi	
ν_r=	166	psi		ν_r=	181	psi	
ν_u=	166	psi		ν_u=	181	psi	
$\phi\nu_n$=	190	psi > ν_u	OK	$\phi\nu_n$=	190	psi > ν_u	OK

Interior Column BE (Reinforcement Needed)

$t_{col,1dir}$=	20	in	b_o=	108.50	in
$t_{col,2dir}$=	20	in	b_1=	27.13	in
$M_{u,long}$=	40.9	ft-k	b_2=	27.13	in
$M_{u,short}$=	33.5	ft-k	$V_{c,1}$=	195.6	kips
			$V_{c,2}$=	293.4	kips
			$V_{c,3}$=	226.2	kips
V_u=	95.3	kips	ϕV_c=	146.7	kips

Transferred by Flexure

γ_f=	0.600				
$M_{ub,long}$=	24.5	ft-k	$M_{ub,short}$=	20.1	ft-k
$M_{ub,totlong}$=	92.5	ft-k	$M_{ub,totshort}$=	116.1	ft-k
$M_{col,lleft}$=	50.2	ft-k	$M_{col,sleft}$=	40.5	ft-k
$M_{col,lright}$=	35.8	ft-k	$M_{col,sright}$=	33.1	ft-k
M_{ub} < M_{col}	Need Reinforcement		M_{ub} < M_{col}	Need Reinforcement	

Description	Left Side	Right Side
Moment: M_u	42.3	56.7
Strip Width: b	45.5	45.5
Effective Depth: d	7.13	7.13
M_u x 12/b	11.2	15.0
$M_n = M_u/\phi$	47.1	63.1
R = M_n x 12000/bd^2	244.4	327.6
ρ = See Table A.5a	0.00423	0.00575
ρ_{min} = See Table A.4	0.0033	0.0033
ρ_{max} = See Table A.4	0.0206	0.0206
Check ρ_{min}	OK	OK
Check ρ_{max}	OK	OK
Use ρ	0.00423	0.00575
A_s = ρbd	1.37	1.86
$A_{s,min}$ = .0018bt	0.70	0.70
Check A_s > $A_{s,min}$	OK	OK
Use A_s	1.37	1.86
No. of Bars	5	7
Min No. of Bars	3	3
Use No. of Bars	5	7

Description	Left Side	Right Side
Moment: M_u	75.6	83.0
Strip Width: b	45.5	45.5
Effective Depth: d	7.13	7.13
M_u x 12/b	19.9	21.9
$M_n = M_u/\phi$	84.0	92.3
R = M_n x 12000/bd^2	436.5	479.4
ρ = See Table A.5a	0.00782	0.00865
ρ_{min} = See Table A.4	0.0033	0.0033
ρ_{max} = See Table A.4	0.0206	0.0206
Check ρ_{min}	OK	OK
Check ρ_{max}	OK	OK
Use ρ	0.00782	0.00865
A_s = ρbd	2.54	2.80
$A_{s,min}$ = .0018bt	0.70	0.70
Check A_s > $A_{s,min}$	OK	OK
Use A_s	2.54	2.80
No. of Bars	9	10
Min No. of Bars	3	3
Use No. of Bars	9	10

Transferred by Eccentricity of Shear

V_u=	95.3	kips			V_u=	95.3	kips		
$M_{uv,long}$=	16.4	ft-k			$M_{uv,short}$=	13.4	ft-k		
Centroid=	13.56	in			Centroid=	13.56	in		
J_c=	96434	in^4			J_c=	96434	in^4		
A_c=	773	in^2			A_c=	773	in^2		
v_l=	96	psi			v_l=	101	psi		
v_r=	151	psi			v_r=	146	psi		
v_u=	151	psi			v_u=	146	psi		
ϕv_n=	190	psi	> v_u	OK	ϕv_n=	190	psi	> v_u	OK

Exterior Column AE (Reinforcement Needed)

$t_{col,1dir}$=	20	in	b_o=	74.25	in
$t_{col,2dir}$=	20	in	b_1=	27.13	in
$M_{u,long}$=	21.5	ft-k	b_2=	23.56	in
$M_{o,short}$=	171.3	ft-k	$V_{c,1}$=	133.8	kips
$M_{u,short}$=	51.4	ft-k	$V_{c,2}$=	200.8	kips
			$V_{c,3}$=	163.2	kips
V_u=	50.1	kips	ϕV_c=	100.4	kips

Transferred by Flexure

γ_f=	0.583				
$M_{ub,long}$=	12.5	ft-k	$M_{ub,short}$=	30.0	ft-k
$M_{ub,totlong}$=	80.5	ft-k	$M_{ub,totshort}$=	126.0	ft-k
$M_{col,lleft}$=	36.1	ft-k	$M_{col,sright}$=	19.0	ft-k
$M_{col,lright}$=	25.8	ft-k	M_{ub} < M_{col}	Need Reinforcement	
M_{ub} < M_{col}	Need Reinforcement				

Description	Left Side	Right Side
Moment: M_u	44.4	54.8
Strip Width: b	32.75	32.75
Effective Depth: d	7.13	7.13
M_u x 12/b	16.3	20.1
$M_n = M_u/\phi$	49.3	60.9
$R = M_n$ x $12000/bd^2$	356.2	439.3
ρ = See Table A.5a	0.00628	0.00787
ρ_{min} = See Table A.4	0.0033	0.0033
ρ_{max} = See Table A.4	0.0206	0.0206
Check ρ_{min}	OK	OK
Check ρ_{max}	OK	OK
Use ρ	0.00628	0.00787
$A_s = \rho bd$	1.47	1.84
$A_{s,min}$ = .0018bt	0.50	0.50
Check $A_s > A_{s,min}$	OK	OK
Use A_s	1.47	1.84
No. of Bars	5	6
Min No. of Bars	2	2
Use No. of Bars	5	6

Description	Value
Moment: M_u	106.9
Strip Width: b	45.5
Effective Depth: d	7.13
M_u x 12/b	28.2
$M_n = M_u/\phi$	118.8
$R = M_n$ x $12000/bd^2$	617.2
ρ = See Table A.5a	0.01144
ρ_{min} = See Table A.4	0.0033
ρ_{max} = See Table A.4	0.0206
Check ρ_{min}	OK
Check ρ_{max}	OK
Use ρ	0.01144
$A_s = \rho bd$	3.71
$A_{s,min}$ = .0018bt	0.70
Check $A_s > A_{s,min}$	OK
Use A_s	3.71
No. of Bars	13
Min No. of Bars	3
Use No. of Bars	13

Transferred by Eccentricity of Shear

V_u=	50.1	kips				V_u=	50.1	kips			
$M_{uv,long}$=	9.0	ft-k				$M_{uv,short}$=	21.4	ft-k			
Centroid=	13.56	in				Centroid=	7.48	in			
J_c=	87096	in^4				J_c=	33980	in^4			
A_c=	529	in^2				A_c=	529	in^2			
v_l=	78	psi				v_l=	-27	psi			
v_r=	112	psi				v_r=	151	psi			
v_u=	112	psi				v_u=	151	psi			
ϕv_n=	190	psi	>	v_u	OK	ϕv_n=	190	psi	>	v_u	OK

Interior Column CF (Reinforcement Needed)

$t_{col,1dir}$=	20	in	b_o=	108.50	in
$t_{col,2dir}$=	20	in	b_1=	27.13	in
$M_{u,long}$=	25.2	ft-k	b_2=	27.13	in
$M_{u,short}$=	62.4	ft-k	$V_{c,1}$=	195.6	kips
			$V_{c,2}$=	293.4	kips
			$V_{c,3}$=	226.2	kips
V_u=	97.5	kips	ϕV_c=	146.7	kips

Transferred by Flexure

γ_f=	0.600				
$M_{ub,long}$=	15.1	ft-k	$M_{ub,short}$=	37.5	ft-k
$M_{ub,totlong}$=	83.1	ft-k	$M_{ub,totshort}$=	133.5	ft-k
$M_{col,lleft}$=	35.8	ft-k	$M_{col,sleft}$=	30.8	ft-k
M_{ub} < M_{col}	Need Reinforcement		M_{ub} < M_{col}	Need Reinforcement	

Description	Value	Description	Value
Moment: M_u	47.3	Moment: M_u	102.7
Strip Width: b	45.5	Strip Width: b	45.5
Effective Depth: d	7.13	Effective Depth: d	7.13
M_u x 12/b	12.5	M_u x 12/b	27.1
$M_n = M_u/\phi$	52.6	$M_n = M_u/\phi$	114.1
$R = M_n \times 12000/bd^2$	273.3	$R = M_n \times 12000/bd^2$	592.6
ρ = See Table A.5a	0.00476	ρ = See Table A.5a	0.01093
ρ_{min} = See Table A.4	0.0033	ρ_{min} = See Table A.4	0.0033
ρ_{max} = See Table A.4	0.0206	ρ_{max} = See Table A.4	0.0206
Check ρ_{min}	OK	Check ρ_{min}	OK
Check ρ_{max}	OK	Check ρ_{max}	OK
Use ρ	0.00476	Use ρ	0.01093
A_s = ρbd	1.54	A_s = ρbd	3.54
$A_{s,min}$ = .0018bt	0.70	$A_{s,min}$ = .0018bt	0.70
Check $A_s > A_{s,min}$	OK	Check $A_s > A_{s,min}$	OK
Use A_s	1.54	Use A_s	3.54
No. of Bars	6	No. of Bars	12
Min No. of Bars	3	Min No. of Bars	3
Use No. of Bars	6	Use No. of Bars	12

Transferred by Eccentricity of Shear

V_u=	97.5	kips	V_u=	97.5	kips
M_{uv}=	10.1	ft-k	M_{uv}=	25.0	ft-k
Centroid=	13.56	in	Centroid=	13.56	in
J_c=	96434	in^4	J_c=	96434	in^4
A_c=	773	in^2	A_c=	773	in^2
ν_l=	109	psi	ν_l=	84	psi
ν_r=	143	psi	ν_r=	168	psi
ν_u=	143	psi	ν_u=	168	psi
$\phi\nu_n$=	190	psi	$\phi\nu_n$=	190	psi
$\phi\nu_n$ > ν_u	OK		$\phi\nu_n$ > ν_u	OK	

Interior Column BF (Reinforcement Needed)

$t_{col,1dir}$=	20	in	b_o=	108.50	in
$t_{col,2dir}$=	20	in	b_1=	27.13	in
$M_{u,long}$=	23.0	ft-k	b_2=	27.13	in
$M_{u,short}$=	31.2	ft-k	$V_{c,1}$=	195.6	kips
			$V_{c,2}$=	293.4	kips
			$V_{c,3}$=	226.2	kips
V_u=	88.8	kips	ϕV_c=	146.7	kips

Transferred by Flexure

γ_f=	0.600				
$M_{ub,long}$=	13.8	ft-k	$M_{ub,short}$=	18.7	ft-k
$M_{ub,totlong}$=	81.8	ft-k	$M_{ub,totshort}$=	114.7	ft-k
$M_{col,lleft}$=	35.8	ft-k	$M_{col,sleft}$=	37.9	ft-k
M_{ub} < M_{col}	Need Reinforcement		$M_{col,sright}$=	30.8	ft-k
			M_{ub} < M_{col}	Need Reinforcement	

Description	Left Side
Moment: M_u	46.0
Strip Width: b	45.5
Effective Depth: d	7.13
M_u x 12/b	12.1
$M_n = M_u/\phi$	51.1
$R = M_n \times 12000/bd^2$	265.4
ρ = See Table A.5a	0.00461
ρ_{min} = See Table A.4	0.0033
ρ_{max} = See Table A.4	0.0206
Check ρ_{min}	OK
Check ρ_{max}	OK
Use ρ	0.00461
$A_s = \rho bd$	1.49
$A_{s,min}$ = .0018bt	0.70
Check $A_s > A_{s,min}$	OK
Use A_s	1.49
No. of Bars	5
Min No. of Bars	3
Use No. of Bars	5

Description	Left Side	Right Side
Moment: M_u	76.8	83.9
Strip Width: b	45.5	45.5
Effective Depth: d	7.13	7.13
M_u x 12/b	20.3	22.1
$M_n = M_u/\phi$	85.4	93.3
$R = M_n \times 12000/bd^2$	443.5	484.5
ρ = See Table A.5a	0.00795	0.00875
ρ_{min} = See Table A.4	0.0033	0.0033
ρ_{max} = See Table A.4	0.0206	0.0206
Check ρ_{min}	OK	OK
Check ρ_{max}	OK	OK
Use ρ	0.00795	0.00875
$A_s = \rho bd$	2.58	2.84
$A_{s,min}$ = .0018bt	0.70	0.70
Check $A_s > A_{s,min}$	OK	OK
Use A_s	2.58	2.84
No. of Bars	9	10
Min No. of Bars	3	3
Use No. of Bars	9	10

Transferred by Eccentricity of Shear

V_u=	88.8	kips			V_u=	88.8	kips		
$M_{uv,long}$=	9.2	ft-k			$M_{uv,short}$=	12.5	ft-k		
Centroid=	13.56	in			Centroid=	13.56	in		
J_c=	96434	in^4			J_c=	96434	in^4		
A_c=	773	in^2			A_c=	773	in^2		
v_l=	99	psi			v_l=	94	psi		
v_r=	130	psi			v_r=	136	psi		
v_u=	130	psi			v_u=	136	psi		
ϕv_n=	190	psi > v_u		OK	ϕv_n=	190	psi > v_u		OK

Exterior Column AF (Reinforcement Needed)

$t_{col,1dir}$=	20	in	b_o=	74.25	in
$t_{col,2dir}$=	20	in	b_1=	27.13	in
$M_{u,long}$=	12.1	ft-k	b_2=	23.56	in
$M_{o,short}$=	159.5	ft-k	V_{c1}=	133.8	kips
$M_{u,short}$=	47.8	ft-k	V_{c2}=	200.8	kips
			V_{c3}=	163.2	kips
V_u=	46.7	kips	ϕV_c=	100.4	kips

Transferred by Flexure

γ_f=	0.583				
$M_{ub,long}$=	7.0	ft-k	$M_{ub,short}$=	27.9	ft-k
$M_{ub,totlong}$=	75.0	ft-k	$M_{ub,totshort}$=	123.9	ft-k
$M_{col,lleft}$=	25.8	ft-k	$M_{col,sright}$=	17.8	ft-k
M_{ub} < M_{col}	Need Reinforcement		M_{ub} < M_{col}	Need Reinforcement	

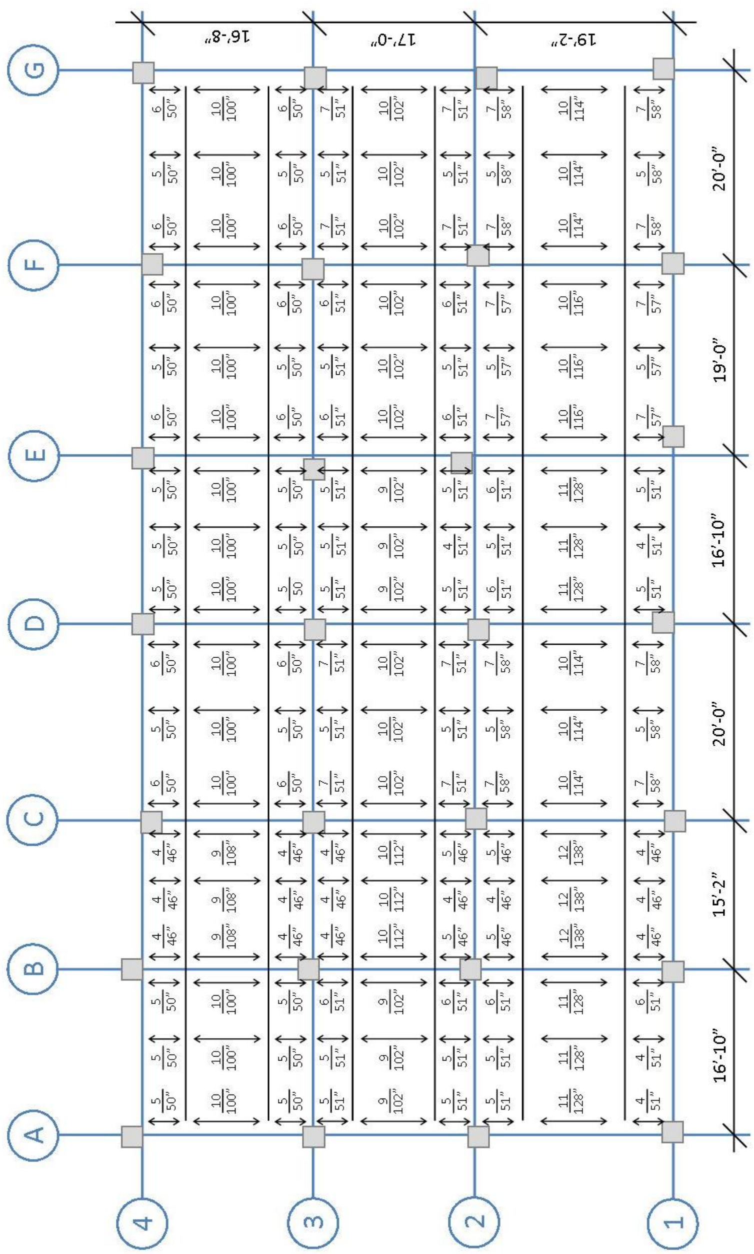
Description	Left Side	Description	Value
Moment: M_u	49.3	Moment: M_u	106.1
Strip Width: b	32.75	Strip Width: b	45.5
Effective Depth: d	7.13	Effective Depth: d	7.13
M_u x 12/b	18.1	M_u x 12/b	28.0
$M_n = M_u/\phi$	54.8	$M_n = M_u/\phi$	117.9
$R = M_n$ x $12000/bd^2$	395.2	$R = M_n$ x $12000/bd^2$	612.5
ρ = See Table A.5a	0.007	ρ = See Table A.5a	0.01134
ρ_{min} = See Table A.4	0.0033	ρ_{min} = See Table A.4	0.0033
ρ_{max} = See Table A.4	0.0206	ρ_{max} = See Table A.4	0.0206
Check ρ_{min}	OK	Check ρ_{min}	OK
Check ρ_{max}	OK	Check ρ_{max}	OK
Use ρ	0.007	Use ρ	0.01134
$A_s = \rho bd$	1.63	$A_s = \rho bd$	3.68
$A_{s,min}$ = .0018bt	0.50	$A_{s,min}$ = .0018bt	0.70
Check $A_s > A_{s,min}$	OK	Check $A_s > A_{s,min}$	OK
Use A_s	1.63	Use A_s	3.68
No. of Bars	6	No. of Bars	12
Min No. of Bars	2	Min No. of Bars	3
Use No. of Bars	6	Use No. of Bars	12

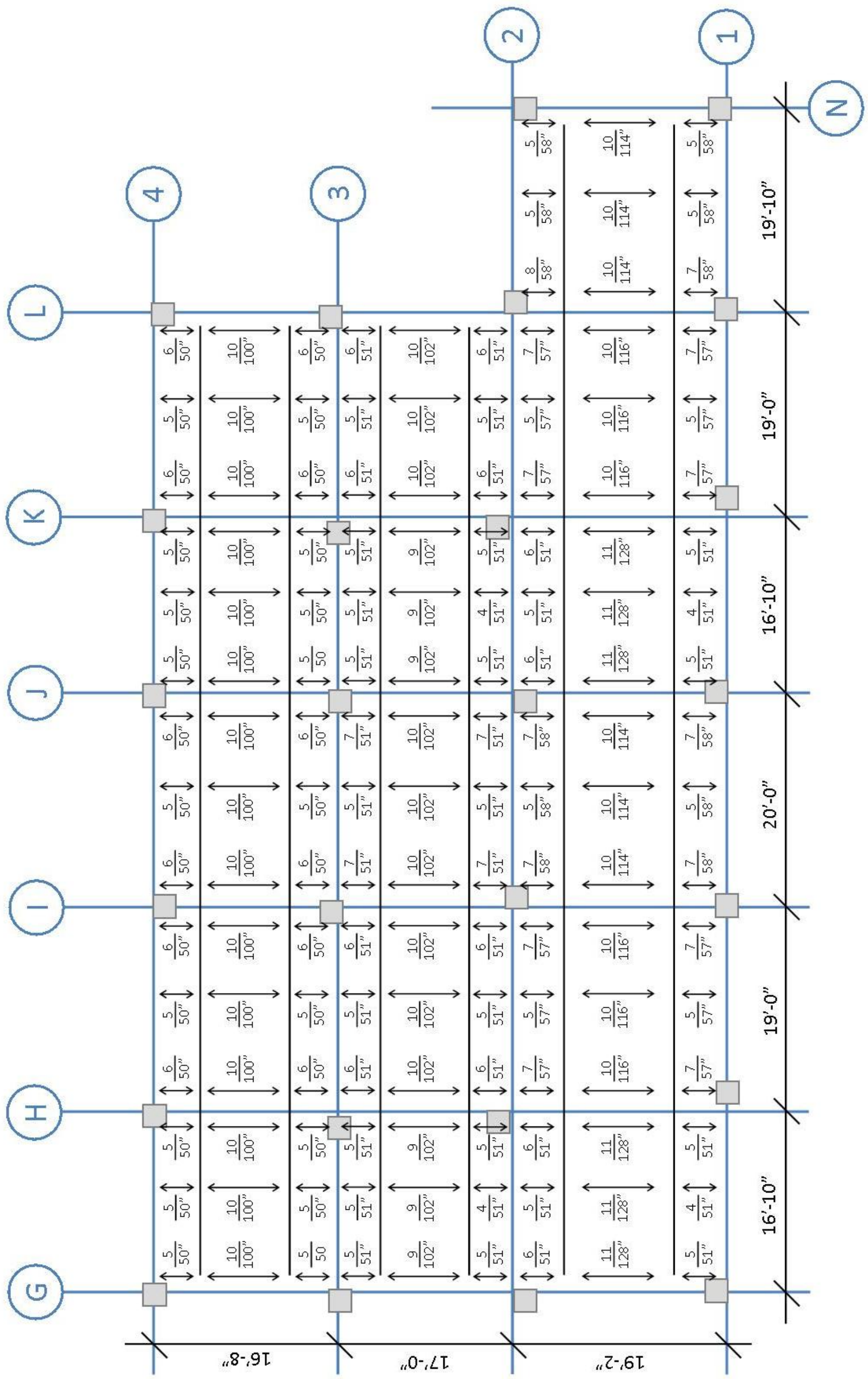
Transferred by Eccentricity of Shear

V_u=	46.7	kips	V_u=	46.7	kips
$M_{uv,long}$=	5.0	ft-k	$M_{uv,short}$=	20.0	ft-k
Centroid=	13.56	in	Centroid=	7.48	in
J_c=	87096	in^4	J_c=	33980	in^4
A_c=	529	in^2	A_c=	529	in^2
ν_l=	79	psi	ν_l=	-25	psi
ν_r=	98	psi	ν_r=	141	psi
ν_u=	98	psi	ν_u=	141	psi
$\phi\nu_n$=	190	psi	$\phi\nu_n$=	190	psi
$\phi\nu_n$ > ν_u	OK		$\phi\nu_n$ > ν_u	OK	

Appendix H: Gravity System Reinf

Second Floor

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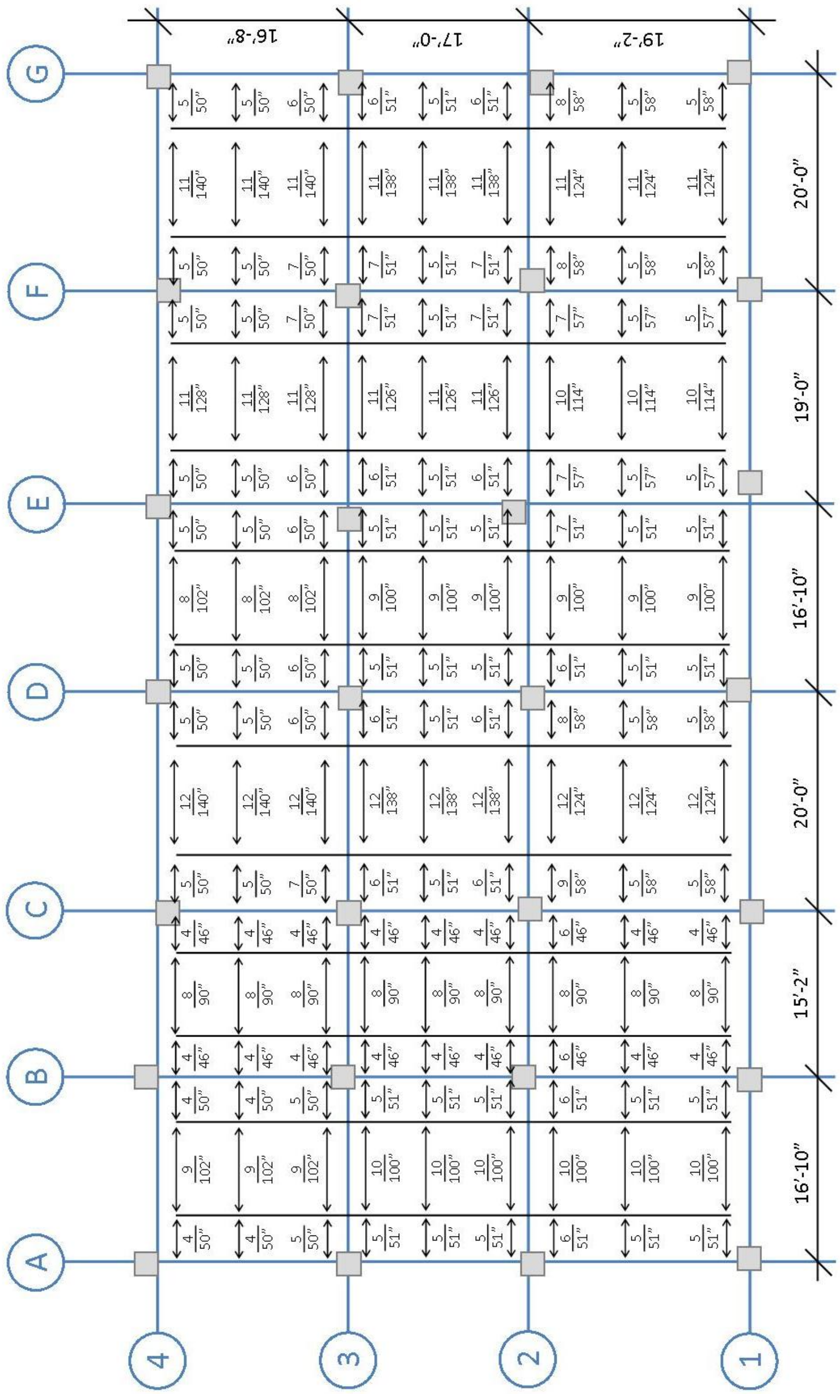
20'-0"
19'-0"
16'-10"
16'-8"
17'-0"
19'-2"


16'-8"
17'-0"
19'-2"
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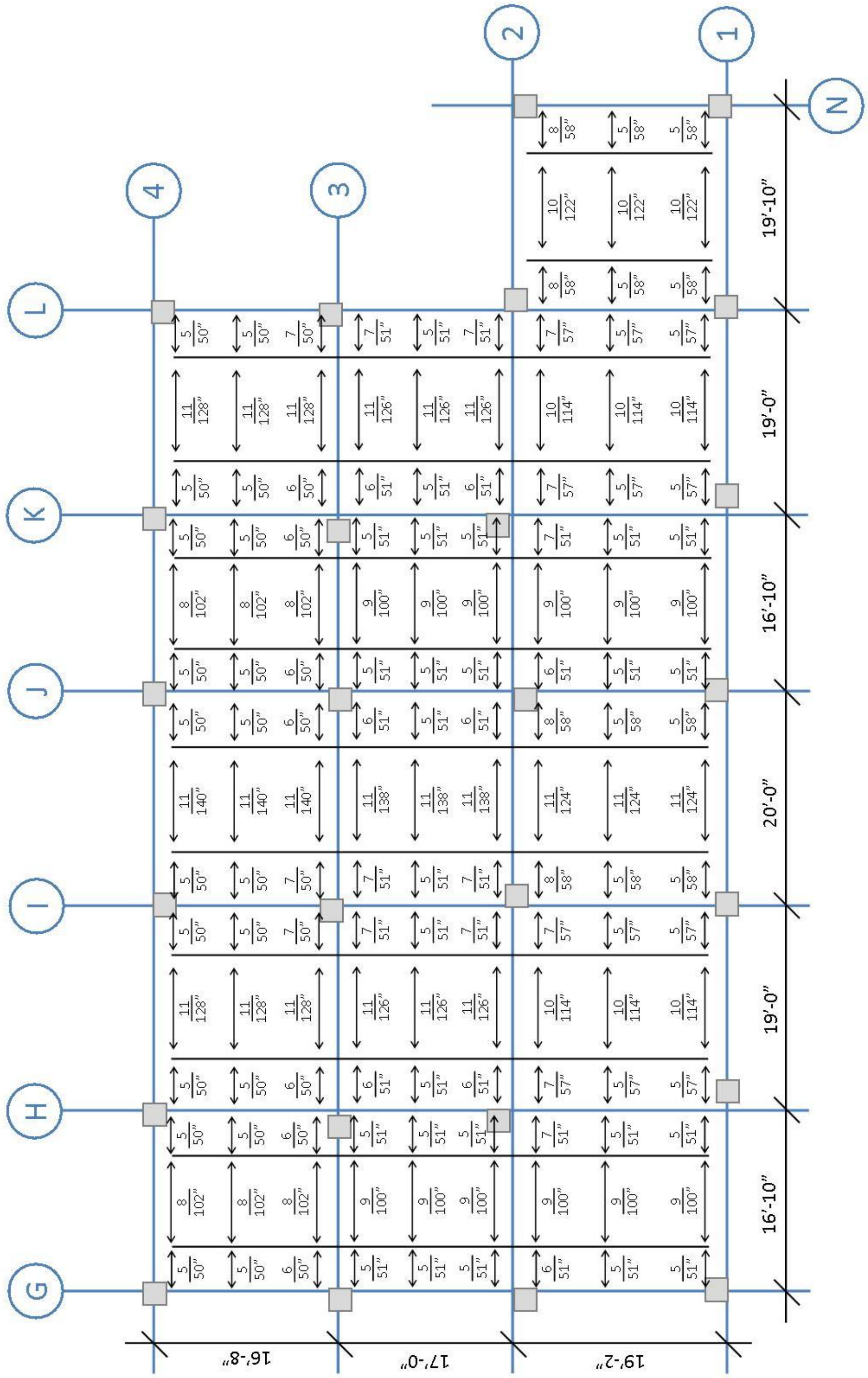
20'-0"
19'-0"
16'-10"
20'-0"
15'-2"
16'-10"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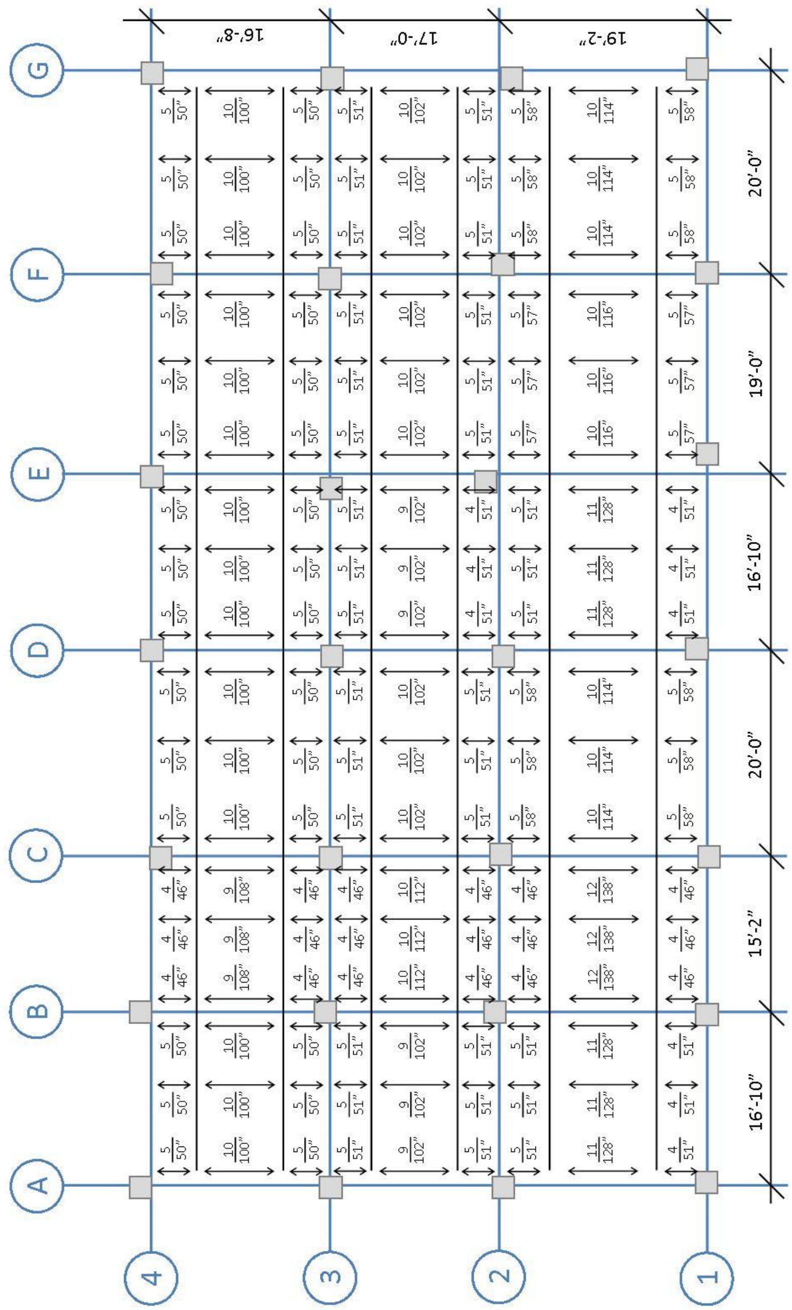
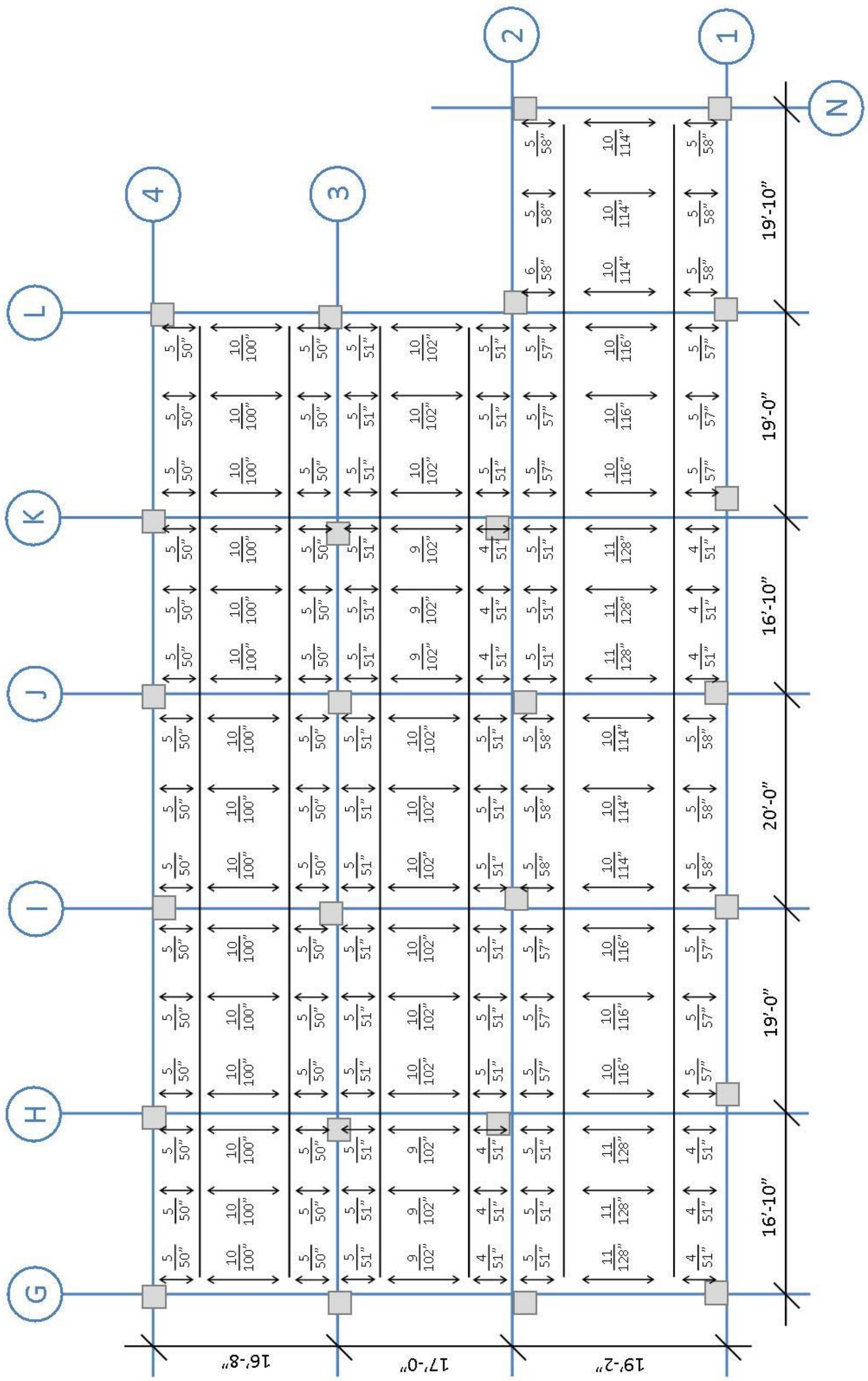
19'-0"
16'-10"
16'-8"
17'-0"
19'-2"

Third Floor





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16'-10"
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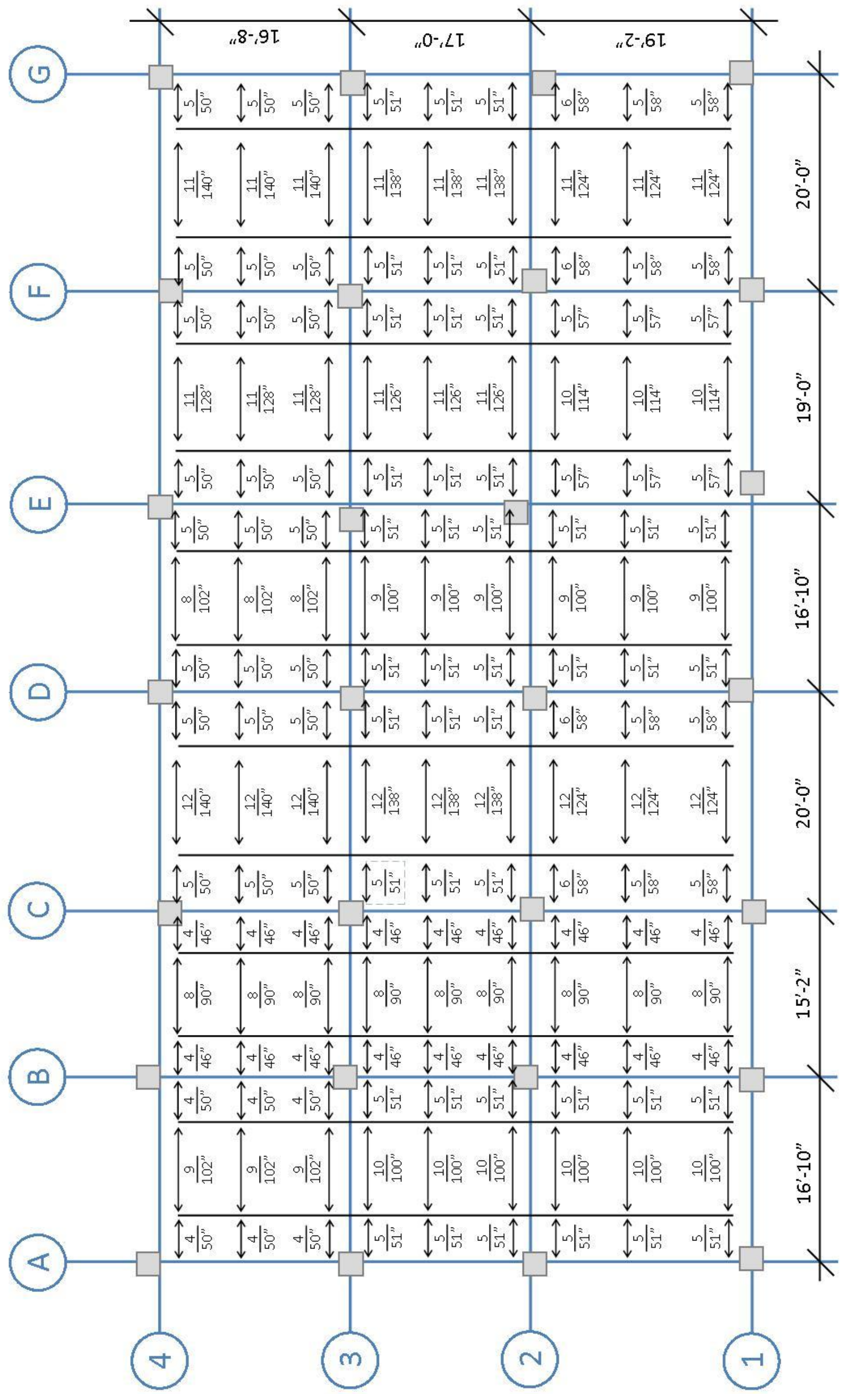
17'-0"
19'-2"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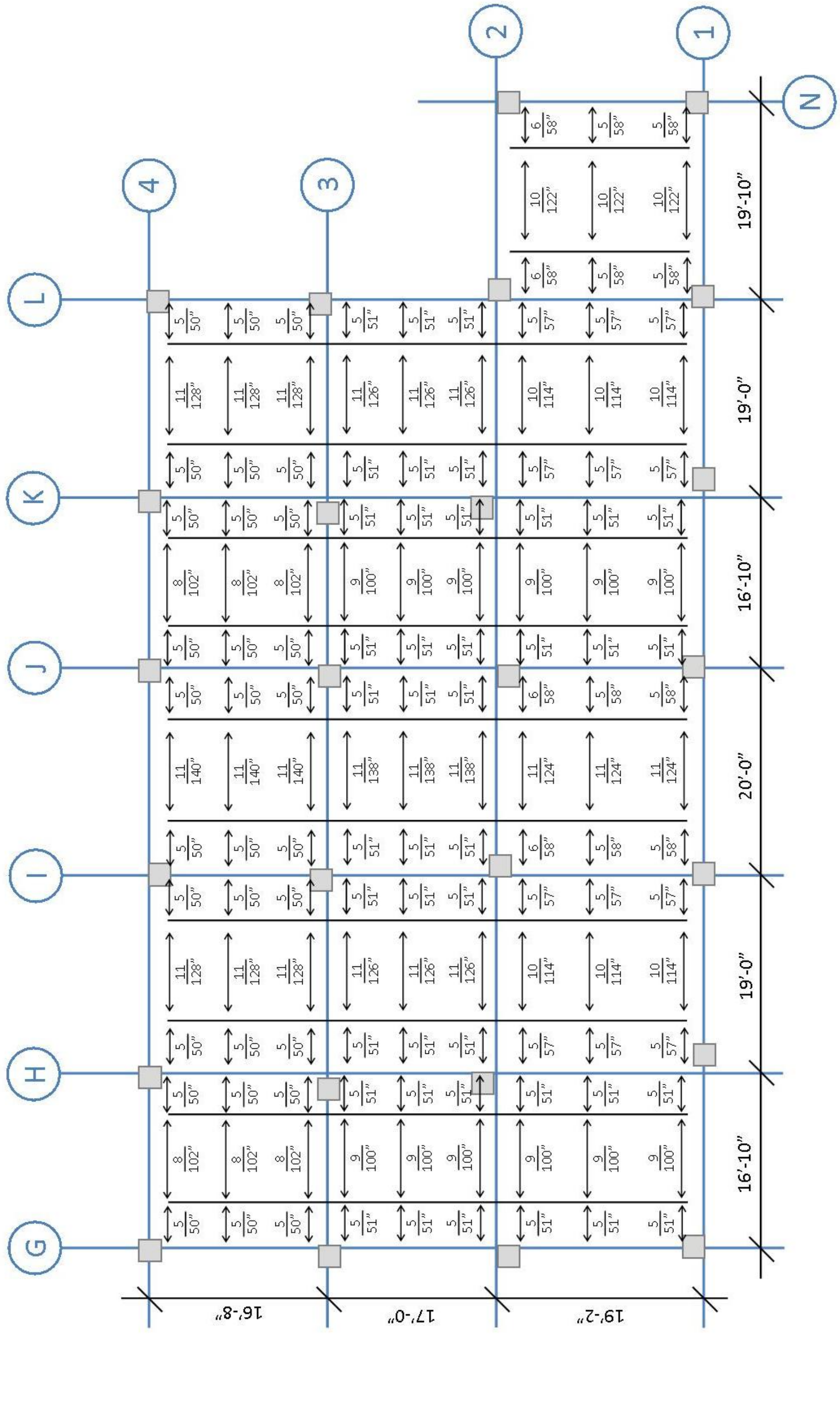
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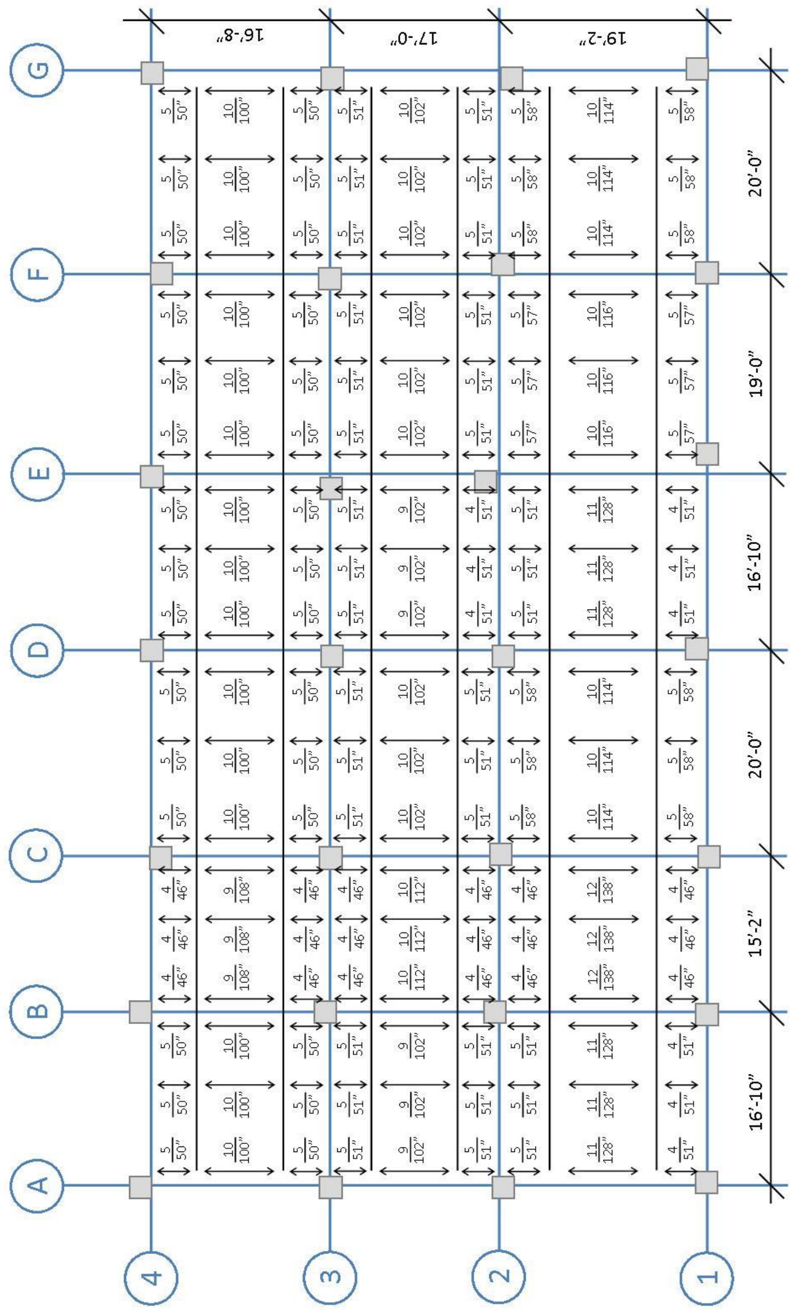
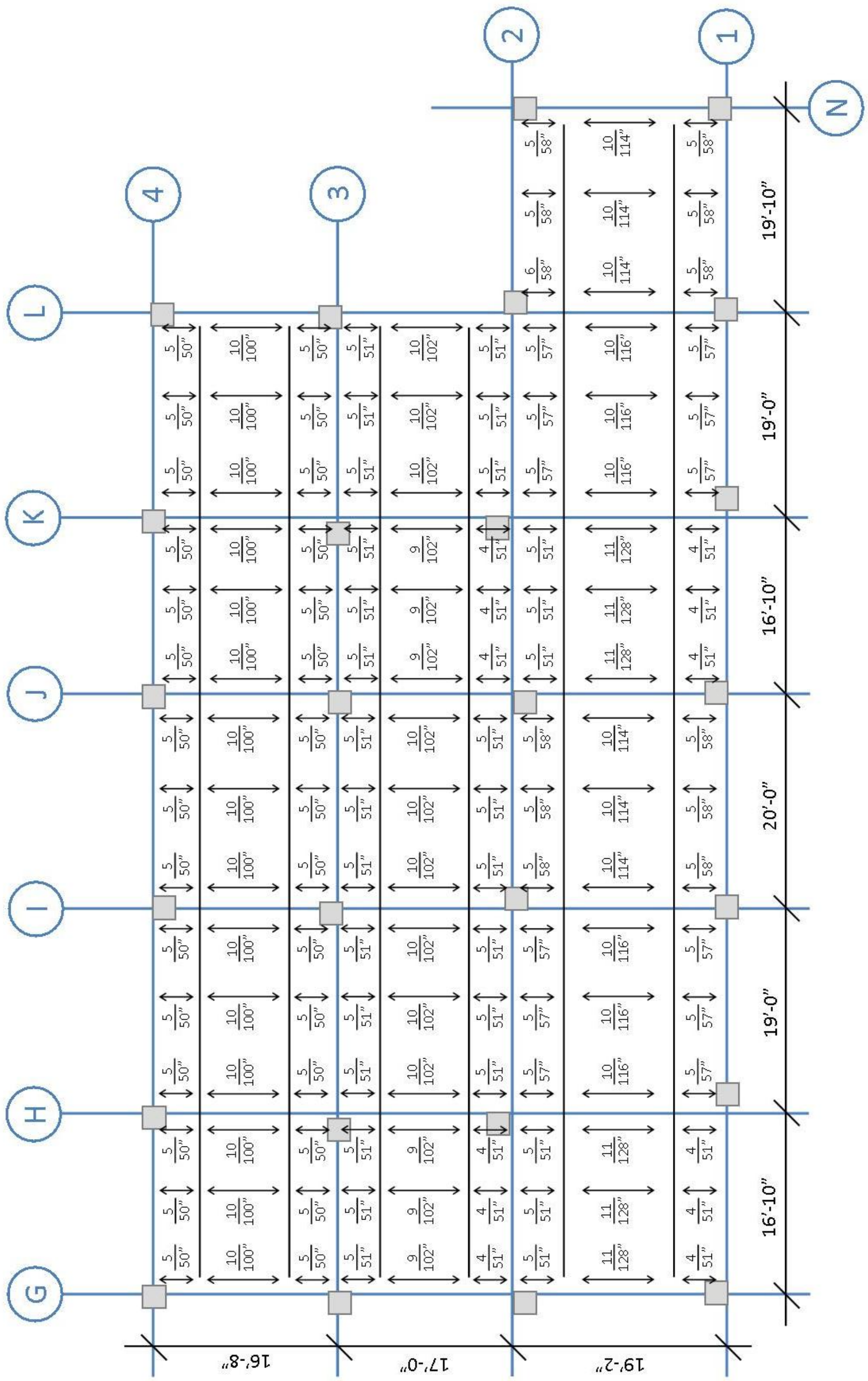
19'-2"

Fourth Floor





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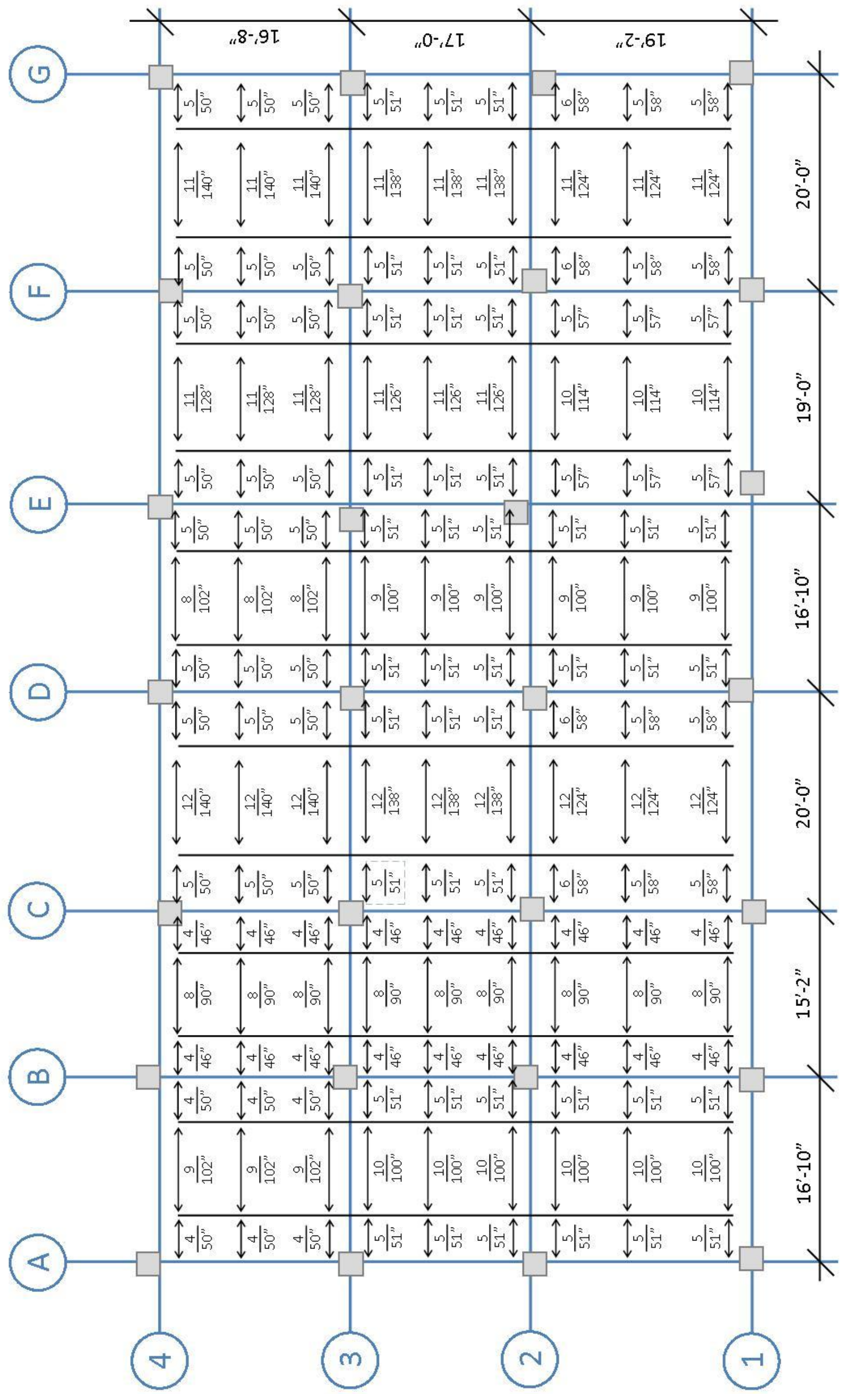
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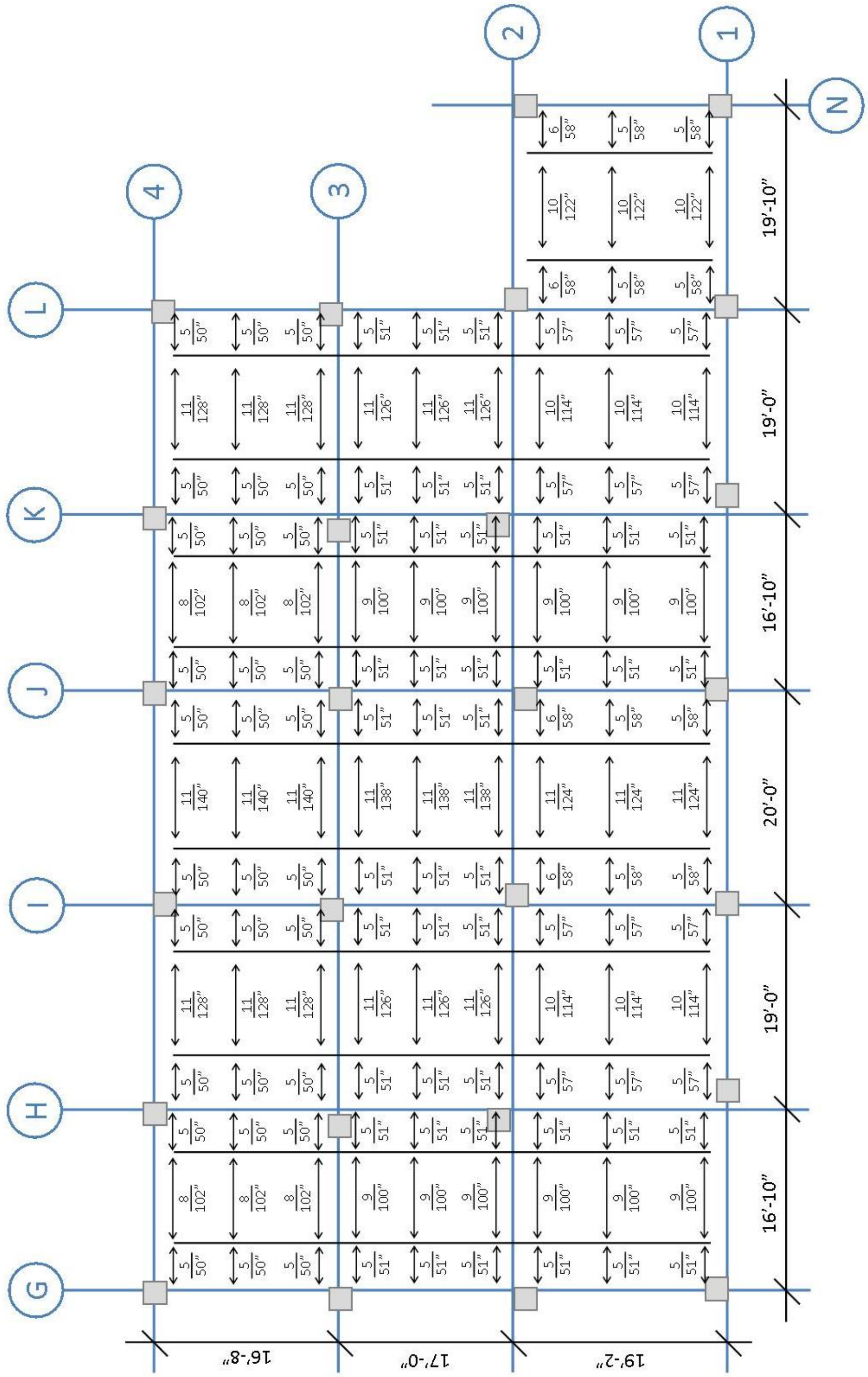

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19'-10"
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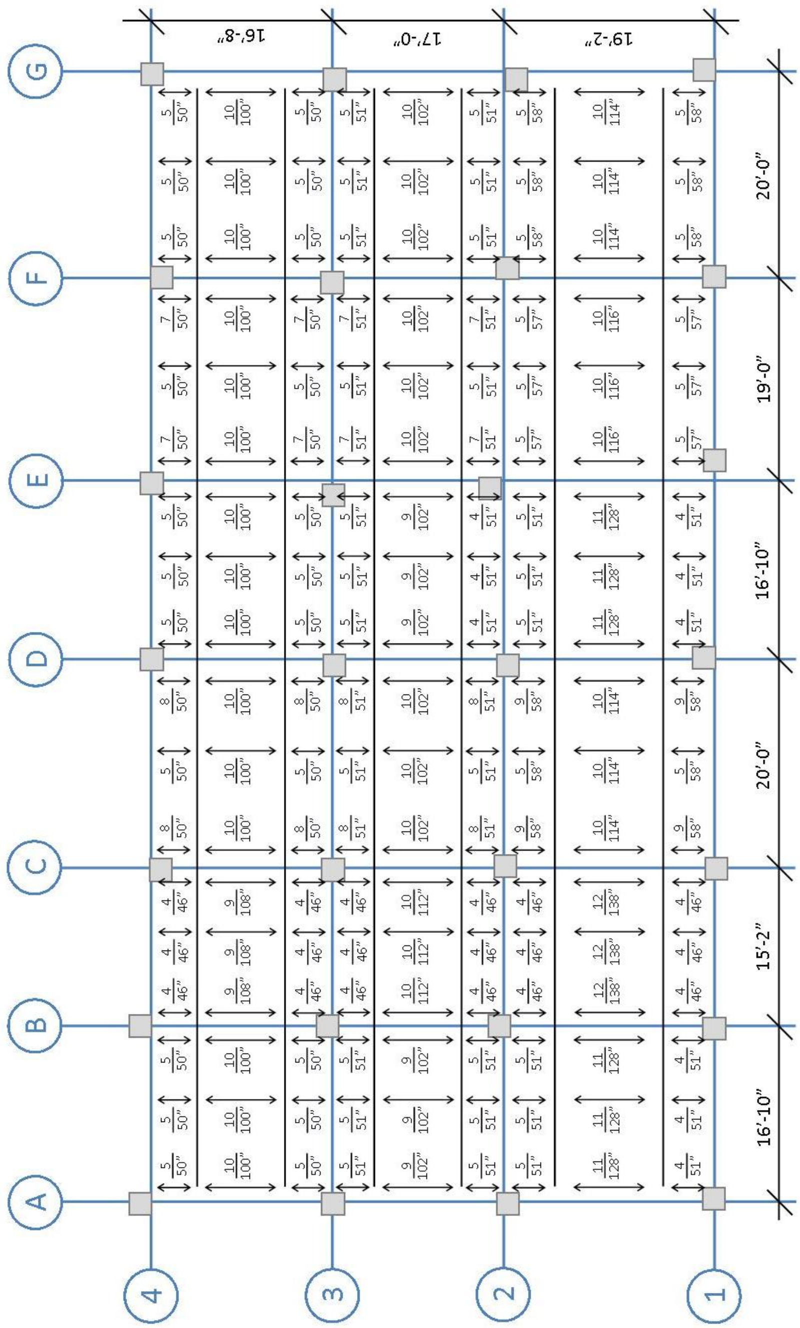
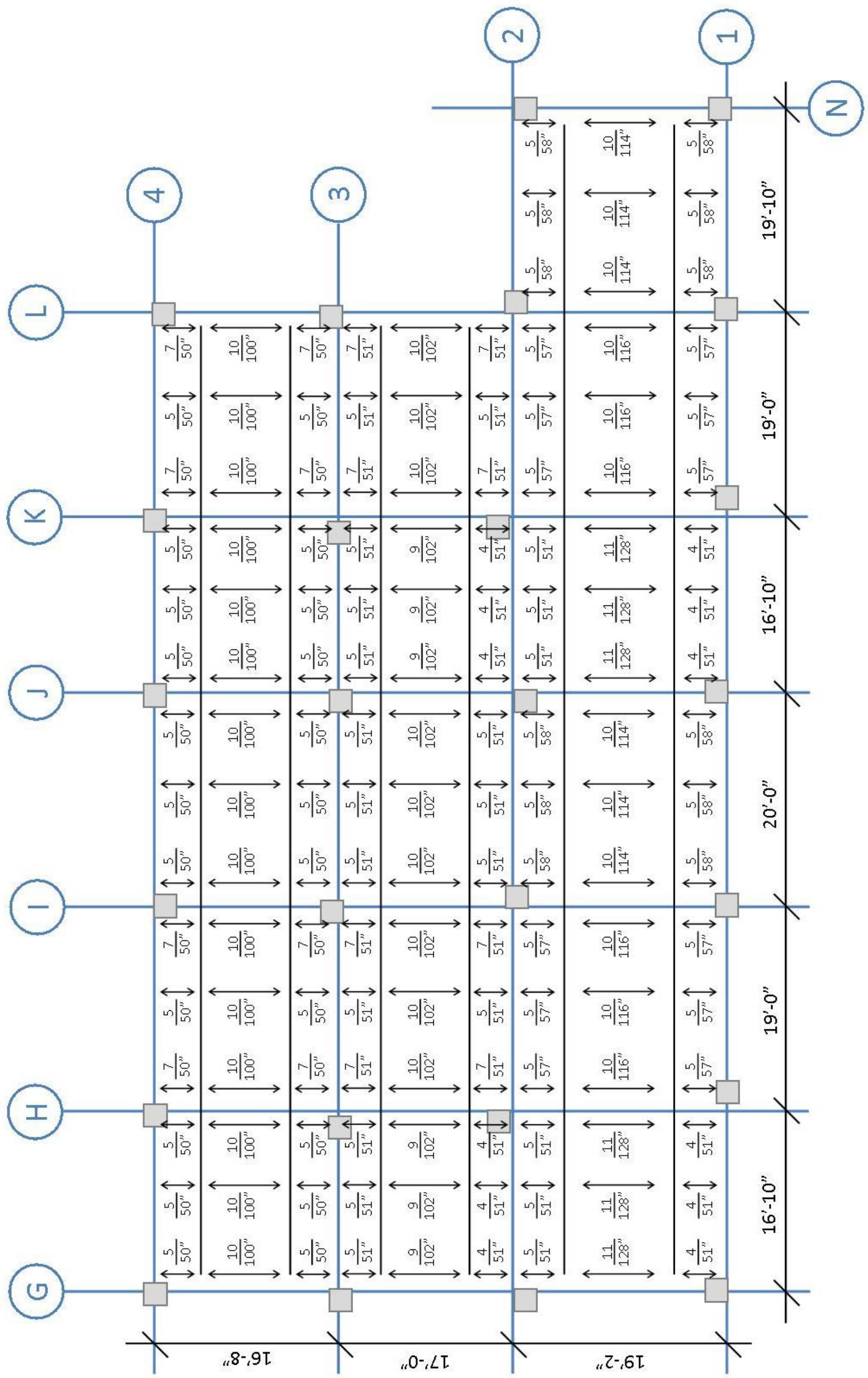
20'-0"
19'-0"
16'-10"
16'-8"
17'-0"
19'-2"

Mechanical Penthouse

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16'-10"
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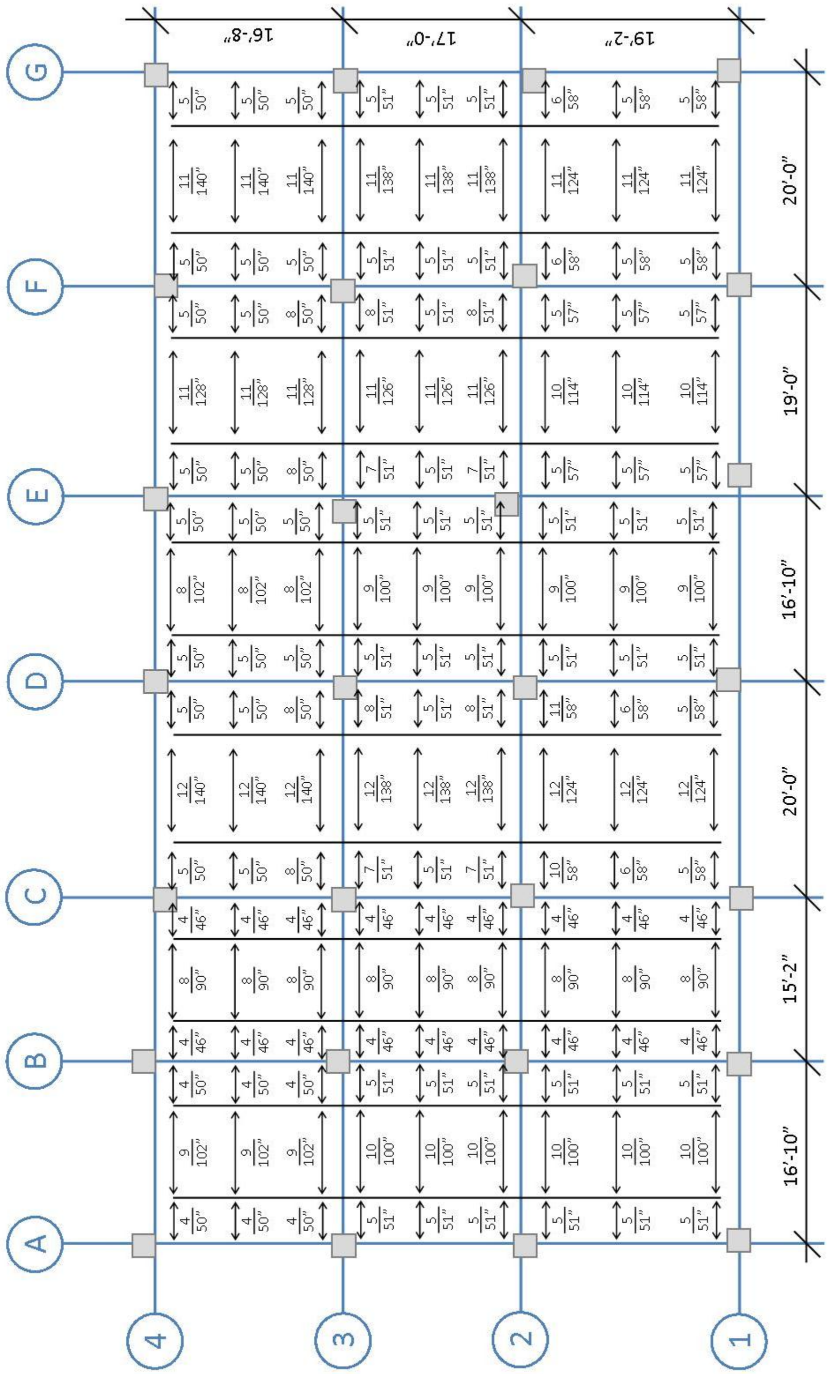
19'-2"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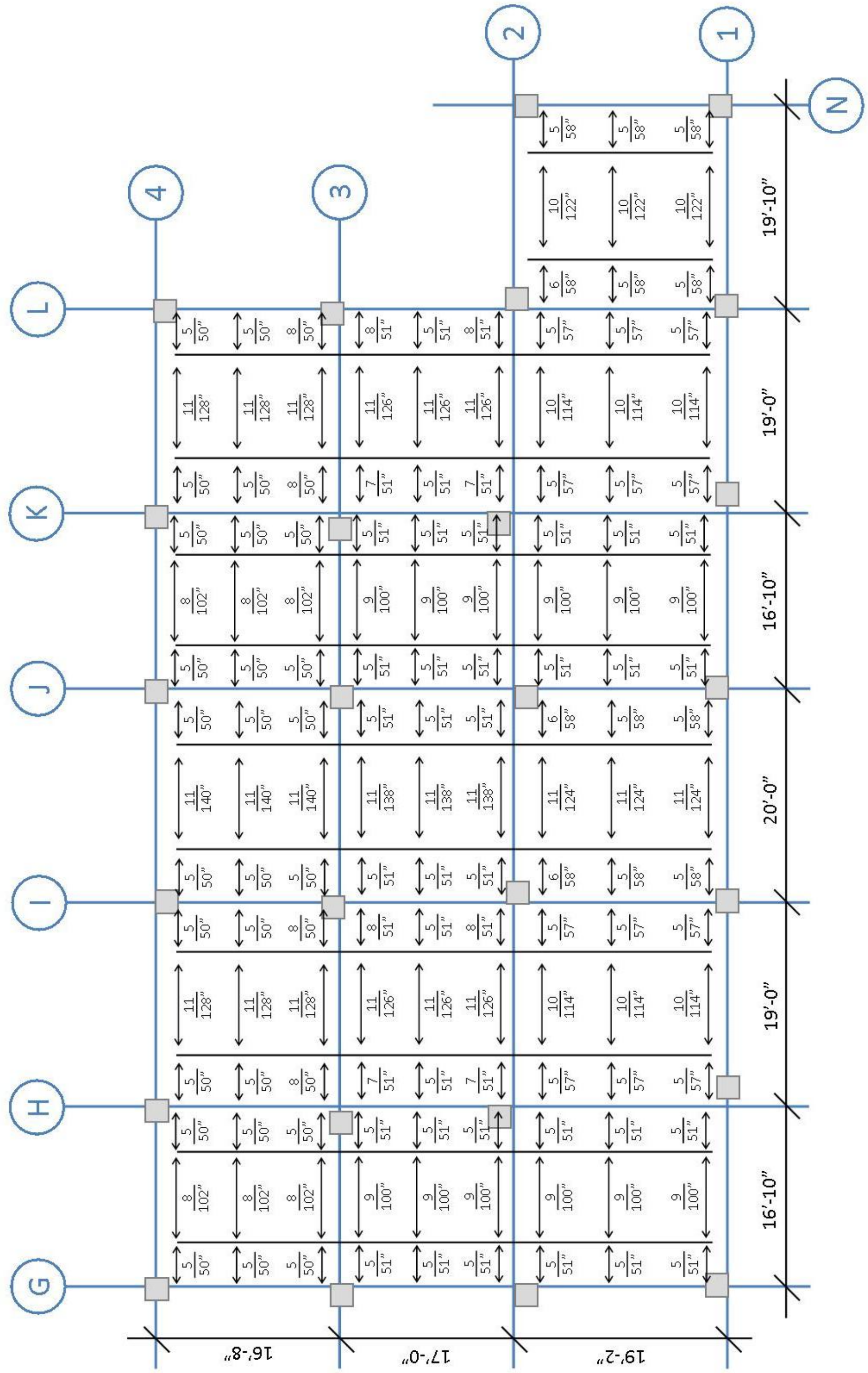
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19'-10"
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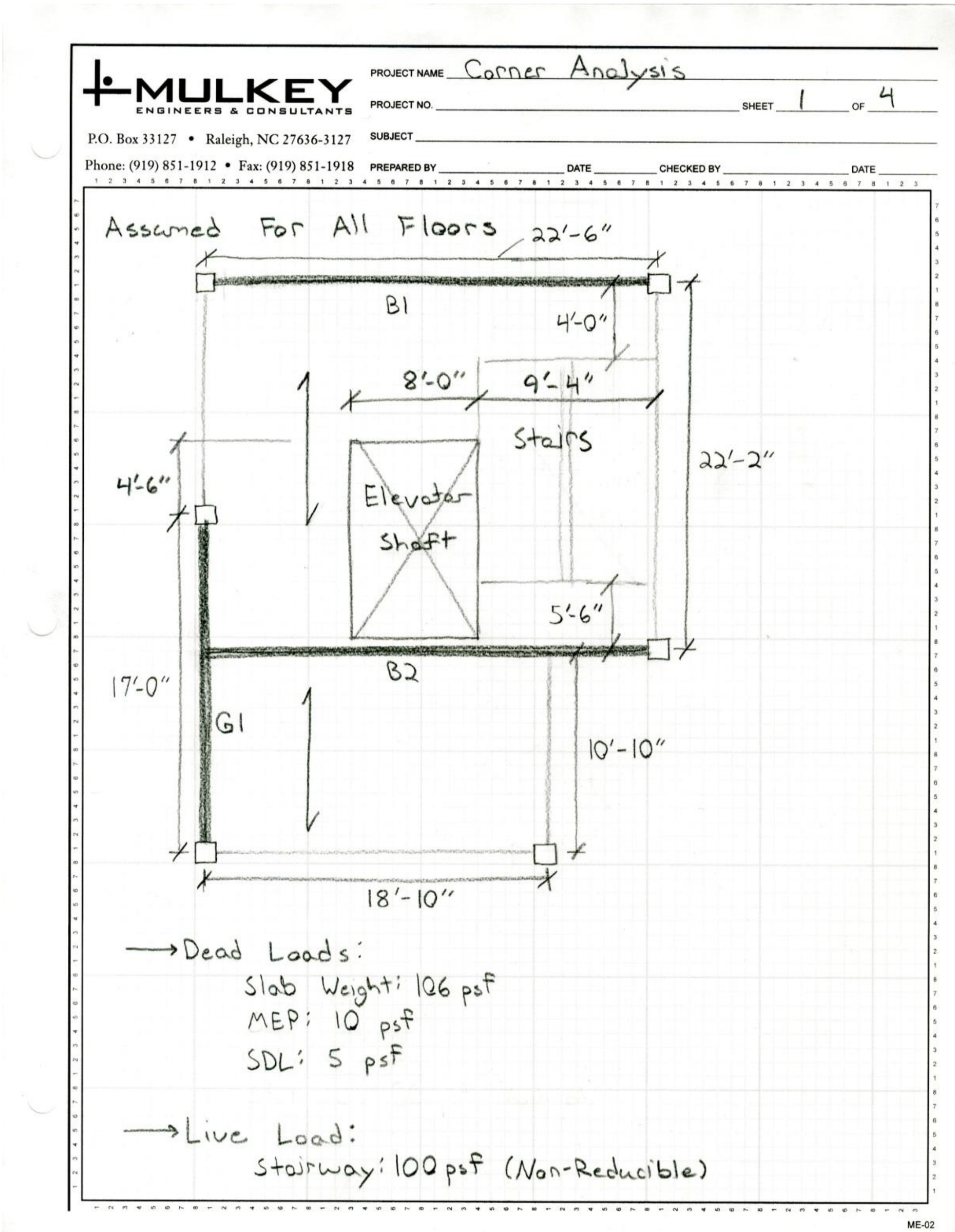
19'-0"
16'-10"
16'-8"
17'-0"
19'-2"

Appendix I: Stairwell Corner Analysis


MULKEY ENGINEERS & CONSULTANTS
P.O. Box 33127 • Raleigh, NC 27636-3127
Phone: (919) 851-1912 • Fax: (919) 851-1918

PROJECT NAME Corner Analysis
PROJECT NO. SHEET 1 OF 4
SUBJECT
PREPARED BY DATE CHECKED BY DATE

Assumed For All Floors

→ Dead Loads:
Slab Weight: 106 psf
MEP: 10 psf
SDL: 5 psf

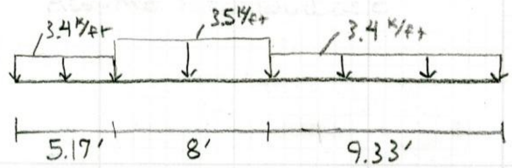
→ Live Load:
Stairway: 100 psf (Non-Reducible)

ME-02

MULKEY ENGINEERS & CONSULTANTS
P.O. Box 33127 • Raleigh, NC 27636-3127
Phone: (919) 851-1912 • Fax: (919) 851-1918

PROJECT NAME Corner Analysis
PROJECT NO. SHEET 2 OF 4
SUBJECT
PREPARED BY DATE CHECKED BY DATE

→ Beam B1



$w_D = 1.34$ k/ft = 1.39 k/ft = 1.34 k/ft
$w_L = 1.11$ k/ft = 1.15 k/ft = 1.11 k/ft
$w_t = 1.2w_D + 1.6w_L$
= 3.4 k/ft = 3.5 k/ft = 3.4 k/ft
└ use worst case to design beam

$$M_u = \frac{w_u \ell_n^2}{8} = \frac{3.5(22.5-1.67)^2}{8} \times 1.1 = 209 \text{ k-ft}$$

└ self wt estimate of 10%

Estimate size: $bd^2 = 20M_u$, Try $b = \frac{4}{5}d$

$d^3 = 20(209)(5/4)$
→ $d = 17.3''$
$h = d + 2.5$ use $h = 20''$ $b = 14''$
$bd^2 = 4288 \text{ in}^3$

Self Wt Effects:

$$w_{sw} = \frac{14(20)}{144} \times 150 = 291.7 \text{ plf}$$

$w_u = 3500 + 1.2(292) = 3850$ plf
$M_u = 3.85 \times 20.83^2/8 = 209$ k-ft
$20 \times 209 = 4180 < 4288$ ✓ ok

Required steel
$A_s = \frac{M_u}{4d} = \frac{209}{4(17.5)}$
$= 3.0 \text{ in}^2$
Use (3)#4

Use b=14", h=20" with (3)#9

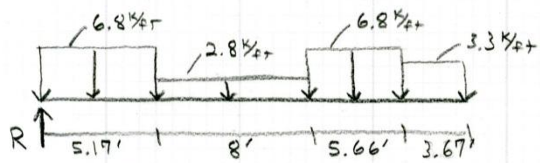
ME-02

MULKEY ENGINEERS & CONSULTANTS
P.O. Box 33127 • Raleigh, NC 27636-3127
Phone: (919) 851-1912 • Fax: (919) 851-1918

PROJECT NAME Corner Analysis
PROJECT NO. SHEET 3 OF 4
SUBJECT
PREPARED BY DATE CHECKED BY DATE

→ Beam B2

For Girder G1:
From ΣM=0, R = 56.5^k



w_D = 2.7 k/ft = 1.3 k/ft = 2.7 k/ft = 1.3 k/ft
w_L = 2.2 k/ft = 1.1 k/ft = 2.2 k/ft = 1.1 k/ft
w_T = 6.8 k/ft = 2.8 k/ft = 6.8 k/ft = 3.3 k/ft
↳ use worst case to design beam

$M_u = \frac{w_u l_n^2}{8} = \frac{6.8(22.5-1.67)^2}{8} \times 1.1 = 406$ k-ft

Estimate size
$d^3 = 20(406)(5/4)$ $h = d + 2.5$
→ $d = 21.7''$
Use $h = 25''$, $b = 18''$ $bd^2 = 4113$ in^3

Self Wt Effects:
$w_{sw} = \frac{18(25)}{144} \times 150 = 464$ plf

$w_u = 6800 + 1.2(469) = 7363$ plf
$M_u = \frac{7.363(20.83^2)}{8} = 399$ k-ft
$20 \times 399 = 7980 < 9113$ ✓ok

Required Steel
$A_s = \frac{M_u}{4d} = \frac{399}{4(22.5)} = 4.433$ use (5) #9

Use b=18", h=25" with (5) #9

ME-02

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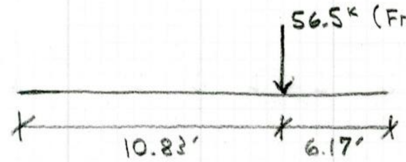
PROJECT NAME Corner Analysis
PROJECT NO. ______ SHEET 4 OF 4
SUBJECT ______
PREPARED BY ______ DATE ______ CHECKED BY ______ DATE ______

→ Girder G1



$$M_u = \frac{Pab}{l} = \frac{56.5(6.17-\frac{1.67}{2})(10.83-\frac{1.67}{2})}{(17-1.67)}$$

$$= 196.5^{k\text{-}ft} \times 1.1 = 216^{k\text{-}ft}$$

Estimate size

$bd^2 = 20 M_u$

└ use same d as B2

$b(22.5)^2 = 20(216) \rightarrow b = 8.533$

use b = 12" for cover reasons

$bd^2 = 6075\ in^3$

Self Wt Effects:

$$w_{sw} = \frac{12(25)}{144} \times 150 = 313\ plf$$

$$M_u = 216 + \frac{1.2(.313)(17-1.67)^2}{8}$$

$= 227^{k\text{-}ft}$ $\quad 20 \times 227 = 4540 < 6075$

✓ok

Required Steel

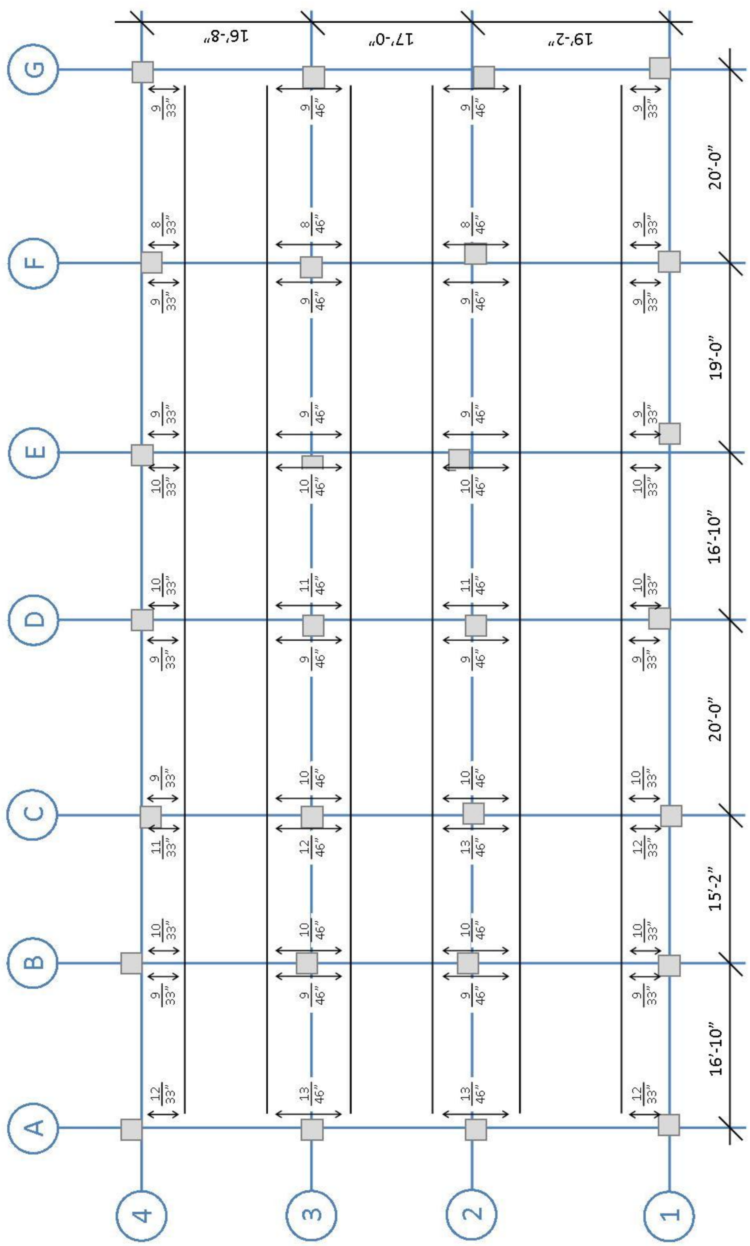
$$A_s = \frac{M_u}{4d} = \frac{227}{4(22.5)} = 2.52 \quad \text{use (3) \#9}$$

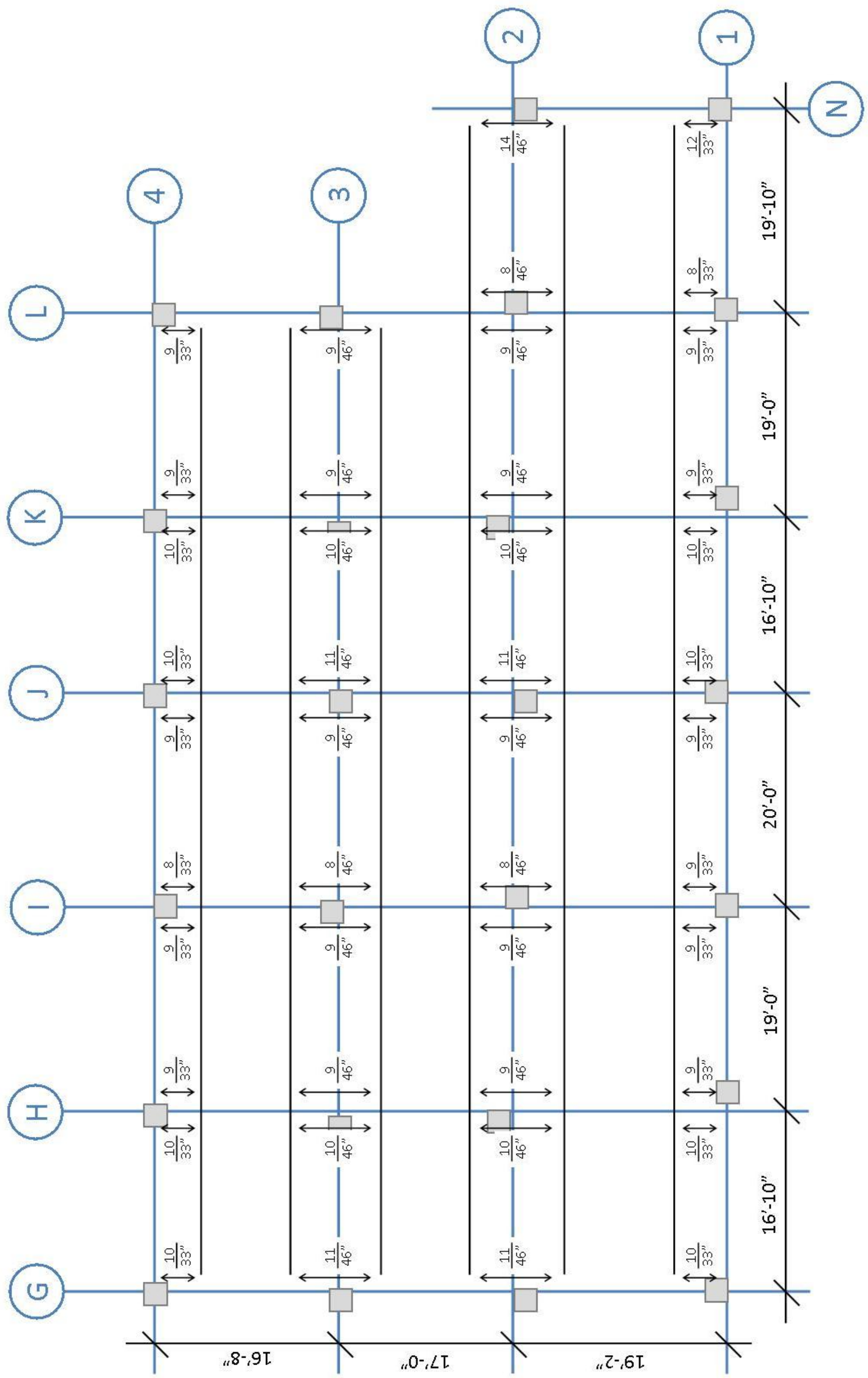
Use b = 12", h = 25" with (3) #9

ME-02

Appendix J: Lateral System Reinf

Second Floor




1
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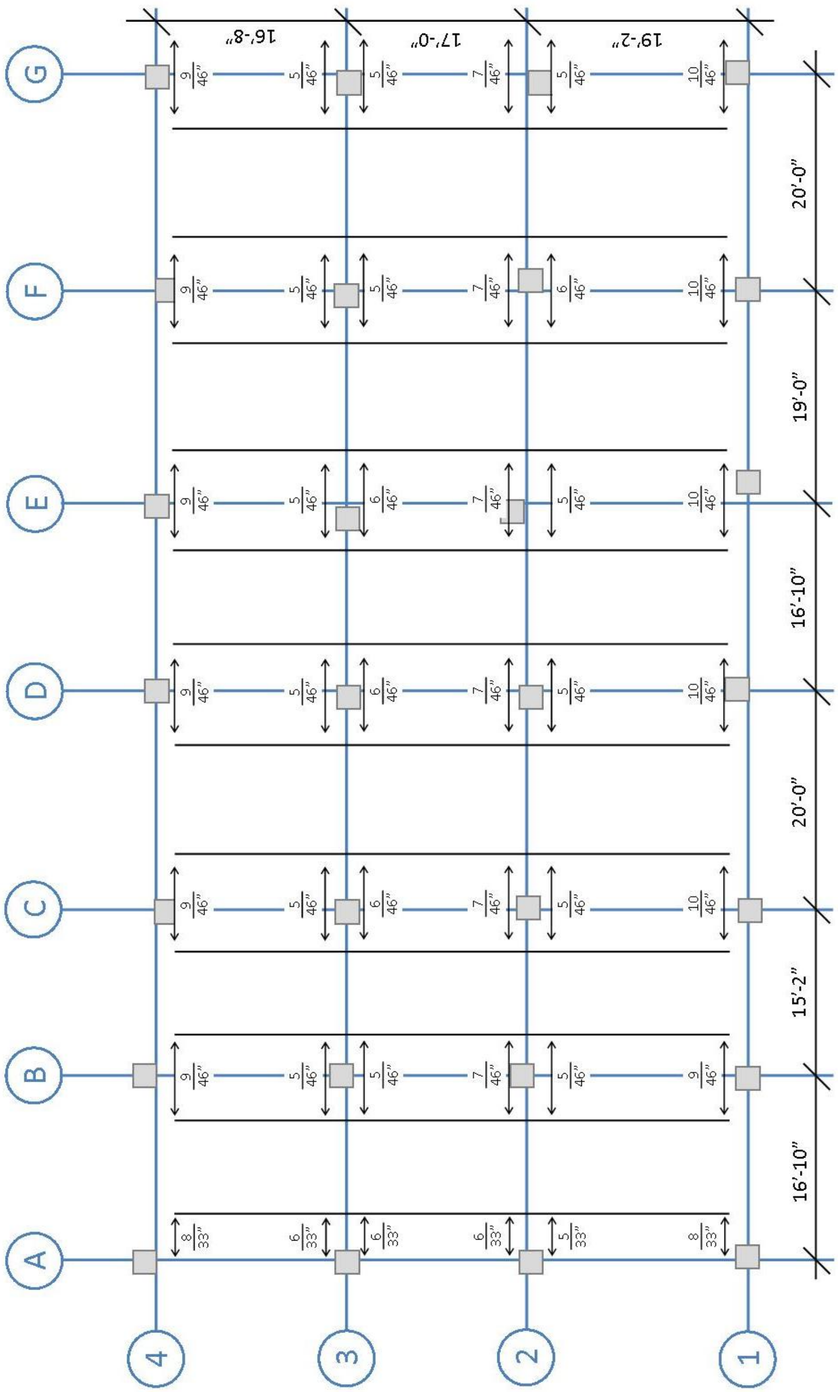
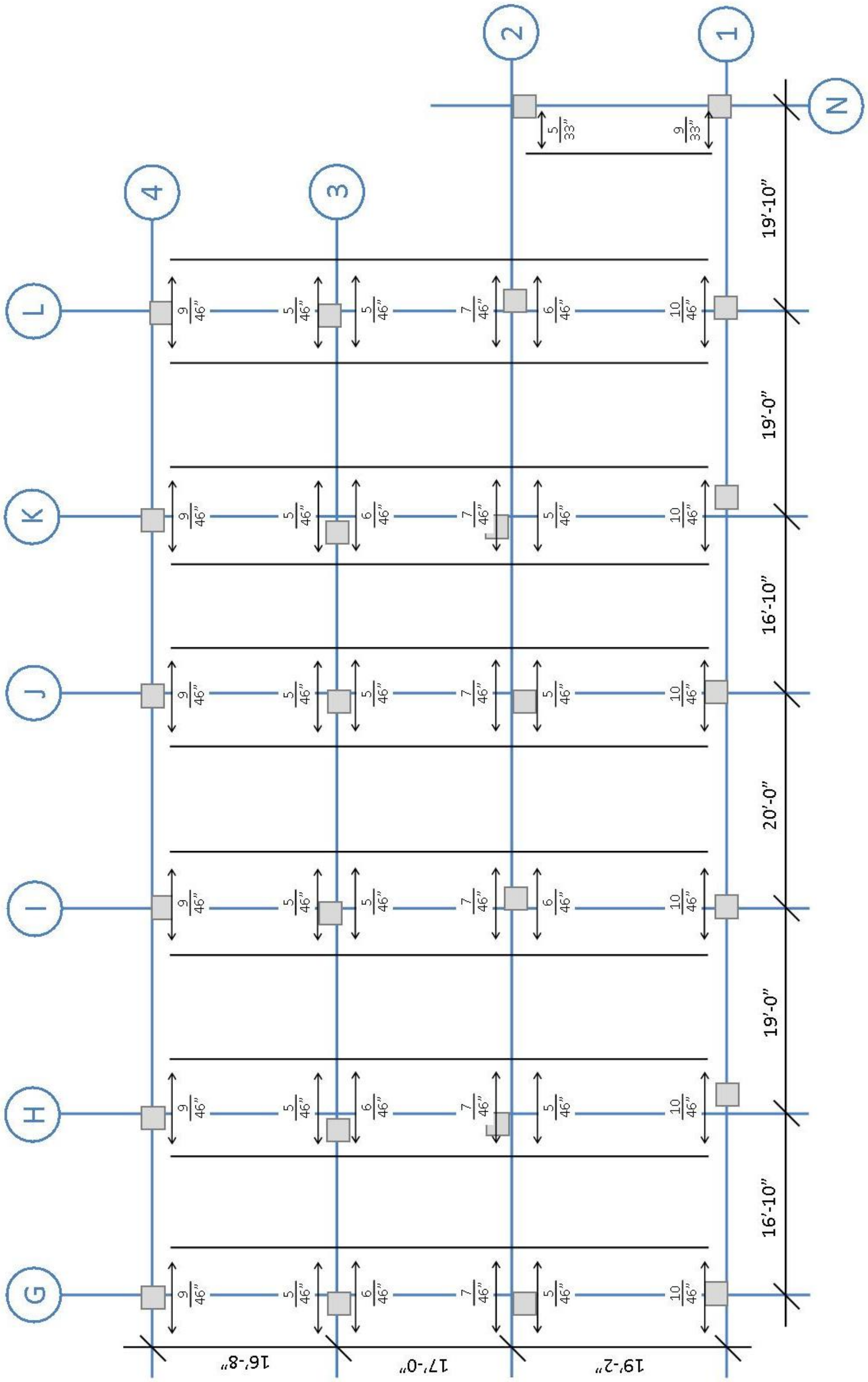
H
G
19'-10"
19'-0"
16'-10"
20'-0"
19'-0"
16'-10"
16'-8"
17'-0"
19'-2"

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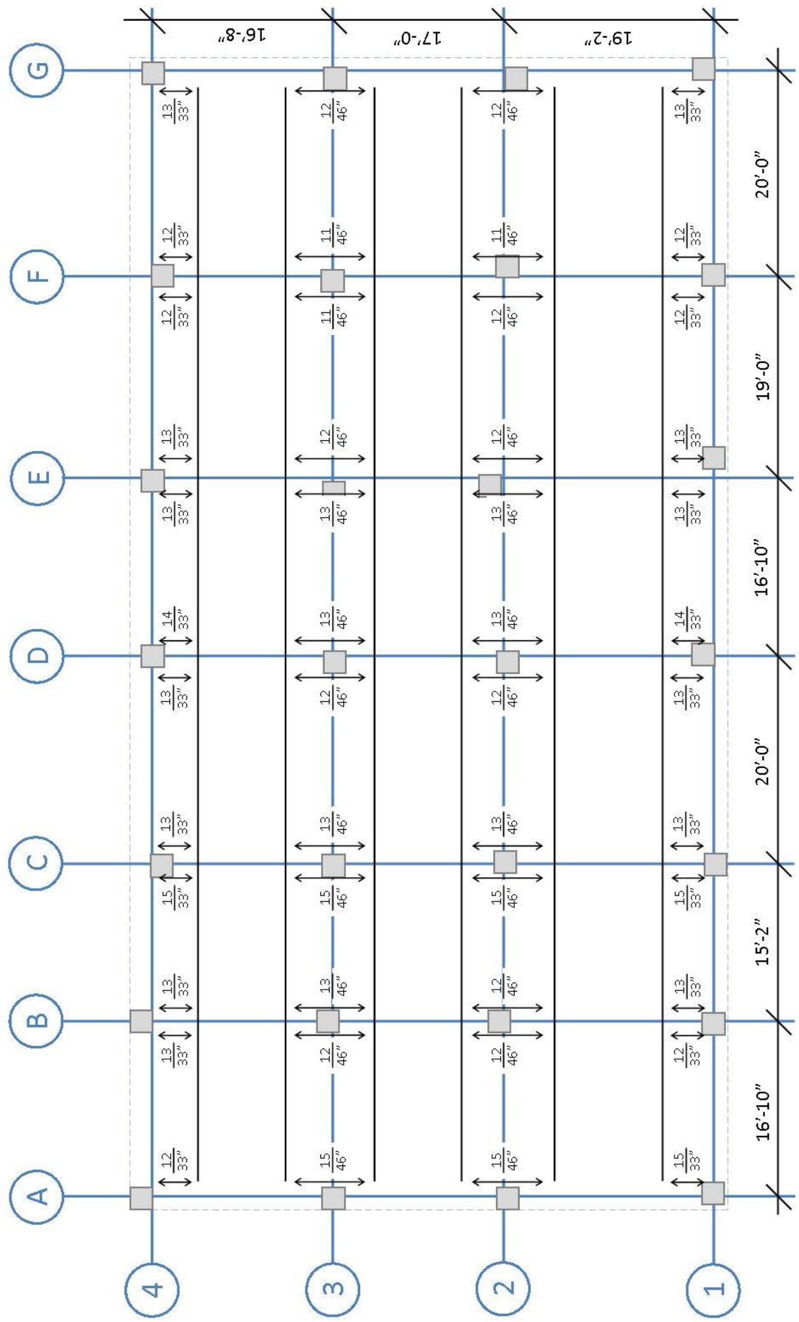
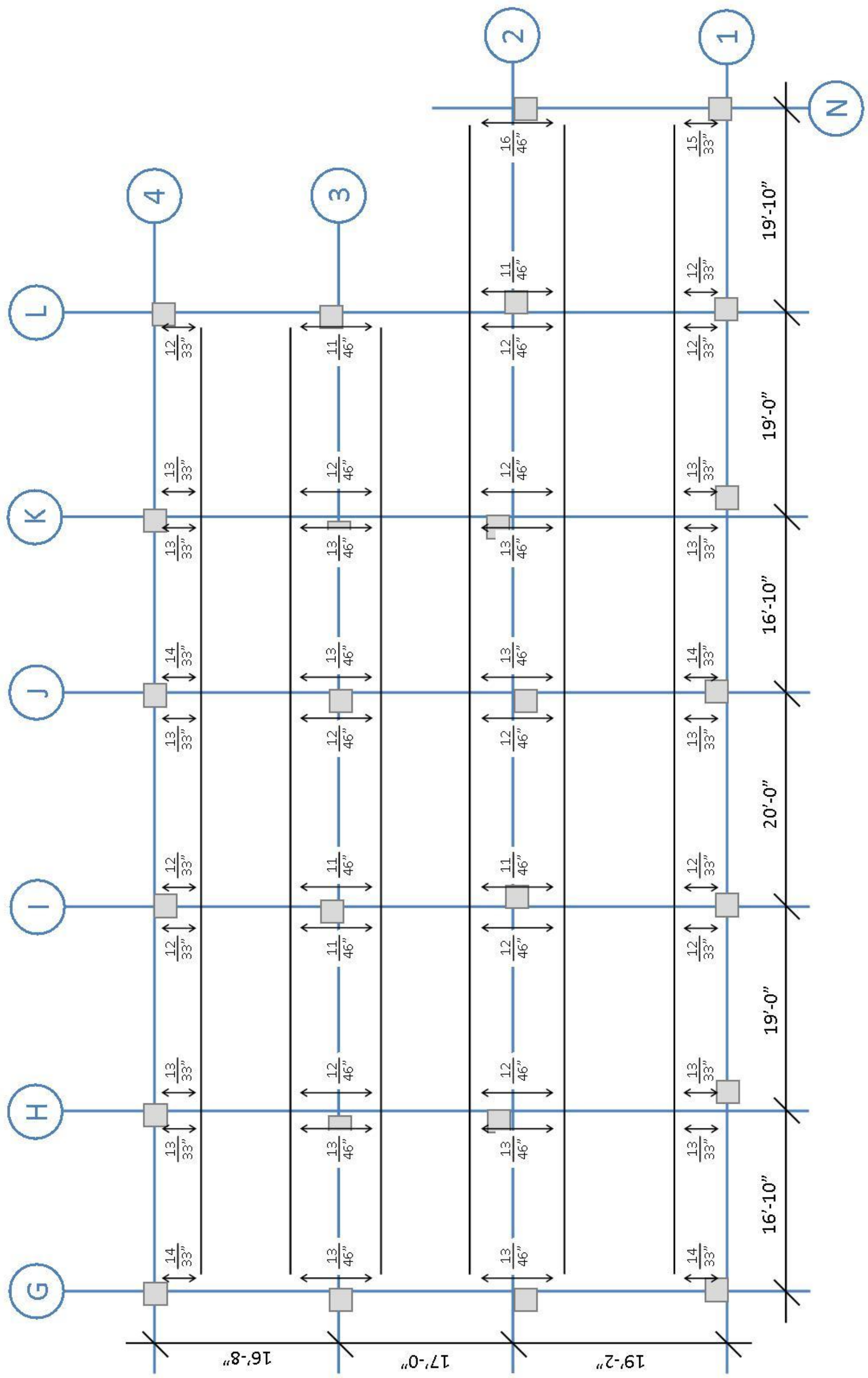
19'-10"
19'-0"
16'-10"
20'-0"
19'-0"
16'-10"
16'-8"
17'-0"
19'-2"

Third Floor

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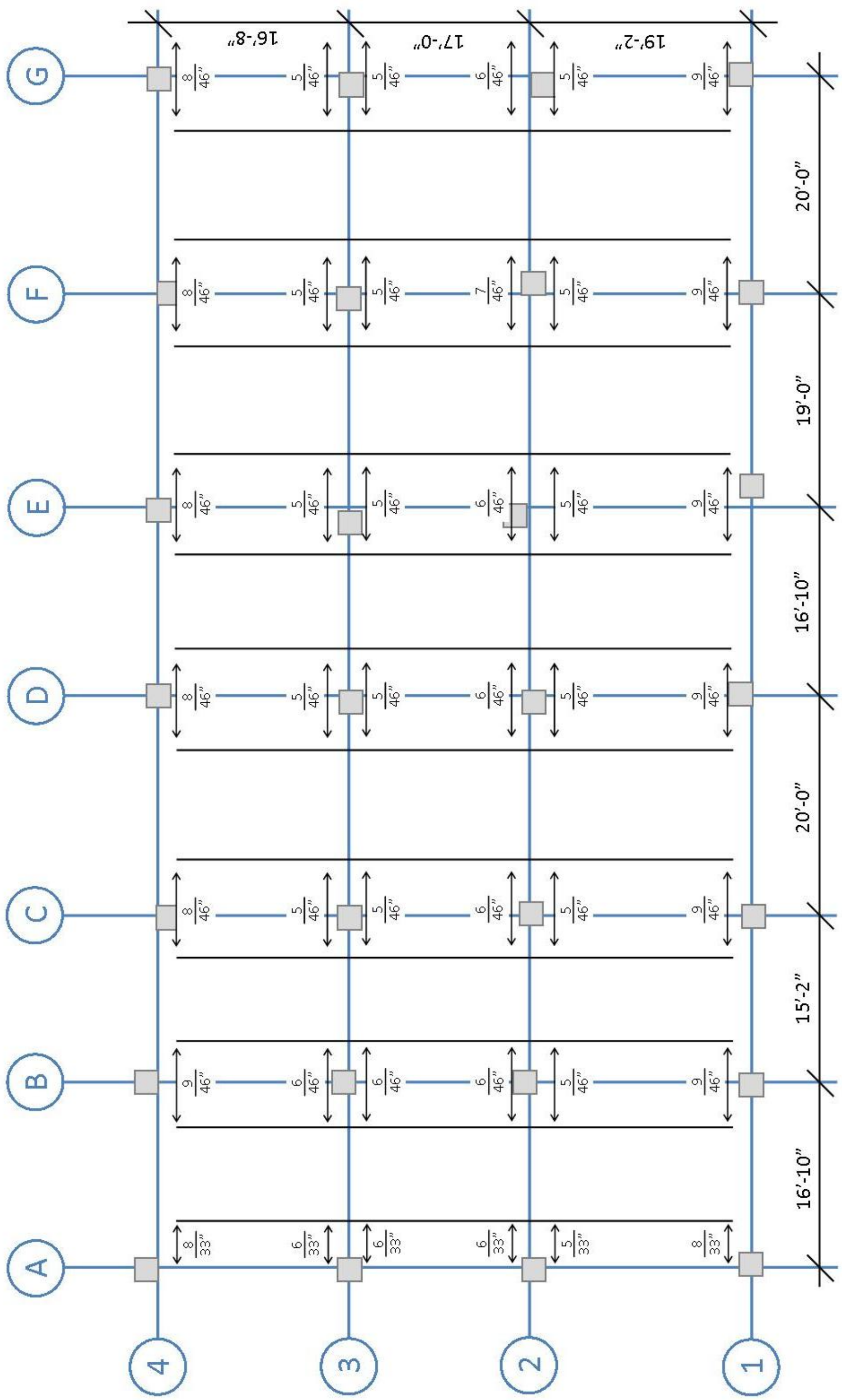
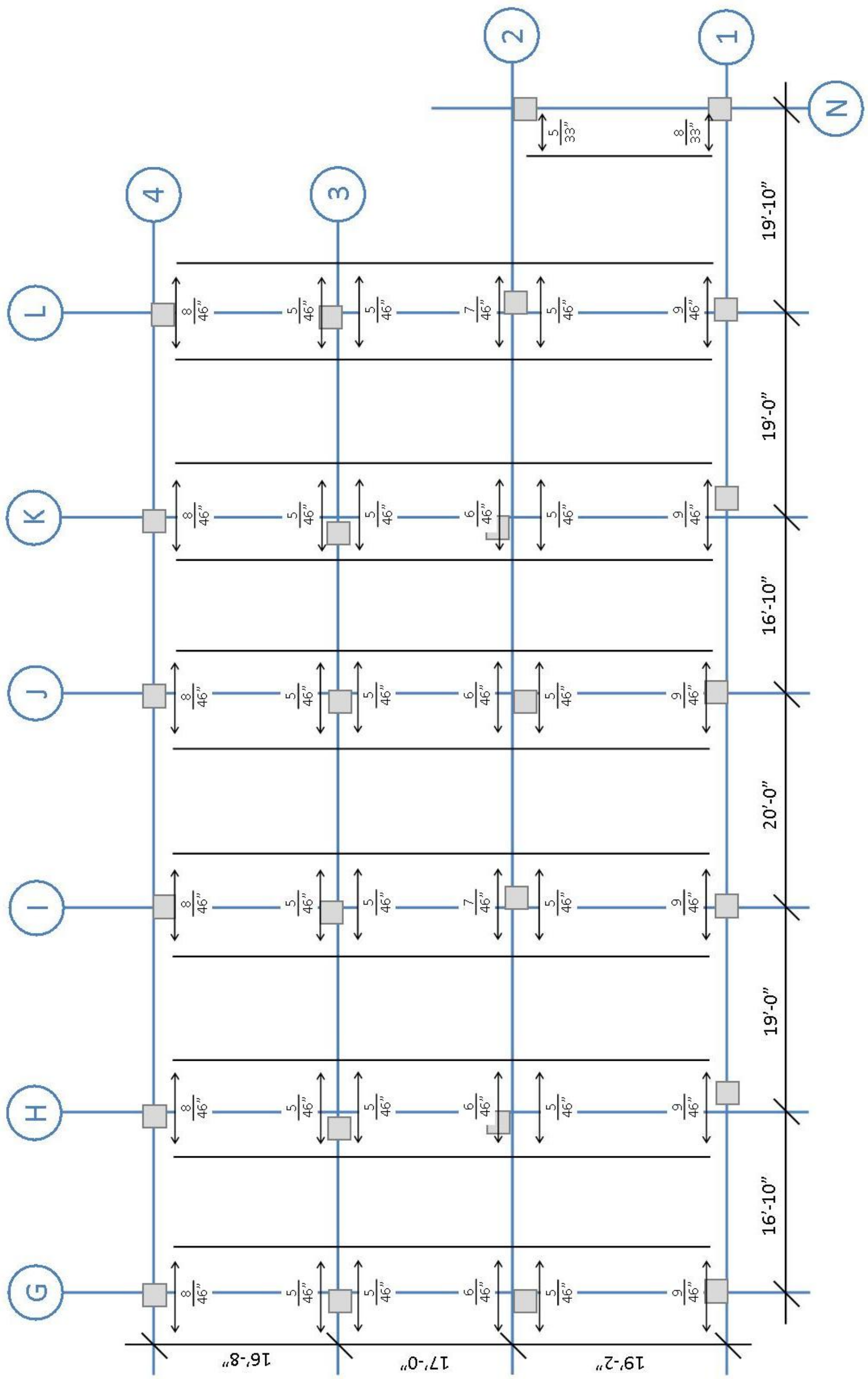
19'-10"
19'-0"
16'-10"
20'-0"
19'-0"
16'-10"
16'-8"
17'-0"
19'-2"


16'-8"
17'-0"
19'-2"
20'-0"
19'-0"
16'-10"
20'-0"
15'-2"
16'-10"
G
F
E
D
C
B
A
4
3
2
1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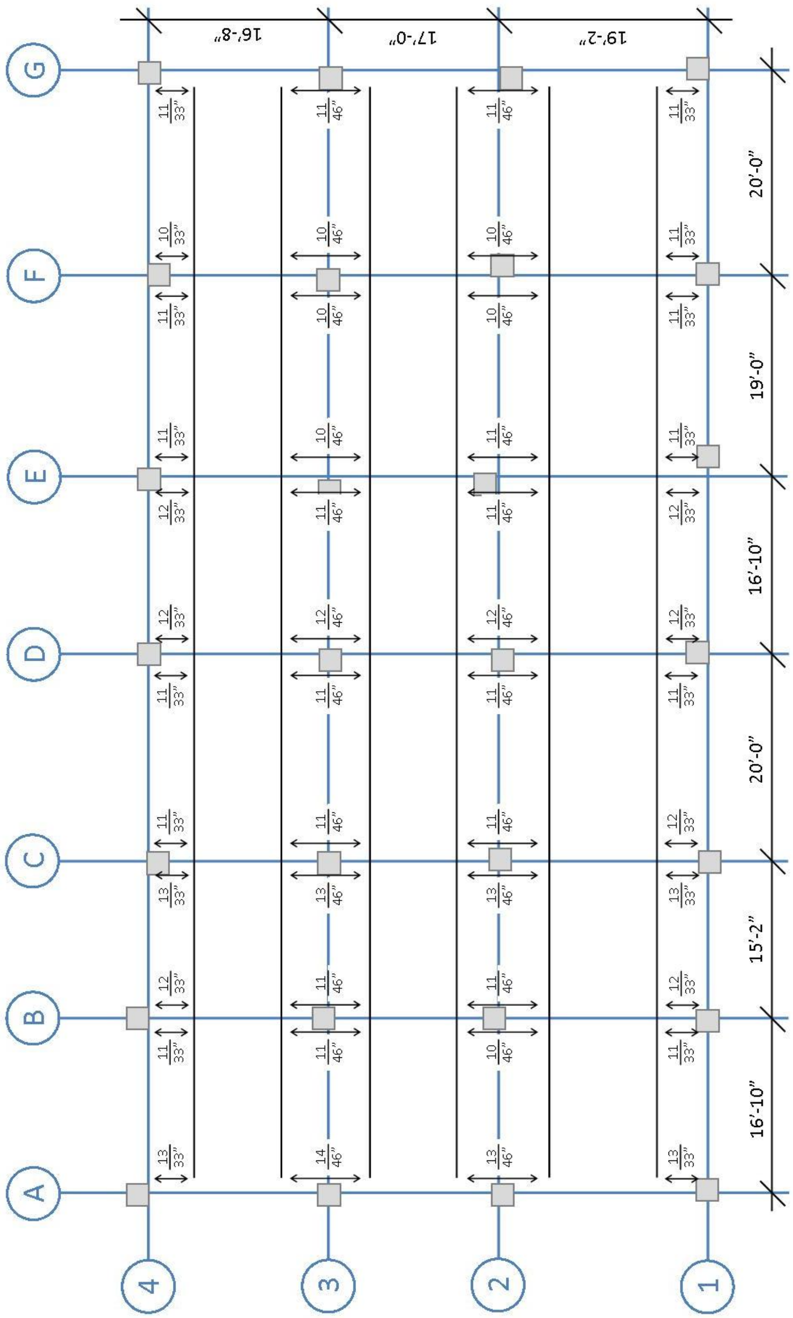
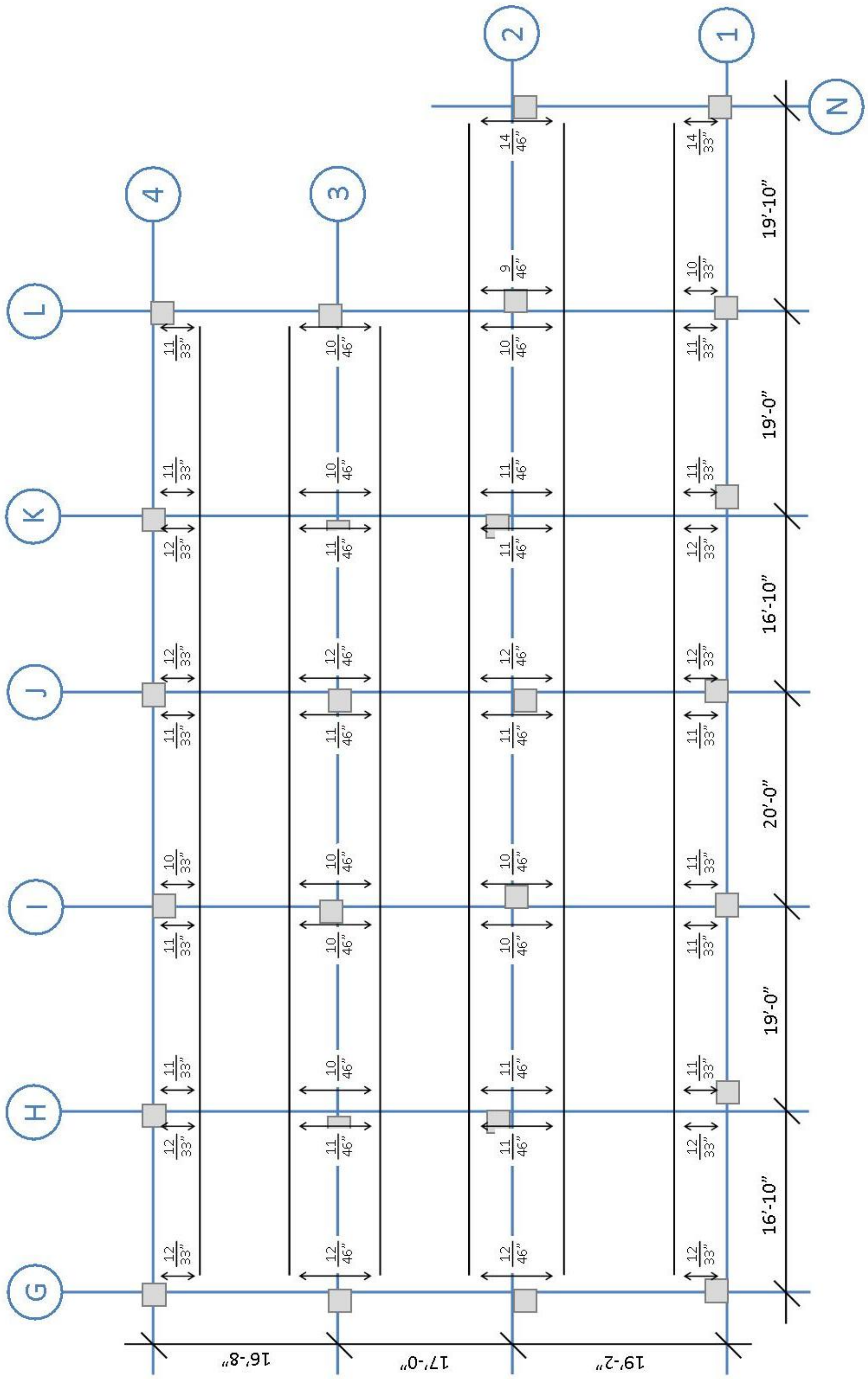
H
G
19'-10"
19'-0"
16'-10"
20'-0"
19'-0"
16'-10"
16'-8"
17'-0"
19'-2"

Fourth Floor





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19'-10"
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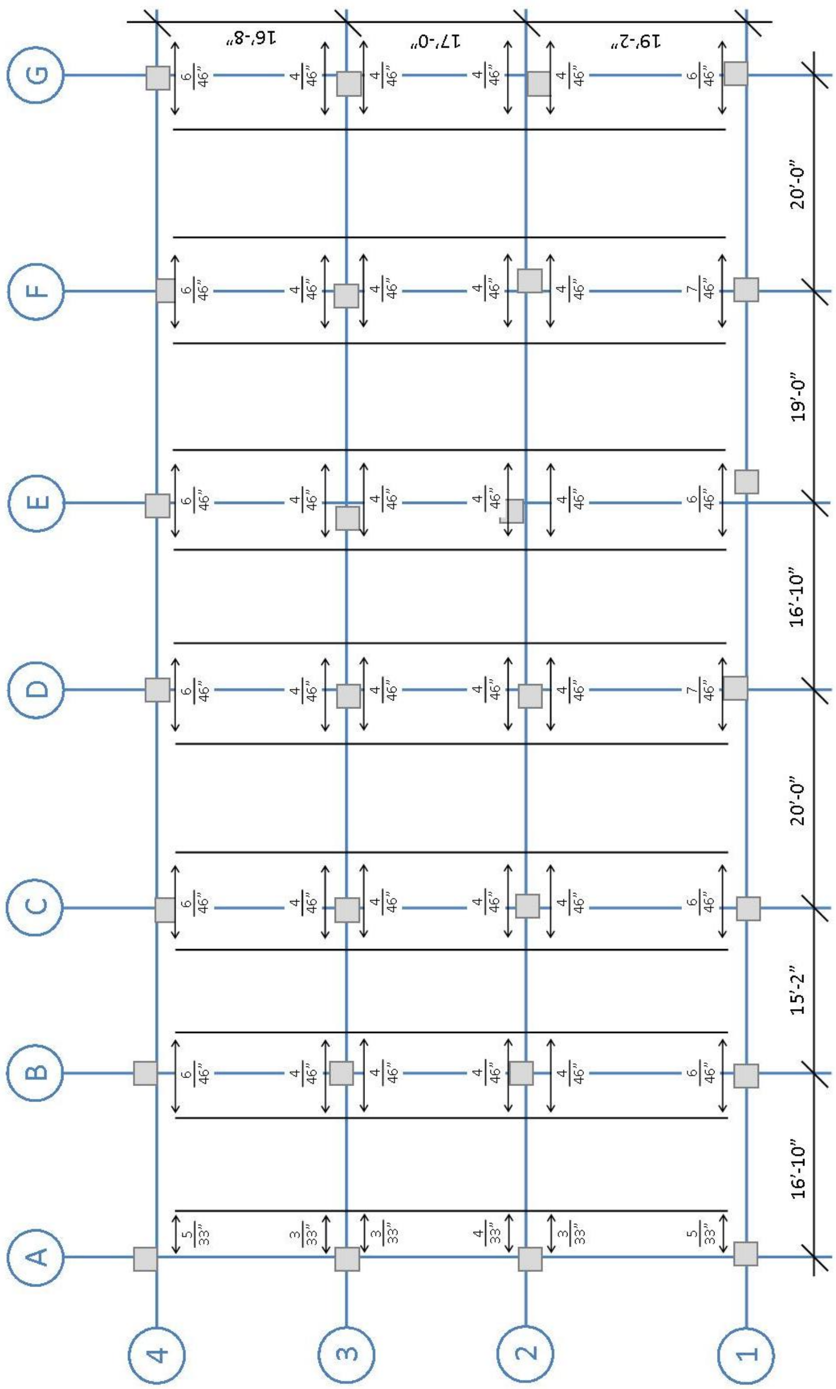
16'-10"
20'-0"
19'-0"
16'-10"
16'-8"
17'-0"
19'-2"



A
B
C
D
E
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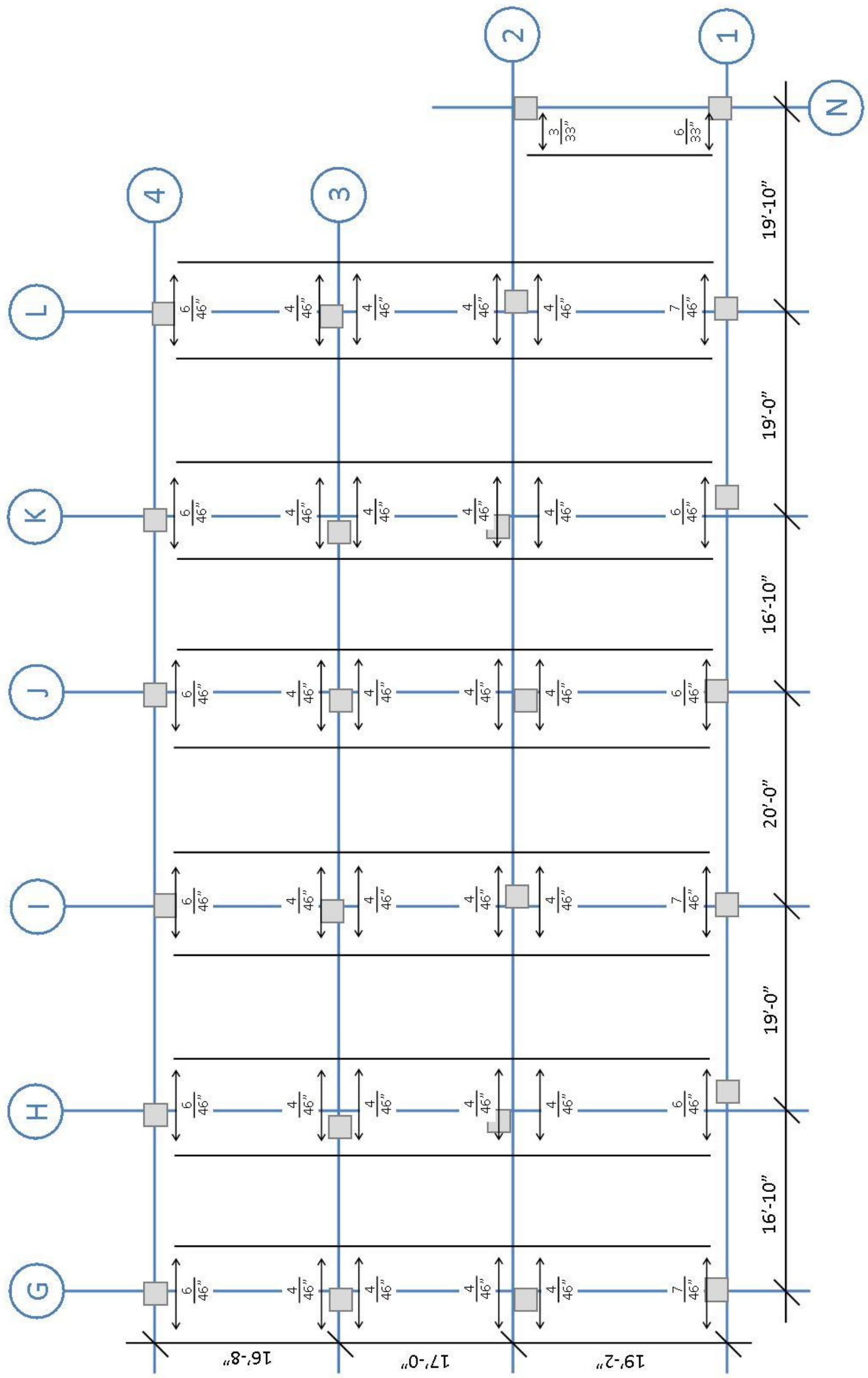
16'-8"
17'-0"
19'-2"
20'-0"
19'-0"
16'-10"
20'-0"
15'-2"
16'-10"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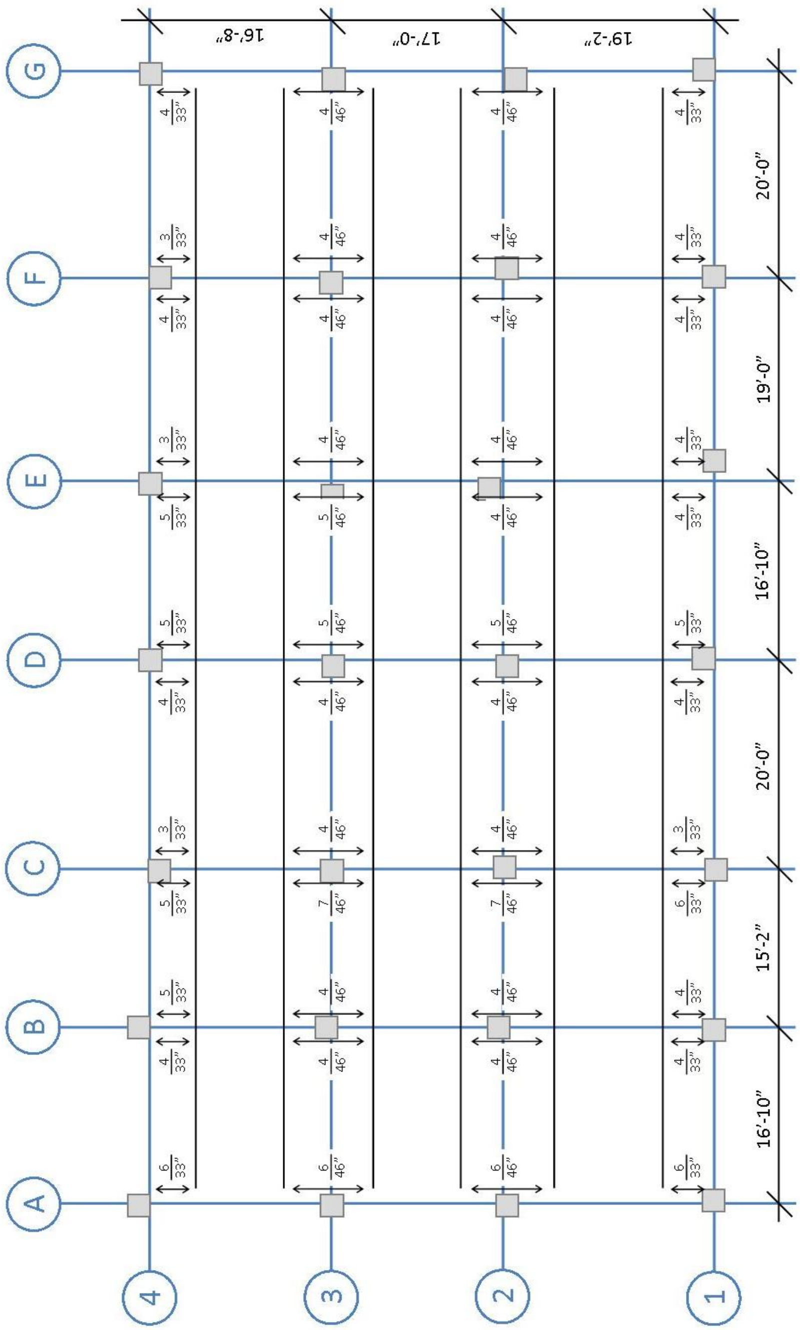
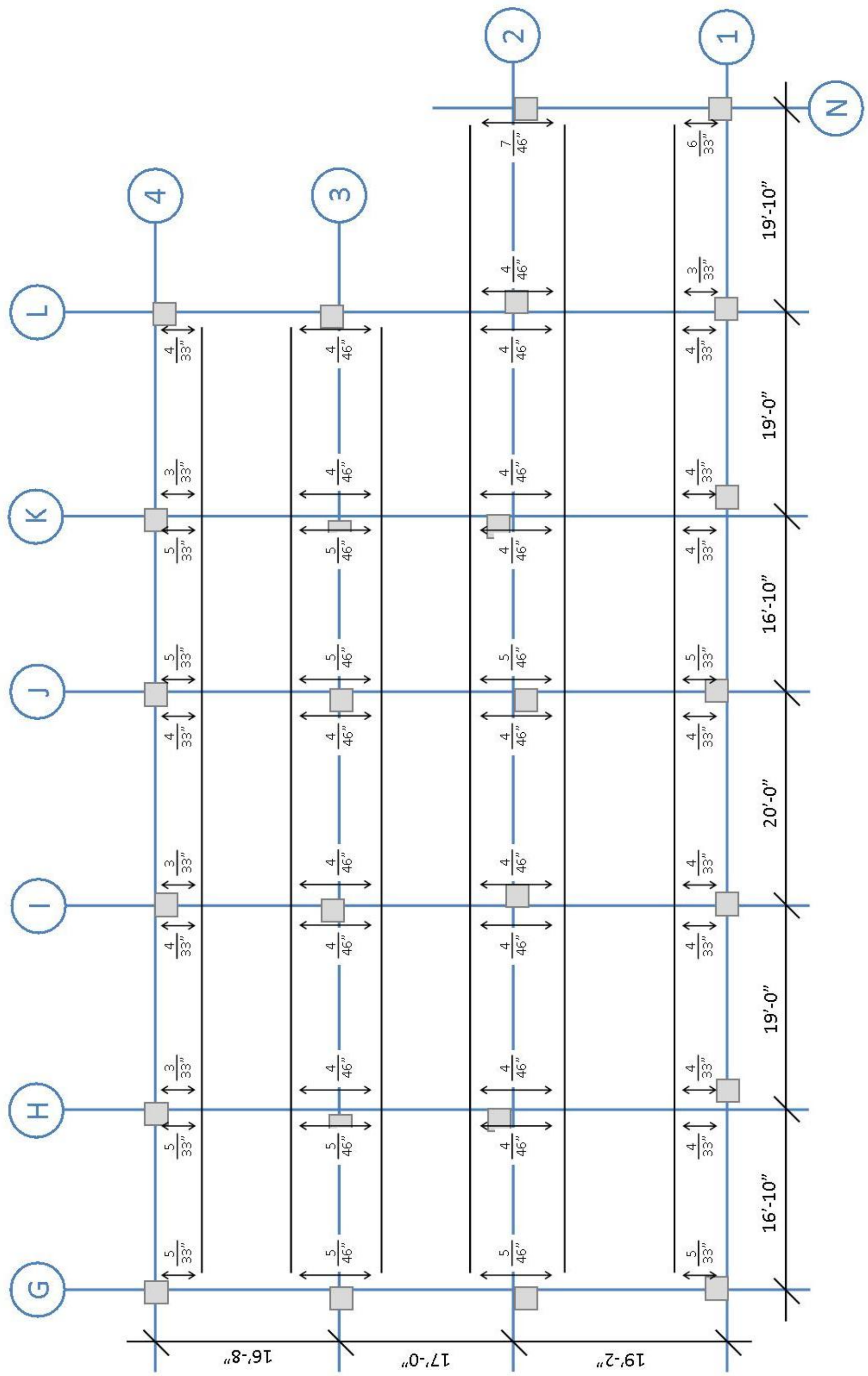
19'-0"
16'-10"
20'-0"
19'-0"
16'-10"
16'-8"
17'-0"
19'-2"
3/33"
6/33"
6/46"
4/46"
7/46"

Mechanical Penthouse

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19'-10"
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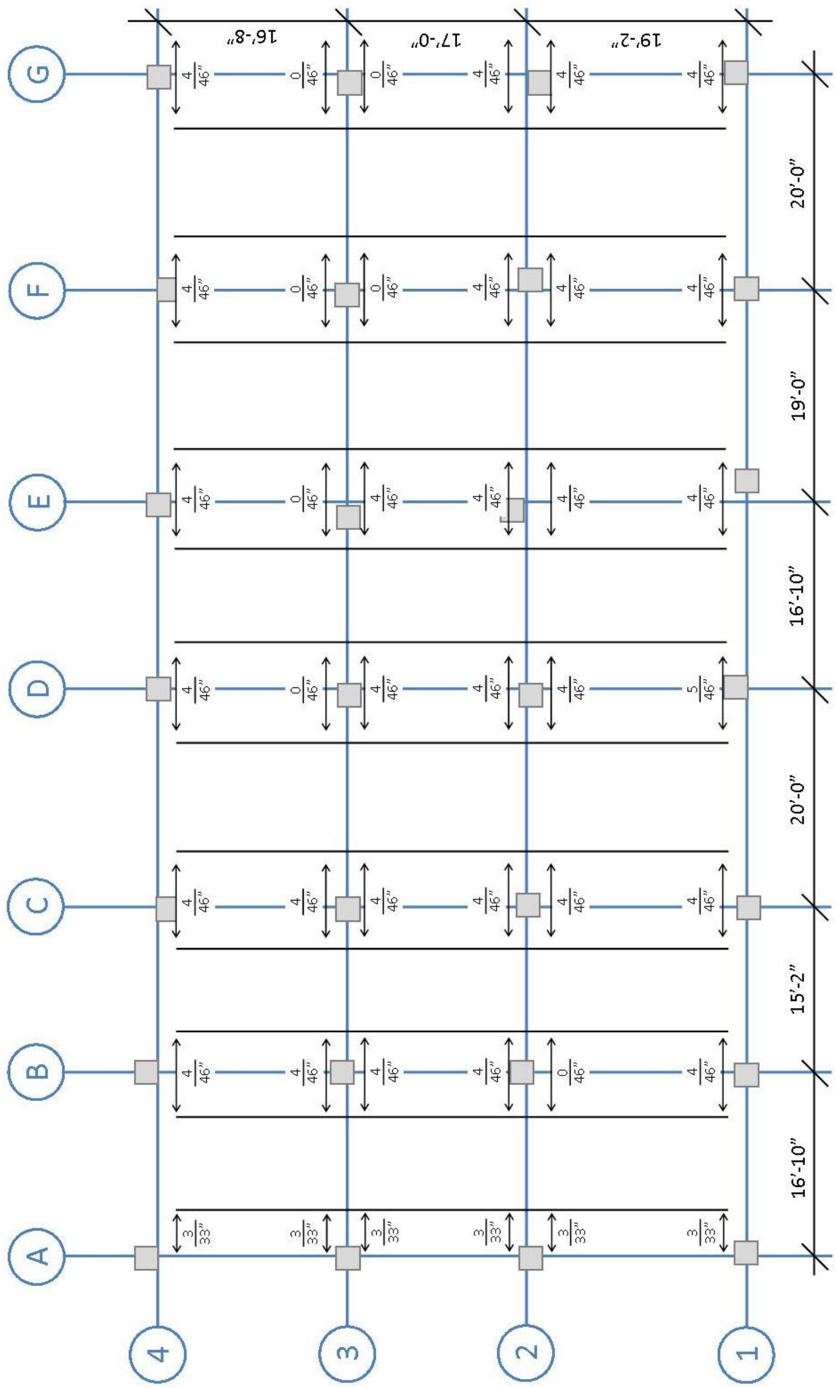
16'-10"
20'-0"
19'-0"
16'-10"
16'-8"
17'-0"
19'-2"


16'-8"
17'-0"
19'-2"
20'-0"
19'-0"
16'-10"
20'-0"
15'-2"
16'-10"
G
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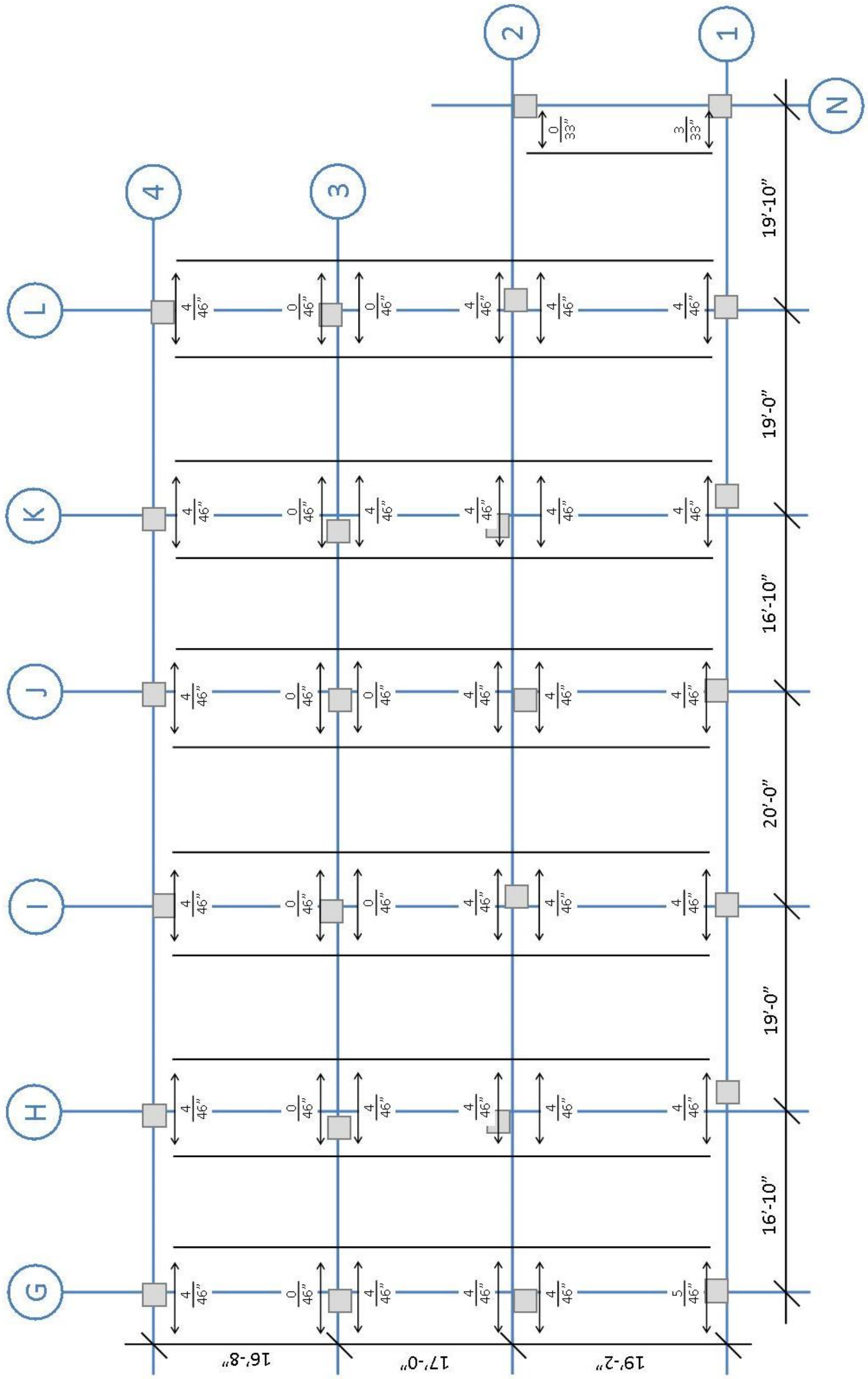
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19'-10"
19'-0"
16'-10"
20'-0"
19'-0"
16'-10"
16'-8"
17'-0"
19'-2"

Appendix K: Cost Analysis

Existing Building - Steel and Wood Frame

Item	Size	Levels	Amount	Unit	Material	Labor	Equipment	Total	Over+Prof	Total	Total Ov+Pr
Steel Decking	18 Gauge	2nd, 3rd	23562	S.F.	1.80	0.40	0.05	2.25	2.80	53014.50	65973.60
Deck FireProofing	1" thick	2nd, 3rd	23562	S.F.	0.53	0.22	0.04	0.79	0.99	18613.98	23326.38
3.25" Slab Pumped	pumped	2nd, 3rd	236	C.Y.	-	16.20	5.70	21.90	31.00	5170.83	7319.44
4000 psi Concrete	3.25" Slab	2nd, 3rd	236	C.Y.	103.00	-	-	103.00	113.00	24319.42	26680.53
Concrete Finish	Bull Float	2nd, 3rd	23562	S.F.	-	0.35	-	0.35	0.57	8246.70	13430.34
Steel Beam (1)	W16x31	2nd	493	L.F.	37.50	2.84	1.79	42.13	48.45	20770.09	23885.60
Fire Proofing (1)	1" thick	2nd	1972	S.F.	0.53	0.43	0.09	1.05	1.39	2070.60	2741.08
Steel Beam (2)	W16x26	2nd	483	L.F.	31.50	2.55	1.61	35.66	40.50	17223.78	19561.50
Fire Proofing (2)	1" thick	2nd	1932	S.F.	0.53	0.43	0.09	1.05	1.39	2028.60	2685.48
Steel Beam (3)	W21x44	3rd	754	L.F.	53.00	3.47	1.65	58.12	66.50	43822.48	50141.00
Fire Proofing (3)	1" thick	3rd	3016	S.F.	0.53	0.43	0.09	1.05	1.39	3166.80	4192.24
Steel Beam (4)	W18x35	3rd	575	L.F.	42.50	3.85	1.83	48.18	55.00	27703.50	31625.00
Fire Proofing (4)	1" thick	3rd	2300	S.F.	0.53	0.43	0.09	1.05	1.39	2415.00	3197.00
Steel Girder (1)	W24x55	2nd, 3rd	856	L.F.	66.50	3.33	1.58	71.41	80.50	61126.96	68908.00
Fire Proofing (1)	1" thick	2nd, 3rd	6848	S.F.	0.53	0.43	0.09	1.05	1.39	7190.40	9518.72
Steel Column	W10x68	Up to 3rd	1791	L.F.	82.50	2.60	1.63	86.73	96.50	155333.43	172831.50
Fire Proofing	1" thick	Up to 3rd	8358	S.F.	1.13	0.93	0.19	2.25	2.98	18805.50	24906.84
Wood Framing	2x6, 10'	3rd, 4th, 5th	1790	L.F.	3.96	7.40	0.00	11.36	15.75	20334.40	28192.50
									Total:	$ 484,969.33	$ **571,588.23**

Location Factor:	0.987	
Floor Area:	11781	ft^2
Concrete Volume:	236	C.Y.

Proposed Building - Concrete Frame

Item	Size	Location	Amount	Unit	Material	Labor	Equipment	Total	Over+Prof	Total	Total Ov+Pr
4000 psi Concrete		All	1492	C.Y.	103.0	-	-	103.0	113.0	153632.2	168548.0
Concrete Finish	Bull Float	All	47124	S.F.	-	0.4	-	0.4	0.6	16493.4	26860.7
Concrete Slab	8.5"	All	1492	C.Y.	-	11.0	5.0	16.0	23.5	23790.6	35052.0
Slab Reinforcing		All	23	Ton	850.0	385.0	-	1235.0	1625.0	28405.0	37375.0
Slab Formwork	4 use	All	47124	SFCA	1.3	2.5	-	3.8	5.6	179071.2	263894.4
Column (Concrete)	20x20	Top 2	257	C.Y.	-	19.1	8.7	27.8	41.0	7118.8	10517.9
Column Reinforcing		All	43	Ton	1175.0	510.0	-	1685.0	2175.0	72455.0	93525.0
Column Formwork	4 use	All	199680	SFCA	0.6	3.2	-	3.8	6.1	765440.0	1214720.0
									Total:	$ 1,230,202.95	$ **1,826,436.50**

Location Factor:	0.987	
Floor Area	11781	ft^2
Building Area	47124	ft^2
Concrete Volume	1492	C.Y.