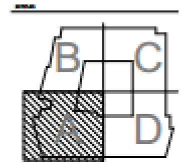
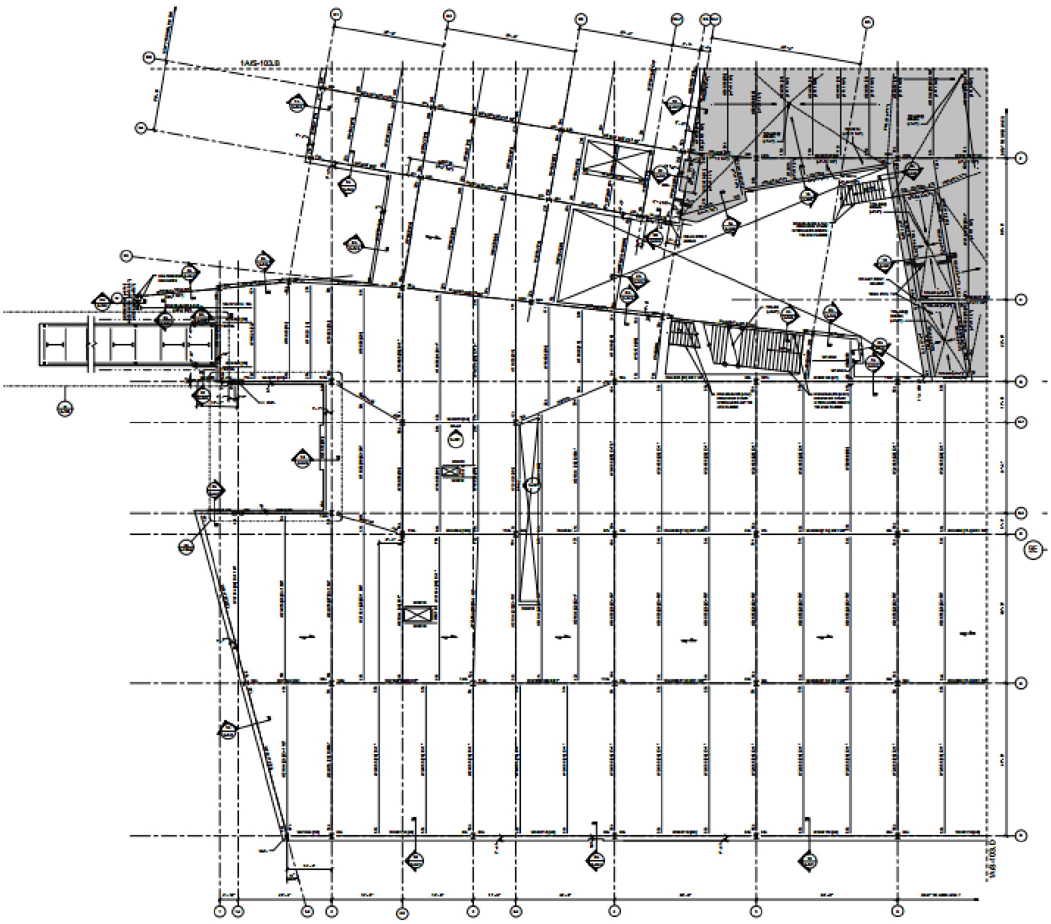
Appendices

Appendix A

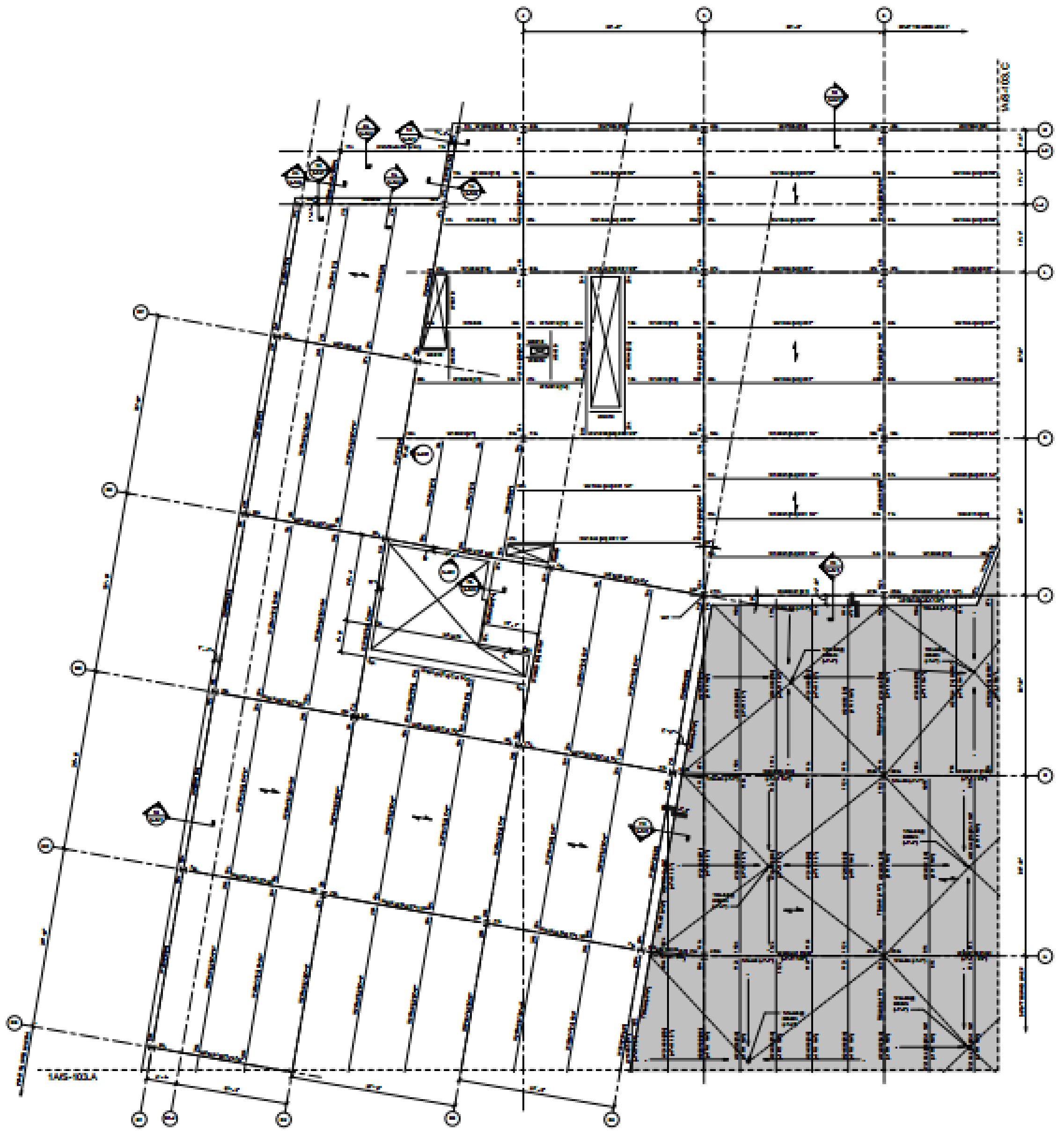
Sample Existing Building Floor Plans and Elevations

Building Key Plan

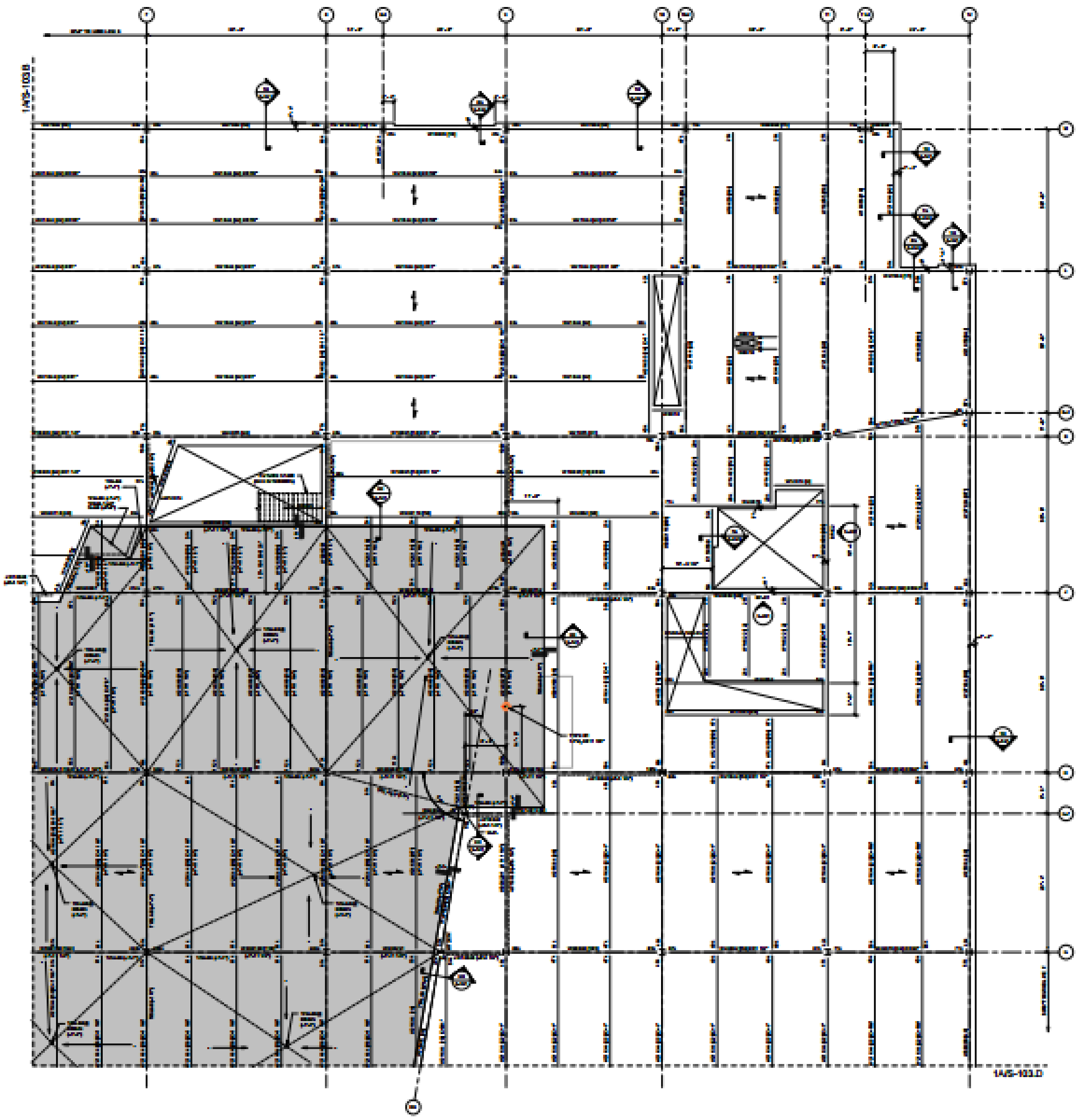




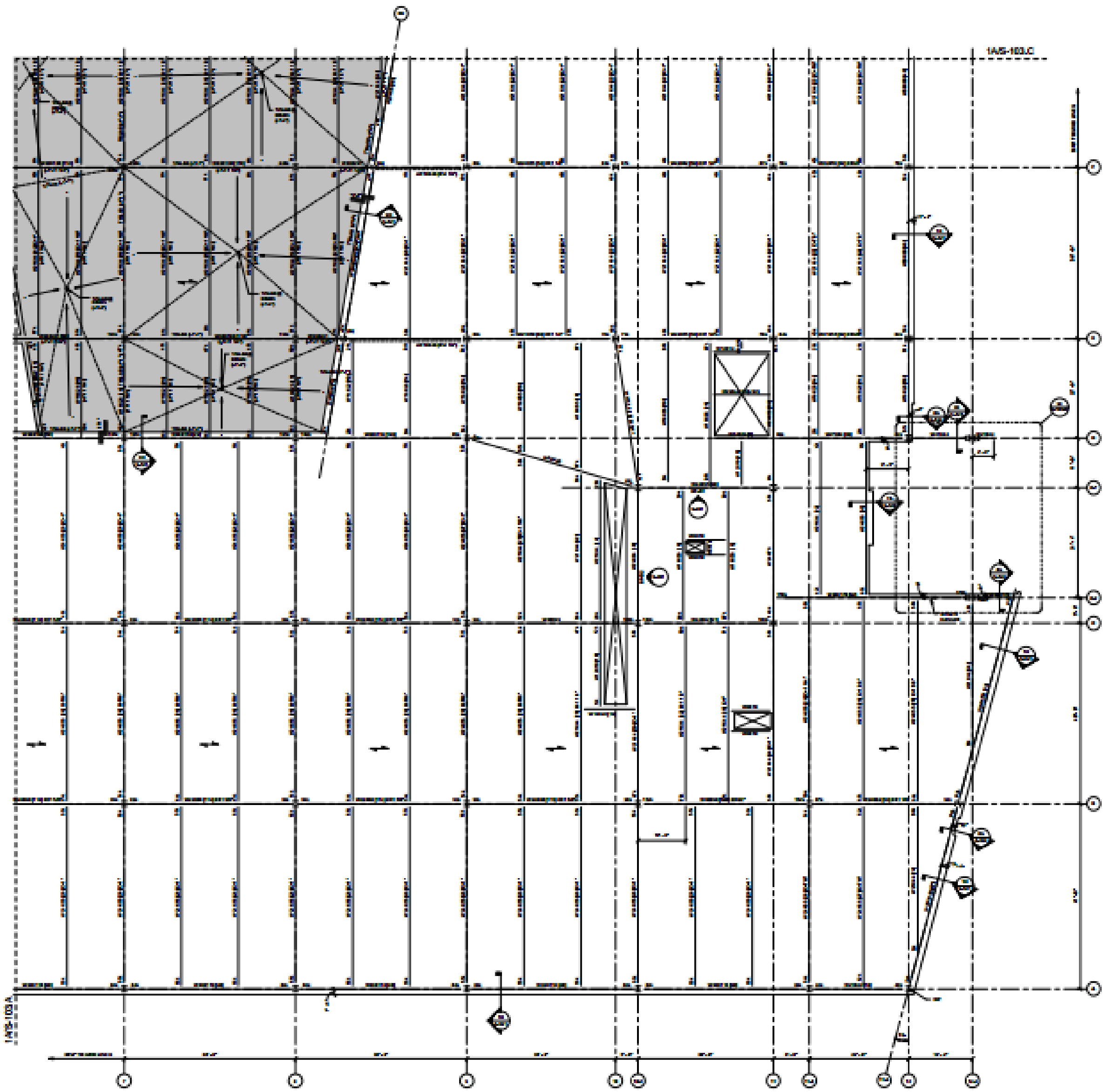
Area A Third Floor Framing



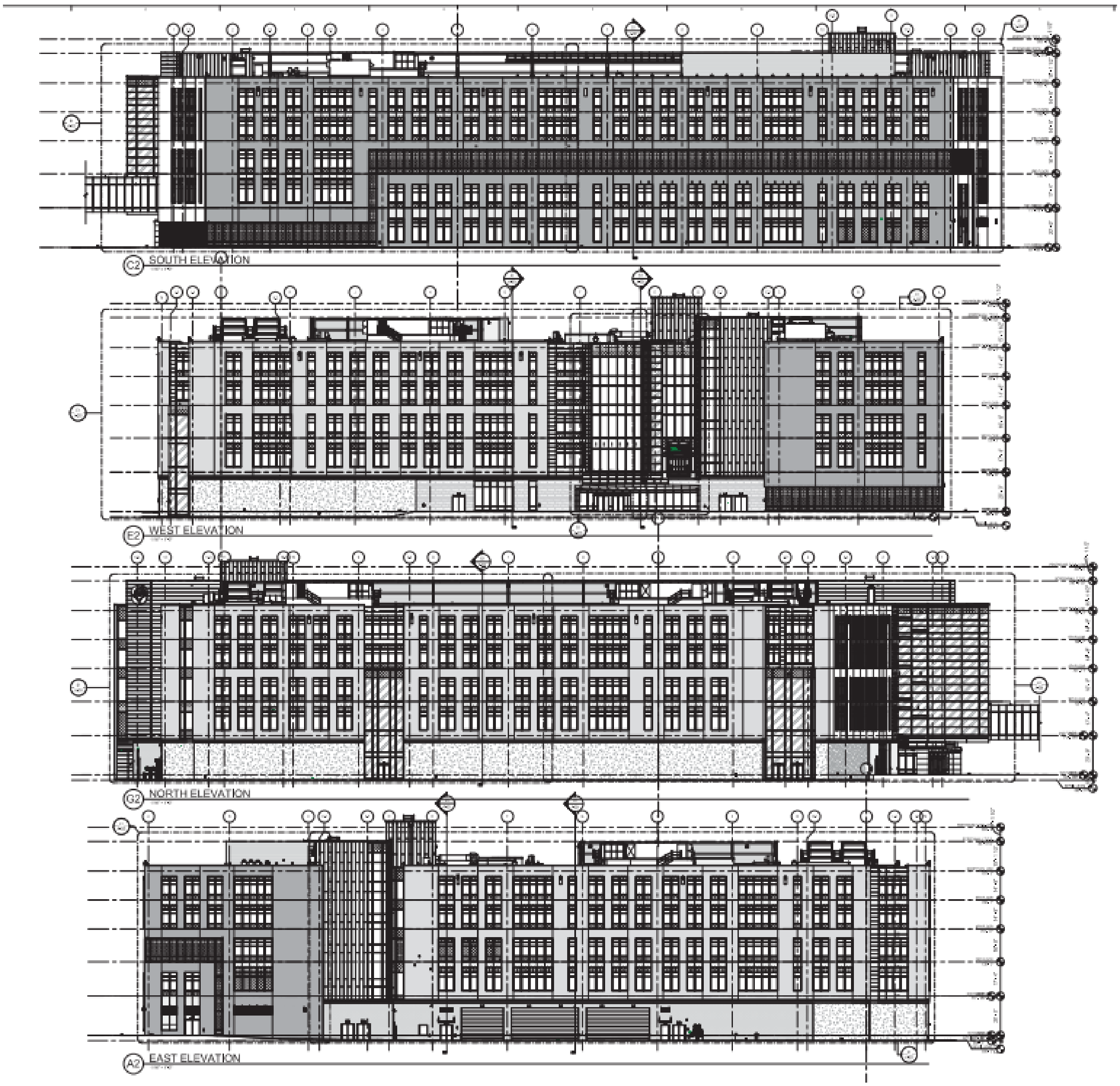
Area B Third Floor Framing



Area C Third Floor Framing



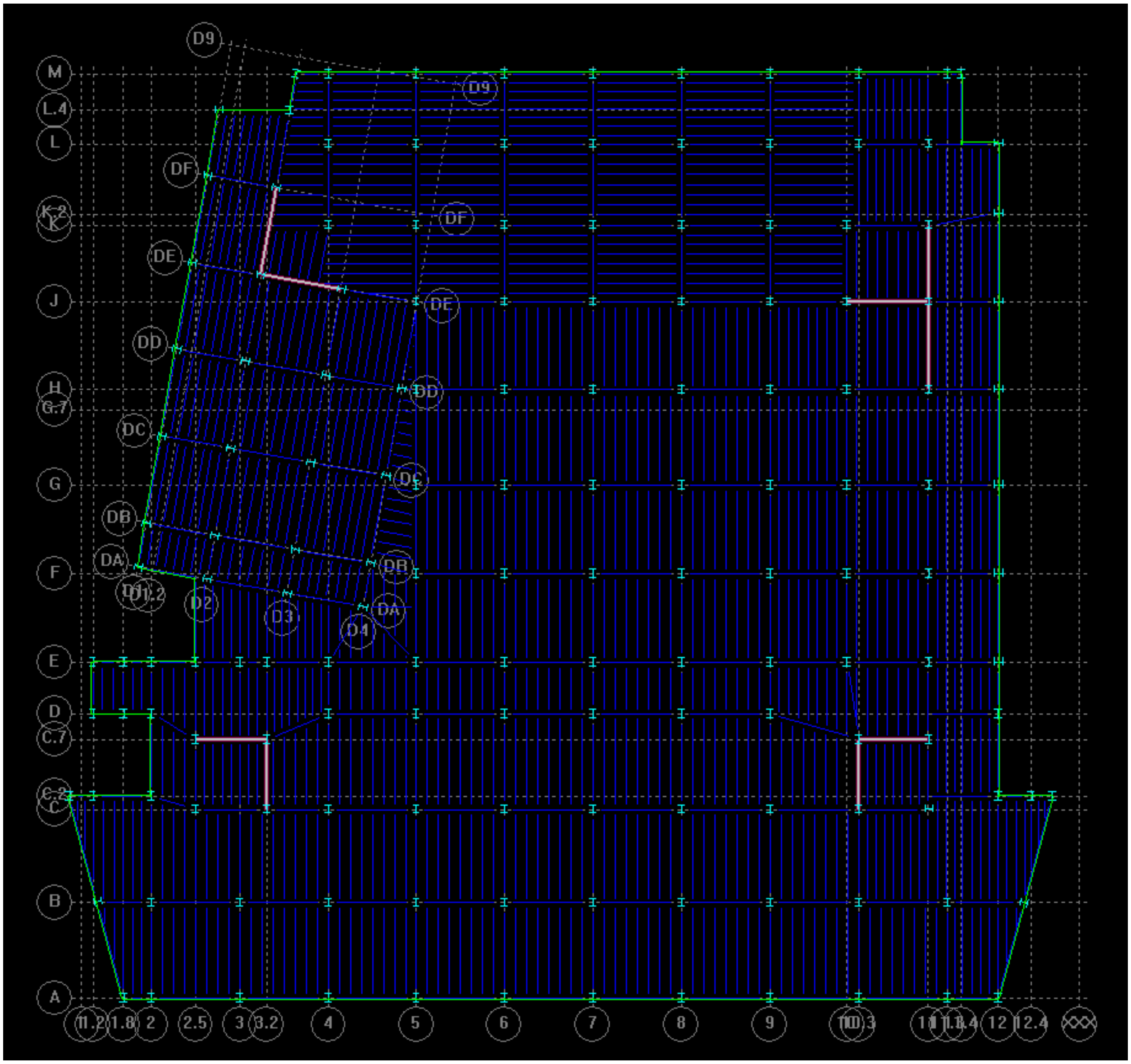
Area D Third Floor Framing



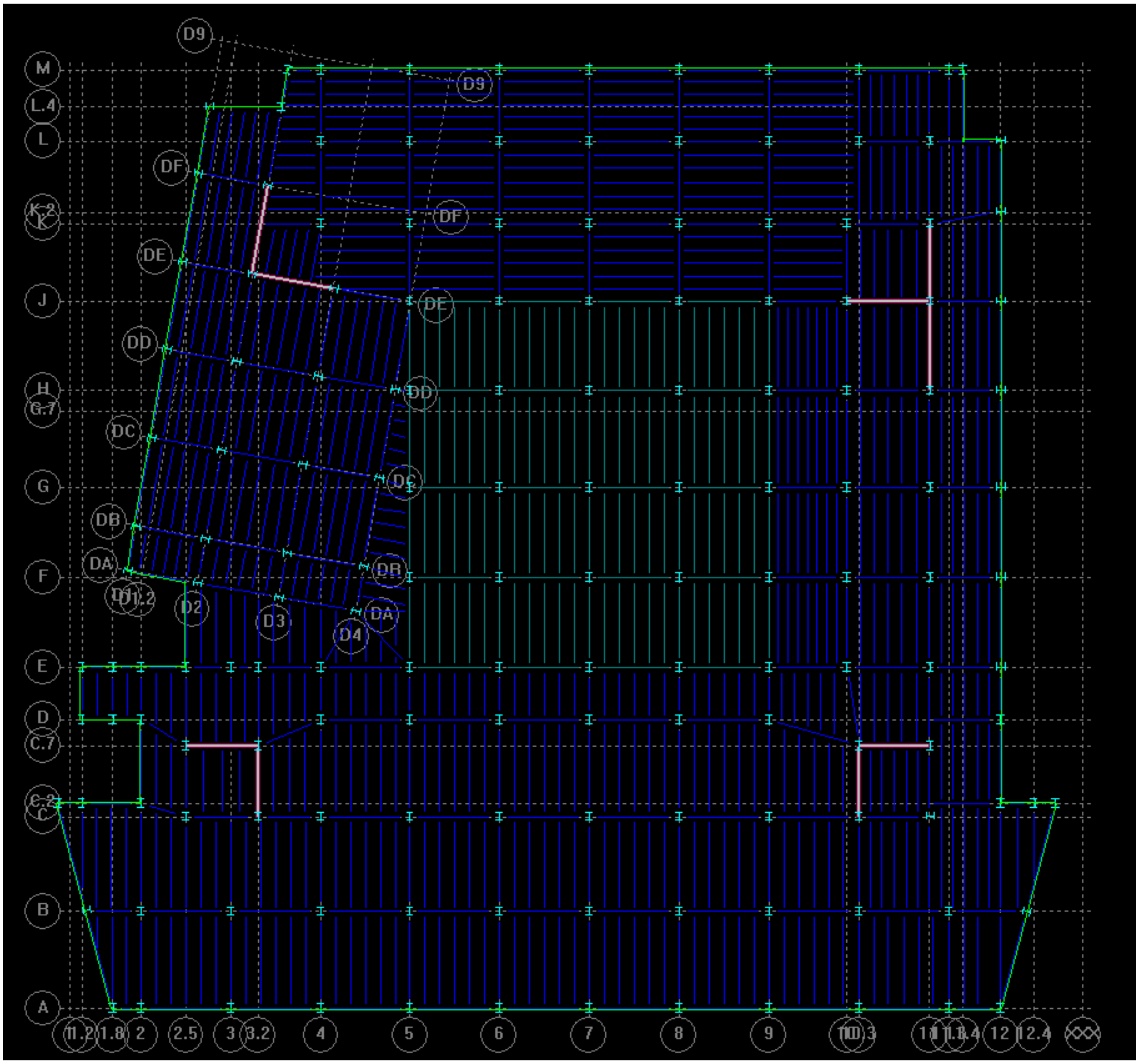
Building Elevations

Appendix B

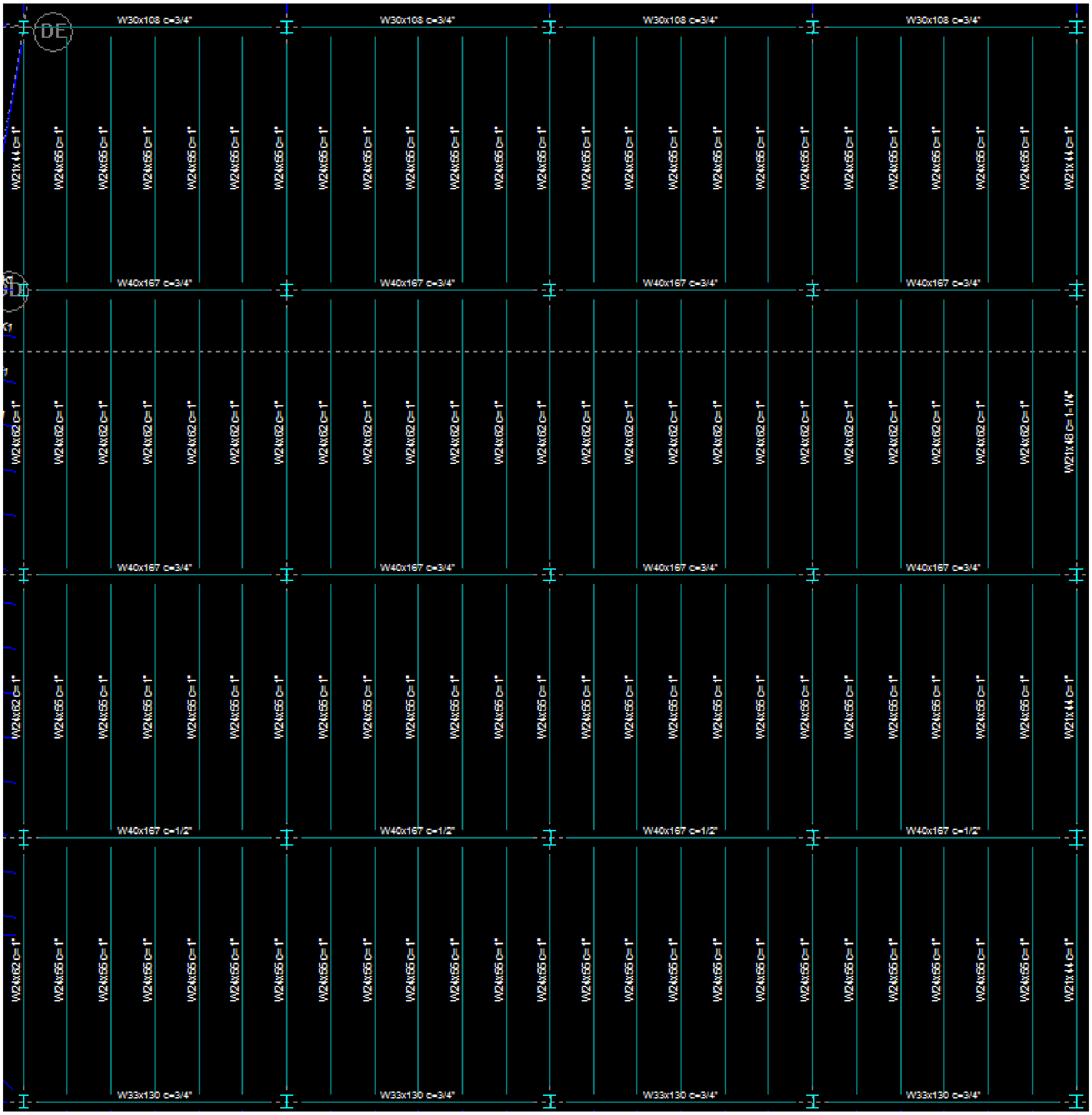
Redesign Structural Framing Plans



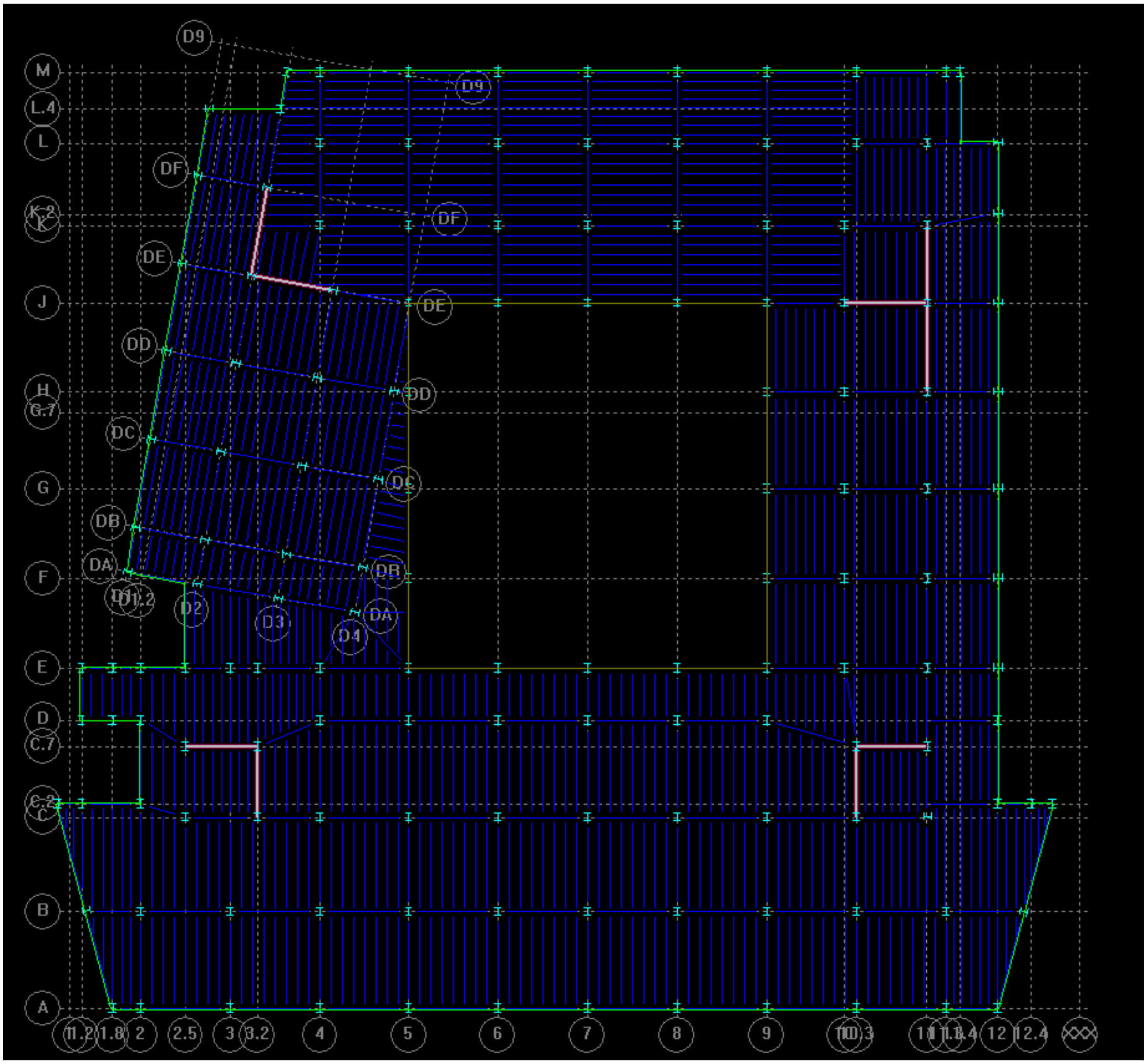
Level 2 Framing Plan



Level 3 (Courtyard Level) Framing Plan



Courtyard Green Roof Framing Plan, sample bay size shown in Figure 19 (clearer member sizes)



Level 4 and 5 Framing Plan (roof framing plan looks identical in plan view)

Appendix C

Gravity Loading Calculations

Gravity System | Roof Deck Calculation | 1/1

Typical Bay Loading

Live Load = 20 psf per ASCE 7-05 - Table 4-1

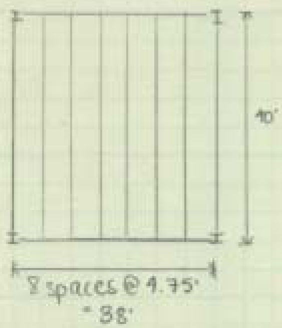
Dead Load

adhered membrane = 1 psf
1/4" roof board = 1.2 psf
insulation = 3 psf
vapor retarder = 1 psf
ceilings = 2 psf
MEP = 10 psf
sprinklers = 3 psf
framing = 10 psf

31.2 ~31 psf

Total Load = 51 psf

Snow Load = 17 psf   20 > 17, live load controls



Determine Deck Size

- try 4" NW concrete for fire rating
- use unshored construction

Try 1.5VL18 (same as floor deck for ease of constructability)

1.5VL18 max unshored clear span
1 span 7'-0"
2 span 9'-1"
3 span 9'-4"

Superimposed live load for 5'-0 span (closest to 4.75') = 400 psf > 51 ✓

Total deck weight

$(4" \times \frac{1}{12})(150 pcf) = 50$ psf
deck SW = 2.82 psf

Total Deck Weight = 52.82 ~53 psf

Use 1.5VL18 w/ 4" Normal Weight Topping

Total Roof DL = 31 + 53 = 84 psf

Gravity System | Floor Deck Calculation | 1/1

Typical Bay Loading

Live Load

office = 50 psf
partitions = 15 psf

65 psf

Live Load Reduction

$L = L_o(0.25 + \frac{15}{\sqrt{K_{LL}A_T}})$

$= 65(.25 + \frac{15}{\sqrt{(2)(38)(40)}})$

L = 41 psf

Dead Load

Framing = 5 psf
ceiling = 2 psf
flooring = 3 psf
MEP = 5 psf
sprinklers = 3 psf

18 psf

TL = 41 + 18 = 59 psf

Courtyard Area Loading

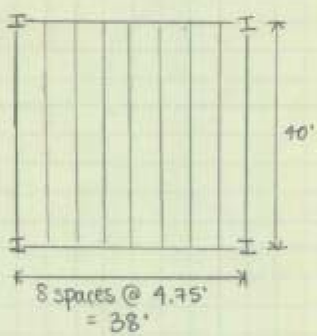
Live Load

assembly area = 100 psf ↳ nonreducable

Dead Load

MEP = 5 psf
Ceiling = 2 psf
Sprinklers = 3 psf
Framing = 5 psf
plantings | pavers = 80 psf
Adhered Membrane = 1 psf
Insulation = 3 psf
Vapor Retarder = 1 psf
TL = 200 psf

*ideally, find a deck to suit both loading patterns



Determine Deck Size

- need 3 1/4" LW conc for 2 hr fire rating
- use unshored construction for economy

Try 1.5VLR18 w/ 3.25" topping
max unshored clear spans
1 span = 8'-2"
2 span = 10'-1"
3 span = 10'-5"
} > 4.75' ∴ ok
use 2 span condition

superimposed Live Load for 5' span = 400 psf
400 > 200 > 59

Total Deck weight

$(3.25" \cdot \frac{1}{12}) \cdot 115$ pcf = 31.15 psf
deck SW = 2.82 psf

Total Deck weight = 34 psf

Total Dead Weight = 52 psf

Use 1.5VLR18 w/ 3.25" LW concrete

M. Julia Haverty | Gravity Loads | Tech Report 2

SNOW LOAD CALCULATIONS

Flat Roof Snow Load, P_f

$P_f = 0.7 C_e C_t I P_g$ (ASCE 7-05 Eq. 7-1)

From S-001

$P_g = 20$ psf
occupancy category II
$I = 1.1$
$C_e = 1.0$
$C_t = 1.1$
exposure B

$P_f = 0.7(1.0)(1.1)(1.1)(20)$ $P_f = 16.94 \sim 17$ psf $P_f = 17$ psf

Snow Drift

- calculated for drift from mechanical penthouse roof
- windward snow drift

$h_b = \frac{P_s}{\gamma}$ in this case, $P_s = P_f = 17$ psf

$\gamma = 0.13 p_g + 14$ but cannot exceed 30 pcf
$= 0.13(20) + 14$
$\gamma = 16.6$

$h_b = \frac{17 \text{ psf}}{16.6 \text{ pcf}}$ $h_b = 1.02$ ft $h_c/h_b > 0.2 \rightarrow$ drift loads must be calculated

$h_c = 15'-1.5"$

$\ell_u = 394' \rightarrow$ from Figure 7-9, $h_d \sim 5.5$ ft

$h_d = 0.43 \sqrt[3]{\ell_u} \sqrt[4]{p_g + 10} - 1.5 = 0.43 \sqrt[3]{394} \sqrt[4]{20+10} - 1.5$
$h_d = 5.88'$
$3/4\, h_d = 4.41'$

$h_d > h_b$ $h_d < h_c \rightarrow w = 4h_d$ $w = 4(4.41)$ $w = 17.64'$

Drift Density $p_d = h_d \gamma$ $p_d = 4.41(16.6)$ $p_d = 73.21$ psf

$h_d = 4.41'$

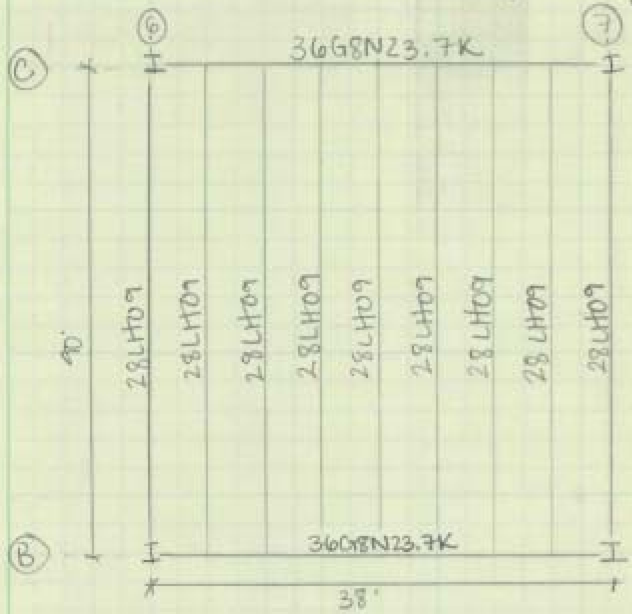
$W = 17.64'$

Appendix D

Gravity Member Checks

Gravity System | Steel Joist Design | 1/3

Joist Spot Check (members designed using RAM)



From 4th floor plan

Dead Load

$3\frac{1}{4}$" LW conc slab $= 115(\frac{3.25}{12}) = 31.15$ psf
18GA Composite Metal Deck $= 2.8 \sim 3$ psf
Ceiling $= 5$ psf
MEP $= 10$ psf
Sprinklers $= 3$ psf

DL = 52 psf + joist self wt

Live Load

offices = 50 psf
partitions = 15 psf
65 psf

$L = L_o(0.25 + \frac{15}{\sqrt{K_{LL} A_T}})$ $K_{LL} = 1.0$

$= 65(.25 + \frac{15}{\sqrt{1(38)(40)}})$ L = 41 plf

Average Joist Spacing = 4.75'
Average Joist Span = 40'

28LH09 = 21 plf
max load < 1232 plf

$w_{u+l} = (1.2(52) + 1.6(65))\,4.75 = 790.4 + 1.2\,SW$
$w_{tl} = (52 + 65)\,4.75 = 555.75$ plf + joist weight

From Vulcraft Catalog, 28LH09 @ 42' span (smallest dimension listed in table)

$w_{utl} = 790.4 + 1.2(21) = 815.6$ plf
$w_{tl} = 555.75 + 21 = 576.75$

w for L/360 = 428 plf
w for L/240 = 428 * 1.5 = 642   642 > 576.75 ✓

use 28LH09 joists spaced at 4.75'

Gravity System | Joist Girder Design | 2/3

Joist Girder Spot Check

36G8N23.7K
SW = 69 plf for 24K

38' × 40' Bays
8 Joist Spaces (N=8), 4.75' spacing

DL = 52 plf + 69 plf = 121 plf

LL = 41 plf (reduced)

TL = 162 plf

4.75' (162 plf) = 770 plf

P = 770 × 40' trib width = 30.8 K , P given in RAM = 23.7K

Check Live Load Deflection (governs)
LL = 41 × 40' = 1640 plf = w = 1.64 klf = .137 k/in

Approximate Joist Girder Moment of Inertia

$I = 0.018NPLd$
$= 0.018(8)(23.7)(38)(36)$
$I = 4668.7\ in^4$

allowable deflection = $L/360 = 38(12)/360 = 1.27"$

deflection = $1.15\left[\frac{5wL^4}{384EI}\right] = 1.15\left[\frac{5\times(0.137)(38\times12)^4}{384(29000)(4668.7)}\right] = 0.66"$

$0.66" < 1.27"$ ✓

Use 36G8N23.7K Joist Girders

Beam Deflection Summary

RAM Steel 14.06.01.00 Page 23/77
DataBase: RAM Model Gravity and Lateral March 29 04/06/15 20:14:04

Bm #	Beam Size	Dead	Live	Total
2346	26K9	0.660	0.531	1.191
2255	24LH06	0.946	0.762	1.708
2248	26K9	0.660	0.531	1.191
2331	28LH10	1.089	0.877	1.965
2354	24LH07	0.825	0.664	1.490
2200	28LH09	0.869	0.699	1.568
2207	28LH09	0.869	0.699	1.568
2214	28LH09	1.092	0.879	1.971
2221	28LH09	0.869	0.699	1.568
2228	24LH07	0.825	0.664	1.490
2326	28LH08	1.069	0.860	1.929
2347	26K9	0.660	0.531	1.191
2256	24LH06	0.946	0.762	1.708
2249	26K9	0.660	0.531	1.191
2332	28LH10	1.089	0.877	1.965
2355	24LH07	0.825	0.664	1.490
2201	28LH09	0.869	0.699	1.568
2208	28LH09	0.869	0.699	1.568
2215	28LH09	1.092	0.879	1.971
2222	28LH09	0.869	0.699	1.568
2229	24LH07	0.825	0.664	1.490
2327	28LH08	1.069	0.860	1.929
2348	26K9	0.660	0.531	1.191
2257	24LH06	0.946	0.762	1.708
2250	26K9	0.660	0.531	1.191
2333	28LH10	1.089	0.877	1.965
1437	28LH08	1.069	0.860	1.929
1383	24LH09	1.004	0.808	1.813
1384	24LH09	1.004	0.808	1.813
1396	28LH09	1.014	0.816	1.831
1431	24LH06	0.946	0.586	1.708
1433	24LH09	0.670	0.539	1.209
2334	28LH10	1.089	0.877	1.965
2314	32LH09	1.223	0.984	2.207
2307	24LH06	0.977	0.787	1.764
2300	22K4	0.405	0.326	0.731
2293	28LH07	0.977	0.787	1.764
2286	28LH07	0.977	0.787	1.764
2279	28LH09	0.936	0.754	1.690
2364	28LH07	0.977	0.787	1.764
2371	24LH06	0.823	0.510	1.487
2378	24LH06	0.888	0.550	1.604
2315	32LH09	1.223	0.984	2.207
2308	24LH06	0.977	0.787	1.764
2301	22K4	0.405	0.326	0.731

Sample of RAM Member Deflection Output

Gravity System | Column Design | 3/3

Column Spot Check

Main Roof
5 W14×68
4 W14×68
3 W14×132
2 W14×132
1 W14×132

Column 6B - Interior Column W14×132

Worst case loading from level 3, look at W14×132

$l_u = 16.67'$

From RAM output, $P_u = 710.19^k$

AISC Table 4-1 : 16.67' unbraced length (check 16' & 17')

$KL = 16'$ $\phi P_n = 1440^k > 710^k$ ✓
$KL = 17'$ $\phi P_n = 1410^k > 710^k$ ✓

W14×132 is acceptable for design

Roof
5 W12×45
4 W12×45
3 W12×79
2 W12×79
1 W12×79

Column 8A - Exterior Column W12×79

$l_u = 16.67'$

From RAM output, $P_u = 371.75 = 372^k$

$M_{ux} = 7.48$ k-ft $M_{uy} = 7.16$ k-ft

Check Table 6-1 in AISC, exposed to shear & flexure

$KL = 16'$: $p = 1.28 \times 10^{-3}$ $b_x = 2.13 \times 10^{-3}$
→ $KL = 17'$: $p = 1.33 \times 10^{-3}$ $b_x = 2.16 \times 10^{-3}$ $b_y = 3.51 \times 10^{-3}$

$pP_u = 1.33 \times 10^{-3}(371.75) = .49 \geq .2$ ∴ use Eqn 6-1

$pP_u + b_x M_{ux} + b_y M_{uy} \leq 1.0$

$1.33 \times 10^{-3}(371.75) + 2.16 \times 10^{-3}(7.48) + 3.51 \times 10^{-3}(7.16) = .54 < 1.0$ ✓

W12×79 is acceptable for design

Gravity Column Design

RAM Steel 14.06.01.00
DataBase: RAM Model Gravity and Lateral March 29 03/30/15 23:12:21
Building Code: IBC Steel Code: AISC 360-10 LRFD

Story level 4th Floor, Column Line 6-B

Fy (ksi) = 50.00 Column Size = W14X132
Orientation (deg.) = 90.0

INPUT DESIGN PARAMETERS:

		X-Axis	Y-Axis
Lu (ft)		16.67	16.67
K		1	1
Braced Against Joint Translation		Yes	Yes
Column Eccentricity (in)	Top	9.85	9.85
	Bottom	9.85	9.85

CONTROLLING COLUMN LOADS - Skip-Load Case 4:

			Dead	Live	Roof
Axial (kip)			438.57	107.73	23.08
Moments	Top	Mx (kip-ft)	-0.07	-0.03	0.00
		My (kip-ft)	0.00	0.00	0.00
	Bot	Mx (kip-ft)	-0.11	-1.90	0.00
		My (kip-ft)	-0.00	-9.39	0.00

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

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

Pu (kip) =	710.19	0.90*Pn (kip) =	1419.31
Mux (kip-ft) =	3.17	0.90*Mnx (kip-ft) =	877.50
Muy (kip-ft) =	15.02	0.90*Mny (kip-ft) =	423.75
Rm =	1.00		
Cbx =	1.72		
Cmx =	0.58	Cmy =	0.60
Pex (kip) =	10943.48	Pey (kip) =	3919.63
B1x =	1.00	B1y =	1.00

INTERACTION EQUATION

Pu/0.90*Pn = 0.500
Eq H1-1a: 0.500 + 0.003 + 0.032 = 0.535

Gravity Column Design

RAM Steel 14.06.01.00 Page 2/3
DataBase: RAM Model Gravity and Lateral March 29 03/30/15 23:12:21
Building Code: IBC Steel Code: AISC 360-10 LRFD

Story level 3rd Floor, Column Line 6-B

Fy (ksi) = 50.00 Column Size = W14X132
Orientation (deg.) = 90.0

INPUT DESIGN PARAMETERS:

		X-Axis	Y-Axis
Lu (ft)		17.33	17.33
K		1	1
Braced Against Joint Translation		Yes	Yes
Column Eccentricity (in)	Top	9.85	9.85
	Bottom	9.85	9.85

CONTROLLING COLUMN LOADS - Skip-Load Case 3:

			Dead	Live	Roof
Axial (kip)			565.13	161.59	23.08
Moments	Top	Mx (kip-ft)	-0.10	-0.04	0.00
		My (kip-ft)	-0.00	0.00	0.00
	Bot	Mx (kip-ft)	-0.08	-1.50	0.00
		My (kip-ft)	0.00	10.36	0.00

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

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

Pu (kip) =	948.25	0.90*Pn (kip) =	1395.76
Mux (kip-ft) =	2.50	0.90*Mnx (kip-ft) =	877.50
Muy (kip-ft) =	16.58	0.90*Mny (kip-ft) =	423.75
Rm =	1.00		
Cbx =	1.76		
Cmx =	0.57	Cmy =	0.60
Pex (kip) =	10125.81	Pey (kip) =	3626.76
B1x =	1.00	B1y =	1.00

INTERACTION EQUATION

Pu/0.90*Pn = 0.679
Eq H1-1a: 0.679 + 0.003 + 0.035 = 0.717

Gravity Column Design

RAM Steel 14.06.01.00 Page 3/3
DataBase: RAM Model Gravity and Lateral March 29 03/30/15 23:12:21
Building Code: IBC Steel Code: AISC 360-10 LRFD

Story level 2nd floor, Column Line 6-B

Fy (ksi)	= 50.00	Column Size	= W14X132
Orientation (deg.)	= 90.0		

INPUT DESIGN PARAMETERS:

		X-Axis	Y-Axis
Lu (ft)		20.00	20.00
K		1	1
Braced Against Joint Translation		Yes	Yes
Column Eccentricity (in)	Top	9.85	9.85
	Bottom	0.00	0.00

CONTROLLING COLUMN LOADS - Skip-Load Case 6:

			Dead	Live	Roof
Axial (kip)			692.04	191.89	23.08
Moments	Top	Mx (kip-ft)	-0.07	-0.03	0.00
		My (kip-ft)	0.00	8.98	0.00
	Bot	Mx (kip-ft)	0.00	0.00	0.00
		My (kip-ft)	0.00	0.00	0.00

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

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

Pu (kip)	= 1149.02	0.90*Pn (kip)	= 1295.81
Mux (kip-ft)	= 0.14	0.90*Mnx (kip-ft)	= 877.50
Muy (kip-ft)	= 14.91	0.90*Mny (kip-ft)	= 423.75
Rm	= 1.00		
Cbx	= 1.67		
Cmx	= 0.60	Cmy	= 0.60
Pex (kip)	= 7602.68	Pey (kip)	= 2723.05
B1x	= 1.00	B1y	= 1.04

INTERACTION EQUATION

Pu/0.90*Pn = 0.887
Eq H1-1a: 0.887 + 0.000 + 0.031 = 0.918

Gravity Column Design

RAM Steel 14.06.01.00
DataBase: RAM Model Gravity and Lateral March 29 03/30/15 23:34:39
Building Code: IBC Steel Code: AISC 360-10 LRFD

Story level 4th Floor, Column Line 8-A

Fy (ksi)	= 50.00	Column Size	= W12X79
Orientation (deg.)	= 90.0		

INPUT DESIGN PARAMETERS:

	X-Axis	Y-Axis
Lu (ft)	16.67	16.67
K	1	1
Braced Against Joint Translation	Yes	Yes
Column Eccentricity (in) Top	8.70	8.55
Bottom	8.70	8.55

CONTROLLING COLUMN LOADS - Skip-Load Case 2:

	Dead	Live	Roof
Axial (kip)	226.28	58.89	11.97
Moments Top Mx (kip-ft)	2.67	1.22	0.00
My (kip-ft)	-0.00	0.00	0.00
Bot Mx (kip-ft)	3.87	1.77	0.00
My (kip-ft)	0.00	4.48	0.00

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

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

Pu (kip)	= 371.75	0.90*Pn (kip)	= 762.46
Mux (kip-ft)	= 7.48	0.90*Mnx (kip-ft)	= 446.25
Muy (kip-ft)	= 7.16	0.90*Mny (kip-ft)	= 203.63
Rm	= 1.00		
Cbx	= 2.21		
Cmx	= 0.32	Cmy	= 0.60
Pex (kip)	= 4735.02	Pey (kip)	= 1544.96
B1x	= 1.00	B1y	= 1.00

INTERACTION EQUATION

Pu/0.90*Pn = 0.488
Eq H1-1a: 0.488 + 0.015 + 0.031 = 0.534

Gravity Column Design

RAM Steel 14.06.01.00 Page 2/3
DataBase: RAM Model Gravity and Lateral March 29 03/30/15 23:34:39
Building Code: IBC Steel Code: AISC 360-10 LRFD

Story level 3rd Floor, Column Line 8-A

Fy (ksi) = 50.00 Column Size = W12X79
Orientation (deg.) = 90.0

INPUT DESIGN PARAMETERS:

		X-Axis	Y-Axis
Lu (ft)		17.33	17.33
K		1	1
Braced Against Joint Translation		Yes	Yes
Column Eccentricity (in)	Top	8.70	8.55
	Bottom	8.70	8.55

CONTROLLING COLUMN LOADS - Skip-Load Case 4:

			Dead	Live	Roof
Axial (kip)			291.55	84.21	11.97
Moments	Top	Mx (kip-ft)	3.73	1.62	0.00
		My (kip-ft)	0.00	0.00	0.00
	Bot	Mx (kip-ft)	3.05	0.00	0.00
		My (kip-ft)	-0.00	-4.70	0.00

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

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

Pu (kip)	= 490.59	0.90*Pn (kip)	= 743.36
Mux (kip-ft)	= 7.07	0.90*Mnx (kip-ft)	= 446.25
Muy (kip-ft)	= 7.53	0.90*Mny (kip-ft)	= 203.63
Rm	= 1.00		
Cbx	= 2.18		
Cmx	= 0.39	Cmy	= 0.60
Pex (kip)	= 4381.23	Pey (kip)	= 1429.53
B1x	= 1.00	B1y	= 1.00

INTERACTION EQUATION

Pu/0.90*Pn = 0.660
Eq H1-1a: 0.660 + 0.014 + 0.033 = 0.707

Gravity Column Design

RAM Steel 14.06.01.00
DataBase: RAM Model Gravity and Lateral March 29
Building Code: IBC

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03/30/15 23:34:39
Steel Code: AISC 360-10 LRFD

Story level 2nd floor, Column Line 8-A

Fy (ksi) = 50.00 Column Size = W12X79
Orientation (deg.) = 90.0

INPUT DESIGN PARAMETERS:

		X-Axis	Y-Axis
Lu (ft)		20.00	20.00
K		1	1
Braced Against Joint Translation		Yes	Yes
Column Eccentricity (in)	Top	8.70	8.55
	Bottom	0.00	0.00

CONTROLLING COLUMN LOADS - Skip-Load Case 10:

			Dead	Live	Roof
Axial (kip)			357.04	99.50	11.97
Moments	Top	Mx (kip-ft)	2.65	1.15	0.00
		My (kip-ft)	-0.00	-4.06	0.00
	Bot	Mx (kip-ft)	0.00	0.00	0.00
		My (kip-ft)	0.00	0.00	0.00

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

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

Pu (kip)	= 593.63	0.90*Pn (kip)	= 664.12
Mux (kip-ft)	= 5.01	0.90*Mnx (kip-ft)	= 446.25
Muy (kip-ft)	= 8.72	0.90*Mny (kip-ft)	= 203.63
Rm	= 1.00		
Cbx	= 1.67		
Cmx	= 0.60	Cmy	= 0.60
Pex (kip)	= 3289.53	Pey (kip)	= 1073.32
B1x	= 1.00	B1y	= 1.34

INTERACTION EQUATION

Pu/0.90*Pn = 0.894
Eq H1-1a: 0.894 + 0.010 + 0.038 = 0.942

Appendix E

Vibration Analysis

Gravity Redesign | Vibration Analysis | 1/4

Vibration Check

28LH09 joists, 4.75' spacing 40' span SW = 21 plf
36G8N23.7* joist girders 38' span SW = 69 plf

DL = 52 psf + joist SW
LL = 65 psf = P_o → reduction = 41 psf

Slab: 3 1/4" LW conc
$f'_c = 3500$
1.5" deck, 4.75" total thickness } 34 psf

$f_{allow} = 50$ ksi

Joist Properties

Determine I_{chord}

$M_{all} = \frac{wL_n^2}{8}$ $w = 667$ plf (ASD)
$L_n = 40' - .33' = 39.67'$

$M_{all} = \frac{667(39.67)^2}{8} = 131.21$ ft-k

$A_j = .85 A_{chord} = .85(A_{top} + A_{bot})$ $A_{top} = 1.25 A_{bot}$ $A_{chord} = A_{top} + A_{bot}$

$A_{bot} = \frac{M_{all}}{(d-1")f_{all}} = \frac{131.21 \cdot 12}{(28-1)(50)} = 1.17 \text{ in}^2$ $A_{top} = 1.46 \text{ in}^2$ $A_{chord} = 2.63 \text{ in}^2$

$A_j = .85(2.63) = 2.24 \text{ in}^2$ $A_j = 2.24 \text{ in}^2$

$y_c = .5" + \frac{A_{bot}(d-1")}{A_{chord}} = .5 + \frac{1.17(28-1)}{2.63}$ $y_c = 12.51"$

$I_{chord} = A_{top}(y_c - .5")^2 + A_{bot}(d - y_c - .5")^2$
$= 1.46(12.51 - .5)^2 + 1.17(28 - 12.51 - .5)^2 = 473.5 \text{ in}^4 = I_{chord}$

$n = E_s / 1.35E_c = 29000 / 1.35 w_c^{1.5}\sqrt{f'c} = 29000 / [1.35(115)^{1.5}\sqrt{3.5}]$ $n = 9.31$

$\bar{y} = \frac{\Sigma Ay}{\Sigma A} = \frac{[(4.75 \cdot 12 \cdot 7/?)/9.31](3.25)(2) + 2.63(4.75 + 12.51)}{[(4.75 \cdot 12)/9.31](3.25) + 2.63}$ $\bar{y} = 3.67"$

$I_{comp} = \Sigma I + \Sigma Ad^2$
$= [(4.75 \cdot 12)/9.31](3.25)^3 + 473.5 + 2.63(12.51 + 4.75 - 3.67)^2$
$+ [(4.75 \cdot 12)/9.31](3.25)(3.67 - 1.5)^2$

$I_{comp} = 1263.1 \text{ in}^4$

Gravity Redesign | Vibration Analysis | 2/4

Using Design Guide 11, pg 15 $L/d = 40(12)/28 = 17.14 \rightarrow$ use eqn 3.16

$C_r = 0.90(1-e^{-.28(L/d)})^{2.8} = 0.90(1-e^{-.28(17.14)})^{2.8}$ $C_r = .88$

$\gamma = \frac{1}{C_r} - 1 = \frac{1}{.88} - 1$ $\gamma = .136$

$I_j = \frac{1}{\frac{\gamma}{I_{chord}} + \frac{1}{I_{comp}}} = \frac{1}{\frac{.136}{4735} + \frac{1}{1063.4}}$ $I_j = 926.85$ $I_j < I_{comp}$ ✓

Determine Δ_j

$W_j = 4.75(52+65) = 555.75$ plf

$\Delta_j = \frac{5 w_j L_j^4}{384 E I_j} = \frac{5(555.75)(40)^4(1728)}{384(29e^6)(926.85)} = 1.19''$

$D_s = \frac{12 d_e^3}{12n} = \frac{12(3.25+.5)^3}{12(9.31)} = 5.66 \text{ in}^3$

$D_j = I_j/S = 926.85/(4.75 \times 12) = 16.26 \text{ in}^3$

$B_j = C_j(D_s/D_j)^{1/4} L_j$ $C_j = 2.0$ $= 2.0(5.66/16.26)^{1/4}(40') = 61.44'$

$W_j = (\omega_j/S) B_j L_j = (555.75/4.75)(61.44)(40)$ $W_j = 287.58 \sim 288^k$

Girder Properties

Determine I_{chord}

$M_{all} = \frac{wL_n^2}{8}$ $w = 23.7(7)/38'$ $w = 4.37$ klf $= 4366$ plf
$L_n = 38' - .33 = 37.67'$

$M = \frac{4366(37.67)^2}{8}$ $M_{all} = 774.4$ ft-k

$A_g = .85 A_{chord} = .85(A_{top} + A_{bot})$ $A_{top} = 1.25 A_{bot}$ $A_{chord} = A_{top} + A_{bot}$

$A_{bot} = \frac{M_{all}}{(d-1)f_{all}} = \frac{774.4 \cdot 12}{(36-1)(50)} = 5.31 \text{ in}^2$ $A_{top} = 6.64 \text{ in}^2$ $A_{chord} = 11.95 \text{ in}^2$

$A_g = .85(11.95)$ $A_g = 10.16 \text{ in}^2$

$y_c = .5 + \frac{A_{bot}(d-1'')}{A_{chord}} = \frac{.5 + 5.31(36-1)}{11.95}$ $y_c = 15.59''$

$I_{chord} = A_{top}(y_c - .5'')^2 + A_{bot}(d - y_c - .5'')^2$
$= 6.64(15.59-.5)^2 + 5.31(36-15.59-.5)^2$ $I_{chord} = 3616.91 \text{ in}^4$

Gravity Redesign | Vibration Analysis | 3/4

$n = E_s / 1.35E_c = 29000 / 1.35(115)^{1.5}\sqrt{3.5} = 9.31$

$b_{eff} = span/8 + span/8 = span/4 = 38/4 = 9.5'$

$\bar{y} = \frac{\Sigma Ay}{\Sigma A} = \frac{((9.5 \times 12)/9.31)(3.25)(1.5) + 11.95(4.75 + 15.59)}{[(9.5 \times 12)/9.31](3.25) + 11.95}$ $\bar{y} = 5.85''$

$I_{comp} = \Sigma I + \Sigma Ad^2$

$= [(9.5 \times 12)/9.31)(3.25)^3 + 3616.91 + 11.95(15.59 + 4.75 - 5.85)^2$

$+ [(9.5 \times 12)/9.31](3.25)(5.85 - 1.5)^2$

$I_{comp} = 120.34 + 3616.91 + 2509.023 + 753.04$ $I_{comp} = 4044.31\ in^4$

$L/d = 38(12)/36 = 12.67 \rightarrow$ eqn 3.16

$C_r = 0.90(1 - e^{-.28(L/d)})^{2.8} = 0.90(1 - e^{-.28(12.67)})^{2.8}$ $C_r = .83$

$\gamma = \frac{1}{C_r} - 1 = \frac{1}{.83} - 1$ $\gamma = .21$

$I_g = \frac{1}{\frac{\gamma}{I_{chord}} + \frac{1}{I_{comp}}} = \frac{1}{\frac{.21}{3616.91} + \frac{1}{4044.31}} = 3287.66 = I_g$ $I_g < I_{comp}$

Determine Δ_g

$W_g = 9.5(52 + 65) + 69$ plf SW $= 1180.5$ plf

$\Delta_g = \frac{5 w_g L_g^4}{384 E I_g} = \frac{5(1180.5)(38)^4(1728)}{384(29e^6)(3287.66)} = .58''$

$D_s = 12 d_e^3 / 12n = \frac{12(3.25 + .5)^3}{12(9.31)} = 5.66\ in^3$

$D_g = I_g / L_g = 3287.66 / (38 \times 12) = 7.21$

$B_g = C_g (D_j / D_g)^{1/4} L_g = 2.0(16.26 / 7.21)^{1/4}(38') = 93.13$

$W_g = (w_g / b_{eff}) B_g L_g = (1180.5/9.5)(93.13)(38) = 439.76^k \sim 440$

$W = \frac{\Delta_j}{\Delta_j + \Delta_g} W_j + \frac{\Delta_g}{\Delta_j + \Delta_g} W_g = \frac{1.19}{1.19 + .58}(287.58) + \frac{.58}{1.19 + .58}(439.76)$ $W = 337.44^k$

$f_n = 0.18\sqrt{\frac{g}{\Delta_g + \Delta_j}}$ $g = 386.4\ in/sec^2$

Gravity Redesign | Vibration Analysis | 9/4

$f_n = 0.18\sqrt{\frac{386.4}{.58+1.19}}$ $f_n = 2.66$ Hz

$\frac{a_p}{g} = \frac{P_o \exp(-0.35 f_n)}{\beta W} \leq \frac{a_o}{g}$

$\frac{a_o}{g} = 0.005$

$\beta = 0.05$

$\frac{a_p}{g} = \frac{65 \exp(-0.35 \times 2.66)}{0.05 \times (337.44 \times 1000)} = .0015 < .005 \therefore$ OK

System vibrations are within walking excitation limits.

Appendix F

Wind Loads

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WIND LOAD CALCULATIONS

· calculated using ASCE 7-05

1) Occupancy Category – II from drawings

confirmed in table 1-1

2) Wind Load Importance Factor

From drawings, V=90 mph, category II
I=1.00, From drawing, I=1.00 → match

3) Basic Wind Speed, From Figure 6-1, confirmed on dwgs

V=90 mph

4) Wind Load Parameters

a. Wind Directionality Factor, K_d, from Table 6-4, confirmed on dwgs.

$K_d = 0.85$

b. Exposure Category (§6.5.6.3)

Exposure B → confirmed in drawings (case 2, not low rise building)

c. Topographic Factor, K_{zt} (§6.4.2.1 & §6.5.7, Table 6-4)

$K_{zt} = 1.0$ → confirmed on dwgs → $K_{zt} = 1.0$ (2-D escarpment) no hill

d. Gust Effect Factor (§6.5.8)

From commentary

$n_1 = 100/H$ → average value $= 100/83 = 1.20$

$n_1 = 75/H$ → lower bound $= 75/83 = .90$ ← use this value to be conservative

exposure B factors (from Table 6-2)

$\alpha = 7.0$
z_g(ft) = 1200
$\hat{a} = 1/7$
$\hat{b} = 0.84$
$\bar{\alpha} = 1/4.0$
$\bar{b} = 0.45$
c = 0.30
ℓ(ft) = 320
$\bar{\epsilon} = 1/3.0$
z_{min}(ft) = 30

$\bar{z}$ = equivalent height of structure $= .6h = .6(83) = 49.8'$

For buildings without concrete shear walls, a simplified procedure can be used

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$$N_1 = \frac{n_1 L_z}{\bar{V}_z} = \frac{.90(367.05)}{74.80} \qquad N_1 = 4.417$$

$$L_z = \ell\left(\frac{\bar{z}}{33}\right)^{\bar{\epsilon}} = 320\left(\frac{49.8}{33}\right)^{1/3} = 367.05 \text{ ft}$$

$$\bar{V}_z = \bar{b}\left(\frac{\bar{z}}{33}\right)^{\bar{\alpha}} V\left(\frac{88}{60}\right) = 0.45\left(\frac{49.8}{33}\right)^{1/4} 90\left(\frac{88}{60}\right) = 65.84 \text{ ft/s}$$

$$Q = \sqrt{\frac{1}{1+0.63\left(\frac{B+h}{L_z}\right)^{0.63}}}$$

h = mean roof height = 83'
B = horizontal dimension of building normal to wind direction
BNS = 326'
BEW = 394'

$$Q_{NS} = \sqrt{\frac{1}{1+.63\left(\frac{326+83}{367.05}\right)}} = .77$$

$$Q_{EW} = \sqrt{\frac{1}{1+.63\left(\frac{394+83}{367.05}\right)}} = .74$$

$$G = 0.925\left(\frac{1+1.7 g_Q I_z Q}{1+1.7 g_v I_z}\right)$$

From §6.5.8.1, g_Q & g_v = 3.4

$$I_z = c\left(\frac{33}{\bar{z}}\right)^{1/6} = .30\left(\frac{33}{49.8}\right)^{1/6} = .28$$

$$G_{NS} = 0.925\left(\frac{1+1.7(3.4)(.28)(.77)}{1+1.7(3.4)(.28)}\right) \qquad G_{NS} = .79$$

$$G_{EW} = 0.925\left(\frac{1+1.7(3.4)(.28)(.74)}{1+1.7(3.4)(.28)}\right) \qquad G_{EW} = .78$$

1.6184

e. Enclosure Classification (§6.5.9 & §6.2)

- Building is enclosed as it does not meet "open" and "partially enclosed" conditions

f. Internal Pressure Coefficient Figure 6-5

$GC_{pi} = \pm 0.18$ for enclosed buildings

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CP Values (Figure 6-6)

- Wind typically blows Southwest in the area the Corporate Headquarters is located. It tends to hit more vertically than horizontally, so for this reason, the north side of the building will be considered windward and the south side will be considered leeward.

L = horizontal dimension of building parallel to wind direction
B = horizontal dimension of building normal to wind direction

Wall C_p Values

Windward wall: $C_p = 0.8$ use with q_z

leeward wall: B = 326' L = 394' $L/B = 394/326 = 1.21$

- need to interpolate to find C_p

$$x = \frac{(1.21-1)(-0.3+0.5)}{(2-1)} + -0.5$$

L/B	Cp
0-1	-0.5
1.21	x
2	-0.3

$C_p = -0.46$ use with q_h

Side wall: $C_p = -0.7$, use with q_h

Roof C_p Values

Roof has 0° slope
- horizontal distance from windward edge = 394' h = 83'
394 > 2h
$C_p = -0.3, -0.18$

Find Wind Pressures

$K_z = 2.01(z/z_g)^{2/\alpha}$ z = height of floor above ground

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

$p = q G_f C_p$

Floor #	z (ft)	Kz	qz (psf)
2	20	0.62	11.0
3	37.33	0.75	13.14
4	54	0.83	14.61
5	68.67	0.89	15.64
roof	83.33	0.94	16.53

Excel Equations: $p = qCP_i$ $G_{NS} = .79$ $G_{EW} = .78$ $q_h \sim 16.5$'

Building width NS = 326' Building width EW = 394'

* See excel sheet for values

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Wind Pressure for Roof

$p = q_h G C_p$

$q_h = 0.00256[2.01(83.33/1200)^{2/7}](1.0)(.85)(90^2)(1.0) = 16.78$ psf

N-S direction

windward: $p = 16.78(.79)(-0.3) = -3.98$ psf

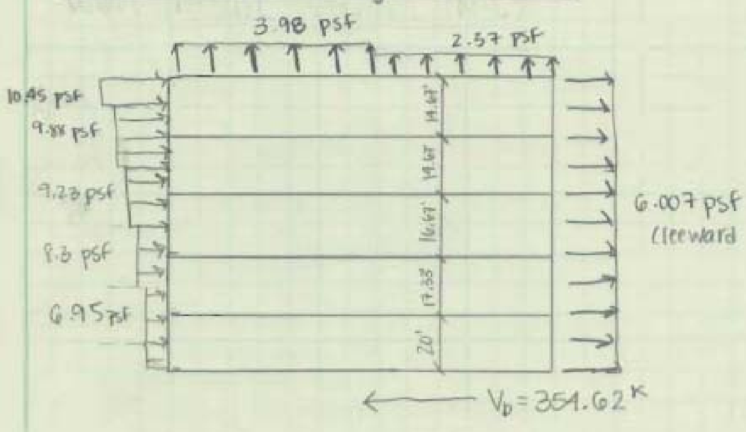
leeward: $p = 16.78(.79)(-0.18) = -2.37$ psf

E-W direction

windward: $p = 16.78(.78)(-0.3) = -3.93$ psf

leeward: $p = 16.78(.78)(-0.18) = -2.36$ psf

Wind Pressure Diagram (N-S)



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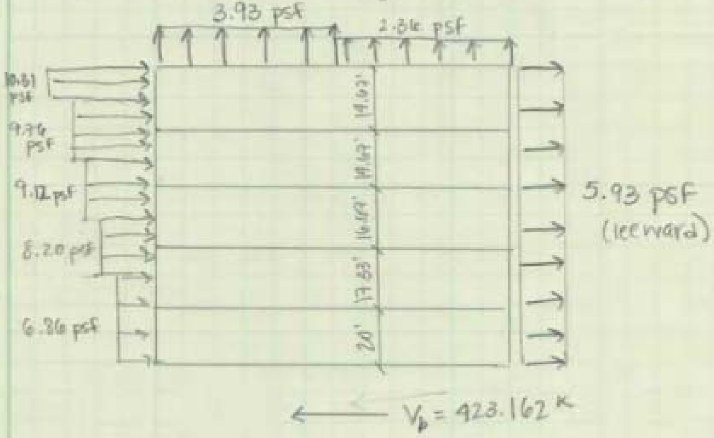
Wind Pressure Diagram (E-W)



Wind Pressure (North-South Direction)							
Floor	z (ft)	qz (PSF)	Windward Pressure (PSF)	Leeward Pressure (PSF)	Tributary Area	Force (K)	Overturning Moment (ft-k)
2	20	11	6.952	-6.007	6096	78.998	1579.962
3	37.33	13.14	8.304	-6.007	5542	79.314	2960.800
4	54	14.61	9.234	-6.007	5314	80.988	4373.359
5	68.67	15.64	9.884	-6.007	4782	75.993	5218.444
roof	83.33	16.53	10.447	-6.007	2390	39.325	3276.950
					Base	354.618	17409.515

Wind Pressure (East-West Direction)							
Floor	z (ft)	qz (PSF)	Windward Pressure (PSF)	Leeward Pressure (PSF)	Tributary Area	Force (K)	Overturning Moment (ft-k)
2	20	11	6.864	-5.931	7368	94.273	1885.466
3	37.33	13.14	8.199	-5.931	6698	94.645	3533.094
4	54	14.61	9.117	-5.931	6422	96.636	5218.328
5	68.67	15.64	9.759	-5.931	5780	90.690	6227.687
roof	83.33	16.53	10.315	-5.931	2888	46.918	3909.638
					Base	423.162	20774.214

Loads and Applied Forces

RAM Frame 14.06.01.00
DataBase: RAM Model Gravity and Lateral March 29 04/01/15 15:30:07

LOAD CASE: Wind 2

Wind ASCE 7-05 / IBC2006/2009
Exposure: B
Basic Wind Speed (mph): 90.0 Importance Factor: 1.000
Apply Directionality Factor, Kd = 0.85
Use Topography Factor, Kzt: 1.00
Use Calculated Frequency for X-Dir.
Use Calculated Frequency for Y-Dir.
Gust Factor for Rigid Structures, G: Use Calculated G for X-Dir.
Gust Factor for Rigid Structures, G: Use Calculated G for Y-Dir.
Damping Ratio for Flexible Structures= 0.01
Mean Roof Height (ft): Top Story Height = 83.34
Ground Level: Base

WIND PRESSURES:

X-Direction: Natural Frequency = 1.617 Structure is Rigid
Y-Direction: Natural Frequency = 2.270 Structure is Rigid
CpWindward = 0.80 qLeeward (qh) = 16.53 psf
GCpn (Parapet): Windward = 1.50 Leeward = -1.00

Height	Kz	Kzt	qz	Gust Factor G		CpLeeward		Pressure (psf)	
ft			psf	X	Y	X	Y	X	Y
83.34	0.938	1.000	16.534	0.786	0.783	-0.487	-0.500	16.724	16.827
68.67	0.888	1.000	15.645	0.786	0.783	-0.487	-0.500	16.165	16.269
54.00	0.829	1.000	14.606	0.786	0.783	-0.487	-0.500	15.512	15.619
37.33	0.746	1.000	13.144	0.786	0.783	-0.487	-0.500	14.593	14.704
20.00	0.624	1.000	10.998	0.786	0.783	-0.487	-0.500	13.243	13.359
0.00	0.575	1.000	10.130	0.786	0.783	-0.487	-0.500	12.698	12.816

APPLIED DIAPHRAGM FORCES

Type: Wind_IBC09_1_X

Level	Diaph.#	Ht	Fx	Fy	X	Y
		ft	kips	kips	ft	ft
Main Roof Level	1	83.34	48.28	0.00	62.00	-100.50
5th Floor	1	68.67	94.29	0.00	62.00	-100.50
4th Floor	1	54.00	96.36	0.00	62.00	-100.50
3rd Floor	1	37.33	98.20	0.00	62.00	-100.50
2nd floor	1	20.00	99.21	0.00	62.00	-100.50

APPLIED STORY FORCES

Type: Wind_IBC09_1_X

Level	Ht	Fx	Fy
	ft	kips	kips
Main Roof Level	83.34	48.28	0.00
5th Floor	68.67	94.29	0.00
4th Floor	54.00	96.36	0.00
3rd Floor	37.33	98.20	0.00

Loads and Applied Forces

RAM Frame 14.06.01.00 Page 2/10
DataBase: RAM Model Gravity and Lateral March 29 04/01/15 15:30:07

2nd floor	20.00	99.21	0.00
		436.34	0.00

APPLIED DIAPHRAGM FORCES

Type: Wind_IBC09_1_Y

Level	Diaph.#	Ht ft	Fx kips	Fy kips	X ft	Y ft
Main Roof Level	1	83.34	0.00	51.72	62.00	-100.50
5th Floor	1	68.67	0.00	101.04	62.00	-100.50
4th Floor	1	54.00	0.00	103.31	62.00	-100.50
3rd Floor	1	37.33	0.00	105.35	62.00	-100.50
2nd floor	1	20.00	0.00	106.54	62.00	-100.50

APPLIED STORY FORCES

Type: Wind_IBC09_1_Y

Level	Ht ft	Fx kips	Fy kips
Main Roof Level	83.34	0.00	51.72
5th Floor	68.67	0.00	101.04
4th Floor	54.00	0.00	103.31
3rd Floor	37.33	0.00	105.35
2nd floor	20.00	0.00	106.54
		0.00	467.97

APPLIED DIAPHRAGM FORCES

Type: Wind_IBC09_2_X+E

Level	Diaph.#	Ht ft	Fx kips	Fy kips	X ft	Y ft
Main Roof Level	1	83.34	36.21	0.00	62.00	-40.80
5th Floor	1	68.67	70.72	0.00	62.00	-40.80
4th Floor	1	54.00	72.27	0.00	62.00	-40.80
3rd Floor	1	37.33	73.65	0.00	62.00	-40.80
2nd floor	1	20.00	74.40	0.00	62.00	-40.80

APPLIED STORY FORCES

Type: Wind_IBC09_2_X+E

Level	Ht ft	Fx kips	Fy kips
Main Roof Level	83.34	36.21	0.00
5th Floor	68.67	70.72	0.00
4th Floor	54.00	72.27	0.00

Appendix G

Seismic Loads

Seismic Loads | Final Report | 1/2

Seismic Load Calculation

1) Building not exempt (§11.1.2)

2) Design Spectral Response Acceleration (§11.4)

a) Site Class C

b) Acceleration Parameters

$S_s = 0.175g$

$S_1 = 0.051g$

c) site class effects (§11.4.3)

$F_a = 1.2$

$F_v = 1.7$

$S_{ms} = F_a S_s = 1.2(0.175) = 0.21g$ $S_{sm} = 0.21g$

$S_{m1} = F_v S_1 = 1.7(0.051) = 0.0867g$ $S_{m1} = 0.0867g$

d) Determine Spectral Acceleration Parameters (§11.4.4)

$S_{DS} = 2/3 S_{MS} = 2/3(0.21)$ $S_{DS} = 0.14$

$S_{D1} = 2/3 S_{M1} = 2/3(0.0867)$ $S_{D1} = 0.0578$

3) Find Seismic Design Category

occupancy category II

Importance factor = 1.0

$S_{DS} < 0.167$ → category A

-matches given SDC A given in drawings

4) Analysis Procedure Selection

§11.7 - buildings and other structures assigned to SDC A need only comply with the requirements of section 11.7

§11.7.1 - seismic loads shall be taken as "E" and combined with other load combinations from Sections 2.3 & 2.4

§1.4 - Eqn 1.4-1 $F_x = 0.01 W_x$

5-9) Skip due to SDC A

10) Calculate effective total seismic weight (W) for each floor

Roof Area = 121940 SF

$W_{RF} = area[DL + .20S] = (121940[84 + .2(17)])/1000 = 10658^k$

Floor 5 & 4 area = 121940 SF $W_4 = W_5 = 6341^k$

$W_{F_{4,5}} = (2)121940(52)/1000 = 12682$ K

Floor 2 : area = 145,500 SF

$W_{F_2} = 145,500(52)/1000 = 7566$ K

Seismic Loads cont | Final Report | 2/2

Courtyard Level
regular floor loading area = 121940 SF
courtyard green roof area = 23560 SF

$W_{reg\ floor} = 121940(52)/1000 = 6341^k$
$W_{green\ roof} = 23560[100 + .2(17)]/1000 = 2436\ k$ } $8777^k = W_{F_3}$

Total Building Seismic Weight = ΣW

$W = 39683^k$ $W = 10658 + 12682 + 7566 + 8777 = 39683^k$

11) Calculate Base shear (V)

$V = C_s W$ $V = 0.01(39683)$ $V = 396.83 \sim 397^k$

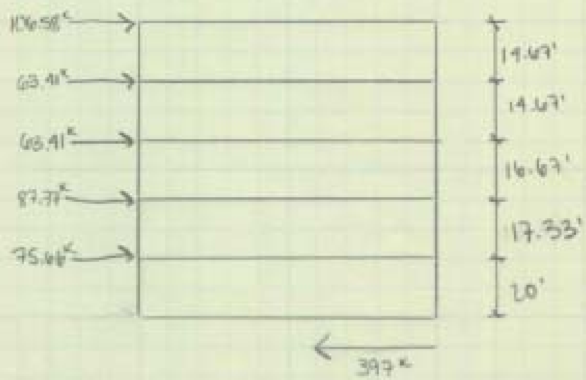
12) Vertical Distribution of Seismic Forces
SDCA → $F_x = 0.01\ W_x$

$F_{ROOF} = 0.01(10658) = 106.58^k$

$F_{level\ 4} = F_{level\ 5} = 0.01(6341) = 63.41^k$

$F_{courtyard\ level} = 0.01(8777) = 87.77^k$

$F_{level\ 2} = 0.01(7566) = 75.66^k$



Overturning Moment
8882.38 ft-k
4354.36 ft-k
3424.14 ft-k
3276.45 ft-k
1513.2 ft-k
ΣM = 21450.53 ft-k

Appendix H

Shear Wall Check

Lateral System | Shear Wall Check | 1/2

30.5' Shear wall — Base level check — $h_w = 83.3'$

$M_u = 4050.9$ k-ft — length = 30.5' — $f'c = 3500$ psi

$V_u = 167.6^k$ — thickness = 12" — $f_y = 60$ ksi

$P_u = 760.57^k$ — #4's @ 12" horizontal & vertical reinf; use (8) #6 flexural reinforcing each end

Shear: $V_u \le \phi V_{n\,max} = \phi 10\sqrt{f'c}\, hd$ — $\phi = .75$ for shear

$d = .8\ell = .8(30.5 \times 12)$ $d = 292.8"$

$\phi V_n = 0.75(10)\sqrt{3500}(6)(292.8)/1000 = 779.5$ kips

$167.6 < 779.5$ ∴ ok

shear strength of concrete $V_c = 2\sqrt{f'c}\, hd$

$V_c = 2\sqrt{3500}(6)(292.8)/1000 = 207.9^k$

$\frac{1}{2}\phi V_c = \frac{1}{2}(.75)(207.9) = 77.95^k < 167.6^k$ ∴ shear reinforcing req'd

check reinforcing provided

for #4 bar, $A_s = 0.2\, in^2/ft$ — $\frac{A_v}{s} = \frac{V_s}{f_y d}$ — $V_s = \frac{A_v}{s} f_y d$

$V_s = \left(\frac{0.2}{12}\right)(60{,}000)(292.8) = 292.8^k$

$\phi V_n = \phi(V_c + V_s) = 77.95 + .75(292.8)$ — $\phi V_n = 297.55$

$\phi V_n = 297.55 > 167.6 = V_u$ ∴ ok

$\rho_t = \frac{A_v}{S_h} = \frac{2(0.2)}{12(12)} = .00278 > .0025$ ∴ ok

spacing ok ✓

use (2) #4 bars @ 12" O.C. for horizontal shear reinforcing

check vertical shear reinforcing

$\rho_\ell = A_v/Sh \ge 0.0025 + 0.5\left(2.5 - \frac{h_w}{\ell_w}\right)(0.0028 - 0.0025)$

$\rho_\ell = A_v/Sh \ge 0.0025 + 0.5\left(2.5 - \frac{83.3}{30.5}\right)(0.0028 - .0025) = .0024 < .0025$

use $\rho_\ell \ge 0.0025$ as a minimum

Lateral System | Shear Wall Check | 2/2

$\frac{A_v}{Sh} = \frac{2(0.2)}{12(12)} = 0.0028 > 0.0025 \rightarrow$ ok

use (2) #4 bars @ 12" o.c. for vertical reinforcement

Check flexural reinforcement

$d = 0.8\ell_w = 0.8(30.5 \times 12) = 292.8$

$M_u = 4050.9$ ft-k

$M_u \le \phi M_n = \phi A_s f_y jd$

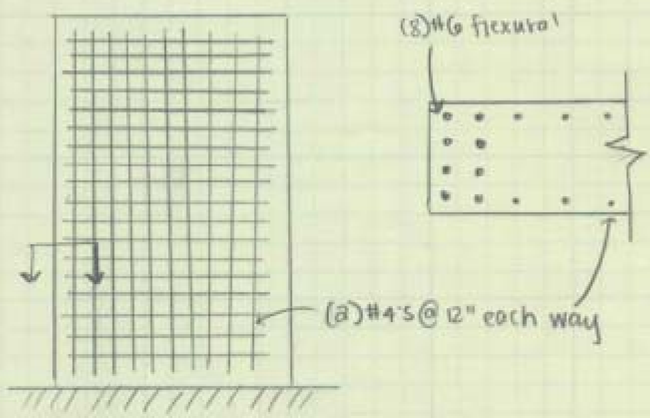
$a = \frac{A_s f_y}{.85 f'c\, b}$ for (8) #6, $A_s = 3.52\ in^2$

$a = \frac{3.52(60)}{.85(2.5)(6)} = 11.83$ $jd = d - a/2 = 292.8 - 11.83/2$ $jd = 286.88$

$4050.9(12) \le (.85)(3.52)(60)(286.88)$

$48610.8 \le 51500.70 \therefore$ ok

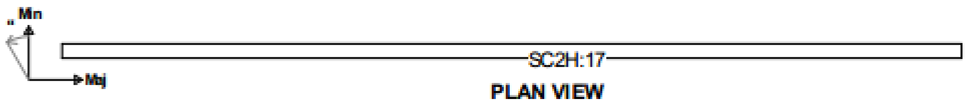
(8) #6 bars is adequate for flexural reinforcement



Section Cut Design Summary

RAM Concrete Shearwall 14.06.01.00
Database: RAM Model Gravity and Lateral March 29 04/01/15 20:20:12
Design Code: ACI 318-08

Section Cut ID: SC2H:17 (Horizontal)
Story: 2nd floor
Ag = 2196 in2 Imaj = 24513946 in4 Imin = 6588 in4
Major Axis Orientation: 0.00 degrees (CCW from global X-axis)
Wall Design Group: 2
Design Status: PASS



PLAN VIEW

Axial/Flexural Results:

Interaction:	0.249	OK	
Pu =	760.57 kips	phiPn =	3054.97 kips
Mu =	4050.9 kip-ft	at Beta =	-0.0 deg CCW from Major axis
Controlling Load Combo:	0.900 D - 1.600 W1 (LC 42)		
Code Ref:	10.3.7		

Shear Results:

Segment SC2H:17:
Length = 30.50 ft Thick = 6.00 in f'c = 3500 psi fy = 60 ksi
Vert Bar Pat: #4@12" oc Horiz Bar Pat: #4@12" oc
Vu = 167.6 kip phiVn = 587.1 kip OK
Controlling Load Combo: 0.900 D + 1.600 W1 (LC 30)
Code Ref: 14.2.3 & 11.9.5

Reinforcement Checks:

Min Vert Reinf Ratio: Limit: 0.250% Actual: 0.572% (11.9.9.4) OK
Segment SC2H:17:
Max Vert Bar Spacing Limit: 18.00 in Actual: 12.00 in (11.9.9.5) OK
Min Vert Bar Spacing Limit: 1.00 in Actual: 11.50 in (7.6.1) OK
Min Longit Reinf Ratio Limit: 0.545% Actual: 0.545% (21.9.4.3) OK
Min Number of Reinf Curtains: 1 Actual: 2 (14.3.4) OK
Min Number of Reinf Curtains: 1 Actual: 2 (21.9.2.2) OK

Appendix I

Story Drifts and Center of Rigidity

Center of Rigidity

RAM Frame 14.06.01.00
DataBase: Existing Building RAM Model April 7 04/07/15 16:25:16

CRITERIA:

Rigid End Zones: Ignore Effects
Member Force Output: At Face of Joint
P-Delta: Yes Scale Factor: 1.00
Ground Level: Base
Mesh Criteria :
Max. Distance Between Nodes on Mesh Line (ft) : 4.00
Merge Node Tolerance (in) : 0.0100
Geometry Tolerance (in) : 0.0050
Walls Out-of-plane Stiffness Not Included in Analysis.
Sign considered for Dynamic Load Case Results.
Rigid Links Included at Fixed Beam-to-Wall Locations
Eigenvalue Analysis : Eigen Vectors

			Centers of Rigidity		Centers of Mass	
Level	**Diaph. #**	**Type**	**Xr**	**Yr**	**Xm**	**Ym**
			ft	**ft**	**ft**	**ft**
Main Roof Level	1	Rigid	61.14	-76.32	68.90	-111.43
5th Floor	1	Rigid	63.93	-66.54	68.63	-111.59
4th Floor	1	Rigid	65.36	-60.50	68.66	-111.59
3rd Floor	1	Rigid	69.30	-55.90	70.03	-107.25
2nd floor	1	Rigid	57.88	-42.54	70.27	-107.01

			Story Lateral Stiffness	
Level	**Diaph. #**	**Type**	**KX**	**KY**
			kips/ ft	**kips/ ft**
Main Roof Level	1	Rigid	15133.34	27342.70
5th Floor	1	Rigid	18677.74	28740.48
4th Floor	1	Rigid	23277.28	36810.86
3rd Floor	1	Rigid	32540.51	48020.54
2nd floor	1	Rigid	57339.36	71555.50

NOTES:
Center of rigidity (CR) values given above are only used for load cases that require explicit calculation of CRs for use in calculation of load eccentricities (for example, ASCE 7-05 Wind Load Case).

Note that this information is never used for analysis. On the other hand, it should be noted that analysis results always include any torsional effects due to having center of rigidity and mass center at different locations. In other words, the analysis always accounts for locations and stiffnesses of frame members and diaphragms. Hence, any torsional effects of the masses being offset from the stiffnesses (i.e., CR) are implicitly and correctly accounted in the analysis.

Existing Building Center of Rigidity

Story Displacements

RAM Frame 14.06.01.00
DataBase: Existing Building RAM Model April 7 04/07/15 16:25:16
Building Code: IBC

CRITERIA:

Rigid End Zones: Ignore Effects
Member Force Output: At Face of Joint
P-Delta: Yes Scale Factor: 1.00
Ground Level: Base
Mesh Criteria :
Max. Distance Between Nodes on Mesh Line (ft) : 4.00
Merge Node Tolerance (in) : 0.0100
Geometry Tolerance (in) : 0.0050
Walls Out-of-plane Stiffness Not Included in Analysis.
Sign considered for Dynamic Load Case Results.
Rigid Links Included at Fixed Beam-to-Wall Locations
Eigenvalue Analysis : Eigen Vectors

LOAD CASE DEFINITIONS:

D	DeadLoad	RAMUSER
Lp	PosLiveLoad	RAMUSER
E1	Seismic	EQ_User
W1	Wind	W_User
W2	ASCE 7 WIND	Wind_IBC09_1_X
W3	ASCE 7 WIND	Wind_IBC09_1_Y
W4	ASCE 7 WIND	Wind_IBC09_2_X+E
W5	ASCE 7 WIND	Wind_IBC09_2_X-E
W6	ASCE 7 WIND	Wind_IBC09_2_Y+E
W7	ASCE 7 WIND	Wind_IBC09_2_Y-E
W8	ASCE 7 WIND	Wind_IBC09_3_X+Y
W9	ASCE 7 WIND	Wind_IBC09_3_X-Y
W10	ASCE 7 WIND	Wind_IBC09_4_X+Y_CW
W11	ASCE 7 WIND	Wind_IBC09_4_X+Y_CCW
W12	ASCE 7 WIND	Wind_IBC09_4_X-Y_CW
W13	ASCE 7 WIND	Wind_IBC09_4_X-Y_CCW
E2	ASCE 7 Seismic	EQ_IBC09_X_+E_F
E3	ASCE 7 Seismic	EQ_IBC09_X_-E_F
E4	ASCE 7 Seismic	EQ_IBC09_Y_+E_F
E5	ASCE 7 Seismic	EQ_IBC09_Y_-E_F

Level: Main Roof Level, Diaph: 1

Center of Mass (ft): (68.90, -111.43)

LdC	Disp X	Disp Y	Theta Z
	in	in	rad
D	-0.01438	0.04909	0.00001
Lp	-0.01068	0.03566	0.00001
E1	0.65083	0.01278	0.00004
W1	0.52824	0.01184	0.00003
W2	0.55501	0.01241	0.00004
W3	0.01007	0.40886	-0.00000

Existing Building Story Displacements

Story Displacements

RAM Frame 14.06.01.00
DataBase: Existing Building RAM Model April 7
Building Code: IBC

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W4	0.38845	0.00605	-0.00003
W5	0.44406	0.01257	0.00008
W6	0.03875	0.31031	0.00006
W7	-0.02365	0.30297	-0.00007
W8	0.42381	0.31595	0.00002
W9	0.40870	-0.29733	0.00003
W10	0.27360	0.23177	-0.00007
W11	0.36211	0.24216	0.00011
W12	0.26227	-0.22820	-0.00007
W13	0.35078	-0.21780	0.00011
E2	0.24413	0.00478	0.00001
E3	0.25496	0.00618	0.00003
E4	0.01169	0.17107	0.00002
E5	0.00018	0.16958	-0.00001

Level: 5th Floor, Diaph: 1

Center of Mass (ft): (68.63, -111.59)

LdC	Disp X in	Disp Y in	Theta Z rad
D	-0.02653	0.06082	0.00002
Lp	-0.01873	0.04302	0.00001
E1	0.54512	0.01052	0.00004
W1	0.46494	0.00940	0.00004
W2	0.48845	0.00986	0.00004
W3	0.00983	0.36319	-0.00000
W4	0.33887	0.00507	-0.00002
W5	0.39380	0.00971	0.00008
W6	0.03818	0.27500	0.00005
W7	-0.02344	0.26978	-0.00006
W8	0.37371	0.27979	0.00003
W9	0.35897	-0.26500	0.00003
W10	0.23657	0.20614	-0.00006
W11	0.32399	0.21354	0.00010
W12	0.22552	-0.20245	-0.00006
W13	0.31293	-0.19505	0.00010
E2	0.20752	0.00390	0.00001
E3	0.21789	0.00484	0.00003
E4	0.01146	0.14819	0.00001
E5	0.00042	0.14718	-0.00001

Level: 4th Floor, Diaph: 1

Center of Mass (ft): (68.66, -111.59)

LdC	Disp X in	Disp Y in	Theta Z rad
D	-0.02924	0.06461	0.00001

Existing Building Story Displacements cont'd

Story Displacements

RAM Frame 14.06.01.00
DataBase: Existing Building RAM Model April 7
Building Code: IBC

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Lp	-0.02045	0.04493	0.00001
E1	0.41869	0.00853	0.00004
W1	0.36230	0.00740	0.00003
W2	0.38001	0.00777	0.00003
W3	0.00808	0.28532	-0.00000
W4	0.26255	0.00418	-0.00001
W5	0.30746	0.00747	0.00006
W6	0.03123	0.21584	0.00004
W7	-0.01911	0.21214	-0.00005
W8	0.29106	0.21982	0.00002
W9	0.27895	-0.20817	0.00003
W10	0.18258	0.16224	-0.00005
W11	0.25402	0.16748	0.00008
W12	0.17349	-0.15875	-0.00004
W13	0.24493	-0.15350	0.00008
E2	0.15800	0.00313	0.00001
E3	0.16629	0.00378	0.00002
E4	0.00926	0.11401	0.00001
E5	0.00044	0.11332	-0.00001

Level: 3rd Floor, Diaph: 1

Center of Mass (ft): (70.03, -107.25)

LdC	Disp X in	Disp Y in	Theta Z rad
D	-0.02129	0.05413	0.00001
Lp	-0.01480	0.03718	0.00001
E1	0.27801	0.00788	0.00003
W1	0.22891	0.00668	0.00002
W2	0.24059	0.00702	0.00002
W3	0.00414	0.18801	-0.00000
W4	0.16648	0.00468	-0.00001
W5	0.19441	0.00585	0.00004
W6	0.01875	0.14166	0.00003
W7	-0.01254	0.14036	-0.00003
W8	0.18355	0.14627	0.00001
W9	0.17734	-0.13574	0.00002
W10	0.11546	0.10878	-0.00003
W11	0.15987	0.11063	0.00005
W12	0.11080	-0.10273	-0.00002
W13	0.15521	-0.10088	0.00006
E2	0.09959	0.00294	0.00001
E3	0.10476	0.00316	0.00002
E4	0.00537	0.07456	0.00001
E5	-0.00013	0.07433	-0.00000

Existing Building Story Displacements cont'd

Story Displacements

RAM Frame 14.06.01.00
DataBase: Existing Building RAM Model April 7
Building Code: IBC

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Level: 2nd floor, Diaph: 1

Center of Mass (ft): (70.27, -107.01)

LdC	Disp X	Disp Y	Theta Z
	in	in	rad
D	-0.02086	0.04525	0.00001
Lp	-0.01441	0.03078	0.00000
E1	0.11116	0.00923	0.00002
W1	0.09501	0.00770	0.00001
W2	0.10017	0.00809	0.00001
W3	0.00159	0.08357	-0.00000
W4	0.06700	0.00534	-0.00000
W5	0.08325	0.00680	0.00002
W6	0.01029	0.06350	0.00001
W7	-0.00790	0.06186	-0.00001
W8	0.07632	0.06875	0.00001
W9	0.07393	-0.05661	0.00001
W10	0.04432	0.05040	-0.00001
W11	0.07016	0.05272	0.00003
W12	0.04253	-0.04362	-0.00001
W13	0.06837	-0.04129	0.00003
E2	0.04108	0.00339	0.00000
E3	0.04410	0.00363	0.00001
E4	0.00278	0.03307	0.00000
E5	-0.00043	0.03281	-0.00000

Existing Building Story Displacements cont'd

Center of Rigidity

RAM Frame 14.06.01.00
DataBase: RAM Model Gravity and Lateral March 29 04/01/15 17:33:48

CRITERIA:

Rigid End Zones: Ignore Effects
Member Force Output: At Face of Joint
P-Delta: Yes Scale Factor: 1.00
Ground Level: Base
Mesh Criteria :
Max. Distance Between Nodes on Mesh Line (ft) : 4.00
Merge Node Tolerance (in) : 0.0100
Geometry Tolerance (in) : 0.0050
Walls Out-of-plane Stiffness Not Included in Analysis.
Sign considered for Dynamic Load Case Results.
Rigid Links Included at Fixed Beam-to-Wall Locations
Eigenvalue Analysis : Eigen Vectors

			Centers of Rigidity		Centers of Mass	
Level	**Diaph. #**	**Type**	**Xr**	**Yr**	**Xm**	**Ym**
			ft	**ft**	**ft**	**ft**
Main Roof Level	1	Rigid	128.30	-127.04	69.30	-111.86
5th Floor	1	Rigid	125.77	-123.34	69.94	-110.29
4th Floor	1	Rigid	122.08	-118.03	69.98	-110.15
3rd Floor	1	Rigid	115.90	-108.87	70.91	-105.24
2nd floor	1	Rigid	107.29	-95.49	70.96	-105.04

			Story Lateral Stiffness	
Level	**Diaph. #**	**Type**	**KX**	**KY**
			kips/ ft	**kips/ ft**
Main Roof Level	1	Rigid	39048.61	59632.67
5th Floor	1	Rigid	53978.85	82333.23
4th Floor	1	Rigid	68228.74	101710.96
3rd Floor	1	Rigid	104353.22	151009.51
2nd floor	1	Rigid	163043.16	218744.04

NOTES:
Center of rigidity (CR) values given above are only used for load cases that require explicit calculation of CRs for use in calculation of load eccentricities (for example, ASCE 7-05 Wind Load Case).

Note that this information is never used for analysis. On the other hand, it should be noted that analysis results always include any torsional effects due to having center of rigidity and mass center at different locations. In other words, the analysis always accounts for locations and stiffnesses of frame members and diaphragms. Hence, any torsional effects of the masses being offset from the stiffnesses (i.e., CR) are implicitly and correctly accounted in the analysis.

Redesign System Center of Rigidity

Story Displacements

RAM Frame 14.06.01.00
DataBase: RAM Model Gravity and Lateral March 29 04/01/15 17:33:48
Building Code: IBC

CRITERIA:

Rigid End Zones: Ignore Effects
Member Force Output: At Face of Joint
P-Delta: Yes Scale Factor: 1.00
Ground Level: Base
Mesh Criteria :
Max. Distance Between Nodes on Mesh Line (ft) : 4.00
Merge Node Tolerance (in) : 0.0100
Geometry Tolerance (in) : 0.0050
Walls Out-of-plane Stiffness Not Included in Analysis.
Sign considered for Dynamic Load Case Results.
Rigid Links Included at Fixed Beam-to-Wall Locations
Eigenvalue Analysis : Eigen Vectors

LOAD CASE DEFINITIONS:

D	DeadLoad	RAMUSER
Lp	PosLiveLoad	RAMUSER
Rfp	PosRoofLiveLoad	RAMUSER
W1	Wind 2	Wind_IBC09_1_X
W2	Wind 2	Wind_IBC09_1_Y
W3	Wind 2	Wind_IBC09_2_X+E
W4	Wind 2	Wind_IBC09_2_X-E
W5	Wind 2	Wind_IBC09_2_Y+E
W6	Wind 2	Wind_IBC09_2_Y-E
W7	Wind 2	Wind_IBC09_3_X+Y
W8	Wind 2	Wind_IBC09_3_X-Y
W9	Wind 2	Wind_IBC09_4_X+Y_CW
W10	Wind 2	Wind_IBC09_4_X+Y_CCW
W11	Wind 2	Wind_IBC09_4_X-Y_CW
W12	Wind 2	Wind_IBC09_4_X-Y_CCW
E1	Seismic	EQ_IBC09_X_+E_F
E2	Seismic	EQ_IBC09_X_-E_F
E3	Seismic	EQ_IBC09_Y_+E_F
E4	Seismic	EQ_IBC09_Y_-E_F
ND1	Notional	NL_AISC360_DL_X
ND2	Notional	NL_AISC360_DL_Y
NL1	Notional	NL_AISC360_LL_X
NL2	Notional	NL_AISC360_LL_Y
NR1	Notional	NL_AISC360_Rf_X
NR2	Notional	NL_AISC360_Rf_Y

Level: Main Roof Level, Diaph: 1

Center of Mass (ft): (69.30, -111.86)

LdC	Disp X in	Disp Y in	Theta Z rad
D	-0.01926	0.01092	0.00001

Redesign System Story Displacements

Story Displacements

RAM Frame 14.06.01.00
DataBase: RAM Model Gravity and Lateral March 29
Building Code: IBC

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Lp	-0.00987	0.00375	0.00000
Rfp	-0.00141	0.00080	0.00000
W1	0.27178	0.03370	-0.00001
W2	0.03172	0.19373	-0.00004
W3	0.20766	0.04243	-0.00004
W4	0.20001	0.00812	0.00001
W5	0.01943	0.12573	-0.00000
W6	0.02815	0.16487	-0.00006
W7	0.22763	0.17058	-0.00004
W8	0.18005	-0.12002	0.00002
W9	0.17686	0.15548	-0.00007
W10	0.16458	0.10039	0.00001
W11	0.14117	-0.06247	-0.00003
W12	0.12890	-0.11756	0.00005
E1	0.13569	0.01891	-0.00001
E2	0.13395	0.01122	0.00000
E3	0.01374	0.08525	-0.00001
E4	0.01560	0.09343	-0.00002
ND1	0.08567	0.00951	-0.00000
ND2	0.00942	0.05680	-0.00001
NL1	0.01844	0.00191	-0.00000
NL2	0.00195	0.01231	-0.00000
NR1	0.00568	0.00068	-0.00000
NR2	0.00064	0.00375	-0.00000

Level: 5th Floor, Diaph: 1

Center of Mass (ft): (69.94, -110.29)

LdC	Disp X in	Disp Y in	Theta Z rad
D	-0.01408	0.00784	0.00001
Lp	-0.00727	0.00439	0.00000
Rfp	-0.00102	0.00050	0.00000
W1	0.22215	0.02549	-0.00001
W2	0.02440	0.15954	-0.00003
W3	0.16955	0.03267	-0.00003
W4	0.16366	0.00556	0.00001
W5	0.01494	0.10419	0.00000
W6	0.02166	0.13512	-0.00005
W7	0.18491	0.13877	-0.00003
W8	0.14831	-0.10054	0.00002
W9	0.14341	0.12584	-0.00006
W10	0.13395	0.08231	0.00001
W11	0.11596	-0.05364	-0.00002
W12	0.10651	-0.09717	0.00004
E1	0.10981	0.01432	-0.00001
E2	0.10846	0.00830	0.00000

Redesign System Story Displacements cont'd

Story Displacements

RAM Frame 14.06.01.00 Page 3/5
DataBase: RAM Model Gravity and Lateral March 29 04/01/15 17:33:48
Building Code: IBC

E3	0.01053	0.08963	-0.00001
E4	0.01196	0.07605	-0.00002
ND1	0.06871	0.00712	-0.00000
ND2	0.00720	0.04585	-0.00001
NL1	0.01541	0.00145	-0.00000
NL2	0.00151	0.01038	-0.00000
NR1	0.00442	0.00051	-0.00000
NR2	0.00048	0.00292	-0.00000

Level: 4th Floor, Diaph: 1

Center of Mass (ft): (69.98, -110.15)

LdC	Disp X in	Disp Y in	Theta Z rad
D	-0.00918	0.00508	0.00000
Lp	-0.00478	0.00300	0.00000
Rfp	-0.00066	0.00029	0.00000
W1	0.16866	0.01760	-0.00001
W2	0.01668	0.12253	-0.00002
W3	0.12825	0.02322	-0.00002
W4	0.12474	0.00318	0.00001
W5	0.01051	0.08047	0.00000
W6	0.01451	0.10333	-0.00004
W7	0.13901	0.10510	-0.00002
W8	0.11399	-0.07870	0.00001
W9	0.10707	0.09491	-0.00004
W10	0.10144	0.06274	0.00001
W11	0.08831	-0.04294	-0.00002
W12	0.08268	-0.07511	0.00003
E1	0.08256	0.00993	-0.00001
E2	0.08175	0.00552	0.00000
E3	0.00725	0.05309	-0.00001
E4	0.00811	0.05779	-0.00001
ND1	0.05123	0.00484	-0.00000
ND2	0.00490	0.03455	-0.00001
NL1	0.01198	0.00100	-0.00000
NL2	0.00105	0.00817	-0.00000
NR1	0.00320	0.00035	-0.00000
NR2	0.00033	0.00214	-0.00000

Level: 3rd Floor, Diaph: 1

Center of Mass (ft): (70.91, -105.24)

LdC	Disp X in	Disp Y in	Theta Z rad
D	-0.00472	0.00260	0.00000
Lp	-0.00248	0.00160	0.00000

Redesign System Story Displacements cont'd

Story Displacements

RAM Frame 14.06.01.00
DataBase: RAM Model Gravity and Lateral March 29
Building Code: IBC

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Rfp	-0.00053	0.00013	0.00000
W1	0.10660	0.00941	-0.00000
W2	0.00955	0.07855	-0.00001
W3	0.08114	0.01301	-0.00001
W4	0.07876	0.00111	0.00001
W5	0.00581	0.05213	0.00000
W6	0.00852	0.06570	-0.00002
W7	0.08711	0.06597	-0.00001
W8	0.07278	-0.05186	0.00001
W9	0.06724	0.05903	-0.00003
W10	0.06343	0.03992	0.00001
W11	0.05649	-0.02934	-0.00001
W12	0.05268	-0.04845	0.00002
E1	0.05182	0.00537	-0.00000
E2	0.05128	0.00277	0.00000
E3	0.00407	0.03394	-0.00000
E4	0.00465	0.03672	-0.00001
ND1	0.03182	0.00254	-0.00000
ND2	0.00277	0.02178	-0.00000
NL1	0.00779	0.00053	-0.00000
NL2	0.00061	0.00540	-0.00000
NR1	0.00196	0.00018	-0.00000
NR2	0.00018	0.00133	-0.00000

Level: 2nd floor, Diaph: 1

Center of Mass (ft): (70.96, -105.04)

LdC	Disp X in	Disp Y in	Theta Z rad
D	-0.00140	0.00078	0.00000
Lp	-0.00074	0.00050	0.00000
Rfp	-0.00010	0.00004	0.00000
W1	0.04682	0.00293	-0.00000
W2	0.00288	0.03562	-0.00001
W3	0.03524	0.00462	-0.00001
W4	0.03499	-0.00021	0.00000
W5	0.00201	0.02396	0.00000
W6	0.00230	0.02947	-0.00001
W7	0.03727	0.02892	-0.00000
W8	0.03296	-0.02452	0.00000
W9	0.02816	0.02557	-0.00001
W10	0.02775	0.01781	0.00000
W11	0.02492	-0.01451	-0.00000
W12	0.02451	-0.02227	0.00001
E1	0.02254	0.00175	-0.00000
E2	0.02248	0.00070	0.00000
E3	0.00130	0.01537	-0.00000

Redesign System Story Displacements cont'd

Story Displacements

RAM Frame 14.06.01.00
DataBase: RAM Model Gravity and Lateral March 29
Building Code: IBC

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E4	0.00138	0.01649	-0.00000
ND1	0.01365	0.00076	0.00000
ND2	0.00084	0.00964	-0.00000
NL1	0.00357	0.00015	0.00000
NL2	0.00019	0.00255	-0.00000
NR1	0.00078	0.00006	-0.00000
NR2	0.00006	0.00055	-0.00000

Redesign System Story Displacements cont'd

Redesign Wind Drifts (E-W)		
	Story Drift (in)	Total Drift (in)
Main Roof	0.272	0.816
Level 5	0.222	0.544
Level 4	0.169	0.322
Level 3	0.106	0.153
Level 2	0.047	0.047

Existing Wind Drifts (E-W)		
	Story Drift (in)	Total Drift (in)
Main Roof	0.555	1.764
Level 5	0.488	1.209
Level 4	0.38	0.721
Level 3	0.241	0.341
Level 2	0.1	0.1

Redesign Wind Drifts (N-S)		
	Story Drift (in)	Total Drift (in)
Main Roof	0.194	0.592
Level 5	0.16	0.398
Level 4	0.123	0.238
Level 3	0.079	0.115
Level 2	0.036	0.036

Existing Wind Drifts (N-S)		
	Story Drift (in)	Total Drift (in)
Main Roof	0.409	1.329
Level 5	0.363	0.92
Level 4	0.285	0.557
Level 3	0.188	0.272
Level 2	0.084	0.084

Redesign Seismic Drift		
	Story Drift (in)	Total Drift (in)
Main Roof	0.136	0.404
Level 5	0.11	0.268
Level 4	0.083	0.158
Level 3	0.052	0.075
Level 2	0.023	0.023

Existing Seismic Drift		
	Story Drift (in)	Total Drift (in)
Main Roof	0.244	0.751
Level 5	0.208	0.507
Level 4	0.158	0.299
Level 3	0.1	0.141
Level 2	0.041	0.041

Appendix J

Green Roof Materials Technical Information

Basic Product Specs

Please contact a LiveRoof Representative for access to the LiveRoof® Spec Writer for customized 3 part green roof specifications.

Get a Detailed Spec

MODULE SIZE	**LiveRoof Standard:** 1' x 2' x 3-1/4" (soil height appx. 4-1/4") **LiveRoof Lite:** 1' x 2' x 1-3/4" (soil height appx. 2-1/2") **LiveRoof Deep:** 1' x 2' x 3-1/4" (soil height appx. 6") **LiveRoof Maxx:** 1' x 1' x 3-1/4" (soil height appx. 8") Soil fills soil elevator, plants and soil obscure module edges.
MODULE WEIGHT	**Standard and Deep:** 14 oz./sq. ft. **Lite:** 10.5 oz./sq. ft. **Maxx:** 14 oz./sq. ft.
MATERIAL	100% recycled polypropylene (avg. 10% post-consumer, 90% post-industrial) 100 mil. thick walls.
WATER DISPERSAL	Approx. 10.0 gal. per min. per lineal foot. *Hi-Flow option available with standard and deep module.*
MODULE COLOR	Black or gray
WEIGHT VEGETATED (fully saturated)	**LiveRoof Standard:** approx. 27-29 lbs./SF

LiveRoof Lite: approx. 15-17 lbs./SF

LiveRoof Deep: approx. 40-50 lbs./SF
LiveRoof Maxx 8": approx. 55-65 lbs/SFDRAINAGEPositive drain holes, at lowest point in module.

SOIL MEDIAProprietary LiveRoof specified engineered soil, based upon German FLL granulometric specifications, 94+% by dry weight inorganic content for minimal shrinkage/decomposition. (92% in British Columbia).
Dry weight approx. 60-65 lbs/cu.ft.
May vary somewhat with local grower.

ACCEPTABLE PROTECTIVE UNDERLYING MATERIALSModules to be placed directly upon heavy duty (HDPE, Polypropylene, TPO, EPDM or recyclable PVC) slip sheet/root barrier of 40-60 mil. thickness with effectively bonded seams. This is placed as an additional protective barrier above roof waterproofing membrane and extended 3 inches vertically along parapet to ward against edge abrasion. This may also be glued to parapet if manufacturer approves.

Confirm suitability of waterproofing membrane with manufacturer. Alternatively low profile drain boards work well and manufacturers of cold fluid applied reinforced urethane membranes typically warrant their systems for use in conjunction with the LiveRoof® system.

IRRIGATION SYSTEMIrrigation is recommended for backup during prolonged hot, dry and windy weather patterns.Simple overhead system is inexpensive and effective insurance. *Irrigation requirements are dependent on plant selection, climate and roof design.*

> In hot, humid or arid climates, irrigation systems should always be installed and used as needed given weather conditions.
> Similarly, irrigation systems are necessary on pitched green roofs and those in wind-challenged conditions, such as in coastal areas and on tall buildings.

> If LiveRoof Lite system is used, irrigation will be essential in all climates.
> If the Deep system is used and populated with non-succulents, irrigation is also essential.

EDGE TREATMENTSCoengineered RoofEdge® aluminum edging with adequate drain perforations recommended. Any edging should allow for adequate drainage (extending to the bottom of the edging) with sidewalls tall enough to completely cover the modules and contain the soil.PAVERSCoengineered LiveRoof RoofStone® recommended.WIND UPLIFTPatent-pending WindDisc™ method for improving wind uplift resistance is recommended for green roofs subject to high wind conditions.PLANTSDrought-tolerant, hardy RoofTop Proven™ plants recommended. Consult the Licensed Grower in your region for specific recommendations.CONVEYANCE METHODPrevegetated modules to be delivered by Hoppit® or other appropriately engineered conveyance device.

http://www.liveroof.com/basic-product-specs/

ANCHOR™
BUILD SOMETHING BEAUTIFUL

Paver Benefits

SEGMENTAL PAVING - The most versatile option featuring individual units placed by hand or machine. Superior design flexibility and an upgraded appearance stand out from typical paving applications.

PAVEMENT TYPES	APPEARANCE	INITIAL COST & INSTALLATION	MAINTENANCE	WINTER DURABILITY	SNOW REMOVAL
Concrete Pavers Best Choice	The widest range of surface finishes, colors, shapes, and sizes. Laying patterns can complement the architectural style of any home because of the wide variety of styles available.	Moderate - Tightly fitted, uniform units are placed over a sand bed and a compacted aggregate base. Immediately ready for use. Can be installed by homeowner or an ICPI Certified Professional.	Low—Stained or broken pavers can be easily replaced without patches. Dark colored pavers can help hide stains. Factory-made pavers last for decades.	High—Small, high density units resist cracking as well as damage from freeze-thaw cycles and salts. Pavers are stronger than ordinary or stamped concrete.	Smooth surface allows for easy snow removal. Darker colored pavers help melt snow faster. Snow-melt systems can be easily integrated to eliminate snow and ice removal.
Cobble Stone	Gives elegant, permanent, yet informal "Old World" feel.	Highest—Non-uniform units must be fitted together by hand.	Low—High quality stone lasts for decades. Wide joints may encourage weeds and ants. Rough surface makes walking and driving dificult.	High—High density stone resists cracking and salts.	Rough surface makes plowing difficult.
Clay Brick	Traditionally comes in shades of red and red-brown. Limited shapes and sizes.	Moderate—High-Mortar-set base may be used which increases costs. Natural variations in dimensions may slow installation or cause difficulty in maintaining straight pattern lines.	Low—Natural surface variations may lead to chipping or possible damage.	Moderate—Salts may cause deterioration in some clay pavers.	Smooth surface allows for easy snow removal. Darker colored pavers help melt snow faster.
Other Paving Options					
Stamped Concrete	Surface is usually colored. Patterns designed to give appearance of segmental paving but saw-cut joints may show.	High—Difficult for homeowner to install. Requires special equipment to stamp stone or paver patterns into surface. Surface sealer often used.	Moderate—Cracking may likely develop. Patched repairs may be hard to match to original color. Color fading also possible over time.	Low—Potential for deterioration from de-icing salts.	Uneven surface of some patterns and textures may make plowing difficult.
Ordinary Concrete	Grey or light brown. Can be colored throughout or on surface only.	Moderate—Difficult for homeowner to install and requires 5 to 7 days for hardening before use. Surface quality varies with weather and installation.	Moderate—Cracking may likely develop. Repairs and replaced sections may leave visible patches. Oil stains difficult to remove.	Low—Cracks from freeze-thaw cycles, settlement and salt deterioration may occur.	Smooth initial surface allows for easy removal. Light colored surface may not melt snow rapidly
Asphalt	Few color options. Achieving neat looking edges may be difficult. Stamped asphalt appears painted and artificial	Low—Installs quickly over compacted aggregate base. Must be professionally installed.	High—Wear and weather will break down surface. Black seal coat required every 2-3 years. Rut or pothole repairs leave visible patches. Subject to erosion from oil drippings.	Low—Cracks from freeze-thaw cycles, settlement and salt deterioration may occur.	Smooth surface allows for easy removal. Dark surface accelerates snow melting.
Crushed Stone or Gravel	Typically rustic look. Appearance varies with color and shape of stones.	Low—Dumped and spread over soil (no base required).	High—Scattered stone must be replaced and leveled regularly. Ruts from tires are likely to develop.	High—Stones resist freeze-thaw cycles and salts.	Stones and surface may become uneven during plowing.

Chart reference is taken from the ICPI's brochure "The Beauty of Choosing The Best Pavement. A comparison guide for consumers" and can be found at www.icpi.org.

ANCHOR BLOCK COMPANY
6101 Baker Rd., Suite 205 - Minnetonka, MN 55345
1.800.440.8657 - www.anchorblock.com

Appendix K

Waterproofing Membrane Specifications

MM6125 Physical Properties Chart | HIDE

PROPERTY	TEST METHOD	TYPICAL RESULTS
Flash Point	ASTM D-92, CGSB-37.50-M89	500 °F (260 °C)*
Low Temperature Crack Bridging Capability	CGSB-37.50-M89	No cracking, adhesion loss, or splitting
Water Vapor Permeability	ASTM E 96, Procedure E, CGSB-37.50-M89	1.6 ng/Pa(s)M^2, (0.018 perm)
Water Resistance (5 days/50 °C)	CGSB-37.50-M89	No delamination, blistering, emulsification, or deterioration
Water Absorption	CGSB-37.50-M89	0.22 g weight gain
Toughness	CGSB-37.50-M89	13.0 Joules
Ratio of Toughness to Peak Load	CGSB-37.50-M89	0.069
Viscosity	CGSB-37.50-M89	7.0 seconds
Heat Stability	CGSB-37.50-M89	No change in viscosity, penetration, flow or low temperature flexibility
Low Temperature Flexibility (- 25 °C)	CGSB-37.50-M89	No delamination, flexibility adhesion loss, or cracking
Penetration	ASTM D 1191, CGSB-37.50-M89	75.0 mm @ 77 °F (25 °C), 121.7 mm @ 122 °F (50 °C)
Flow	ASTM D 1191, GSB-37.50-M89	0.0 mm @ 140 °F (60 °C)
Softening Point	ASTM D 36	180 °F (82 °C)
Elongation	ASTM D 1191	1000 % minimum
Resiliency	ASTM D 3407	40% minimum
Bond to Concrete @ 0 °F, (18 °C)	ASTM D 3408	Pass
Hydrostatic Pressure Resistance	ASTM D-08.22, Draft 2	100 psi (=231 foot head of water)
Acid Resistance	ASTM D 896 Procedure 7.1 (N-8)	Pass 50% Nitric Acid, 50% Sulfuric Acid
Salt Water Resistance (20% sodium carbonate and calcium chloride)	ASTM D-896 similar	No delamination, blistering, emulsification, or deterioration
Fertilizer Resistance (undiluted 15/5/5 nitrogen /phosphorus/potash)	ASTM D-896 similar	No delamination, blistering, emulsification, or deterioration
Animal Waste Resistance	3 year exposure	No deterioration
Solids Content	NO	100% no solvents
Shelf Life		10 years (sealed)
Specific Gravity		1.23 ± .02
45 °F more than the application temperature recommended by the manufacturer.		

American Hydrotech MM6125

TYPICAL PHYSICAL PROPERTIES
(Meets or exceeds CGSB-37.50 M89 Standards)

Properties	Test Method	Test Requirement	Test Results	Comments
Color	NA	NONE	N.A.	Black
Softening Point	ASTM-D-36		83°C (181°)	Pass
Solids Content	CGSB-37-GP-50	100%	100%	Pass
Ratio of toughness to peak load	CGSB-37-GP-50	Min.0.040	0.059	Pass
Low temperature crack bridging capacity	CGSB-37-GP-50	No Cracking No Adhesion Loss No Splitting	No Cracking No Adhesion Loss No Splitting	Pass
Toughness, J	CGSB-37-GP-50	Min. 5.5	11.7	Pass
Penetration 0.1 mm	CGSB-37-GP-50	Max 110 @ 25°C (77°F) Max 200 @ 50° C (122°F)	80 @ 25° C 155 @ 50° C	Pass
Flow, MM	CGSB-37-GP-50	Max 3 @ 60°C (140°)	0.50 @ 60° C	Pass
Flash Point	CGSB-37-GP-50 ASTM-D-92	Min 260° C (500° F)	327°C (620°F)	Pass
Water Resistance 50° C (122°F) for 4 days	CGSB-37-GP-50 ASTM-D-92	No delamination No blistering No Emulsification No deterioration No pinholes	No delamination No blistering No Emulsification No deterioration No pinholes	Pass
Adhesion	CGSB-37-GP-50	Min. 1	1.2	Pass
Viscosity	CGSB-37-GP-50	Min 2, Max 15	4 Sec.	Pass
Water Vapor Permeability	CGSB-37-GP-50	Max 1.7 0.35 g max gain	0.18 ng/Pa.m2.s	Pass
Water absorption	CGSB-37-GP-50	Min 0.18 0.18 g max loss	0.22 g gain	Pass
Low Temperature flexibility & adhesion	CGSB-37-GP-50	No Cracking No delamination No adhesion lose	No Cracking No delamination No adhesion loss	Pass
Heat stability	CGSB-37-GP-50	Aged Samples, No change in viscosity, penetration flow or low temp	Aged Samples, No change in viscosity, penetration flow or low temp	Pass

Barret Roofing ram-Tough 250

TREMCO

TYPICAL PHYSICAL PROPERTIES

CAN/CGSB 37.50-M89 Specification for Hot-Applied, Rubberized Asphalt for Roofing and Waterproofing

Property	Requirement	Test Method	Result
Flash Point	Min. 500 °F (260 °C)	ASTM D92	>572 °F (300 °C)
Cone Penetration	Max. 110 dmm at 77 °F (25 °C) Max. 200 dmm at 122 °F (50 °C)	ASTM D3407	As received: <45 dmm at 77 °F (25 °C) <100 dmm at 122 °F (50 °C) After heat aging: <60 dmm at 77 °F (25 °C) <125 dmm at 122 °F (50 °C)
Flow	Max. 3 mm	ASTM D5329	As received: 0 mm After heat aging: 0 mm
Toughness	Min. 5.5 J	CAN/CGSB 37.50-M89; Section 4.4	>10J
Ratio of Toughness to Peak Load	Min. 0.040	CAN/CGSB 37.50-M89; Section 4.5	>0.15
Adhesion Rating	Threads shall be covered with membrane material	CAN/CGSB 37.50-M89; Section 4.6	Pass
Water Absorption	Max. 0.35 g gain in mass	CAN/CGSB 37.50-M89; Section 4.8	<0.3 g gain in mass
Pinholing	Shall not show more than one pinhole	CAN/CGSB 37.50-M89; Section 4.9	No pinholes
Low Temperature Flexibility	Shall not show any cracking	CAN/CGSB 37.50-M89; Section 4.10	As received: No cracking After heat aging: No cracking
Crack Bridging Capability	Shall not show any evidence of cracking, splitting or loss of adhesion	CAN/CGSB 37.50-M89; Section 4.11	Pass
Water Vapor Transmission – Dessicant Method	Max 1.7 ng/Pa*s*m^2	ASTM E96	1.32 ng/Pa*s*m^2
Viscosity Test	2 - 15 s	CAN/CGSB 37.50-M89; Section 4.13	Pass
Shelf Life			24 months when properly stored in original, unopened packaging
Specific Gravity			1.29

Tremco TREMproof 6100

Appendix L

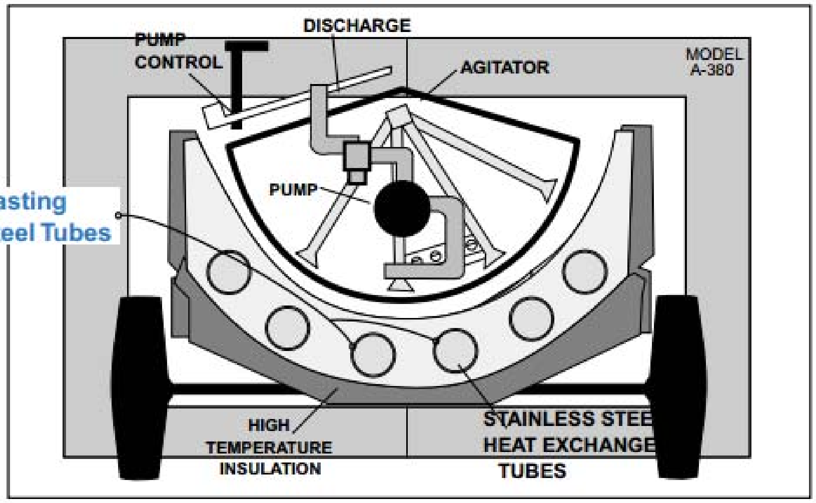
Rubber Melter Specifications

A&A MELTERS

1-888-469-4480

The Superior Air-Jacketed Hot Rubber Melters

380 FRONT END VIEW



SPECIFICATIONS: A-380 (360 US gallon capacity)

Heat Transfer Oil ....None Required Fire tubes..........5" Sch 80 Stainless steel
Capacity (Custom Sizes Available) .... Std. 360 US Gallons
Agitator ....Honda 9.0 H.P. Air-Cooled Engine or Optional Yanmar 7.0 HP Diesel Motor
Overall Dimensions.. L-172" W-80" H-70"
Burner.......Adjustable Liquid Propane 2 X 750,000 BTU or Optional Beckett Diesel Burners
Temperature Controls .... Optional
Inner Shell .... 1/4" Rolled Steel
Outer Shell .... 3/16" Rolled Steel
Insulated Jacket .... 1" Super High Temp. plus 2" High . Fiberglass
Suspension 4" Drop Axle .... 7000 lb. Axle and Springs
Tires .... 2 X 8.00 X 16" 10 Ply Rating
Tandem Axle .... Optional
Chassis .... 6" Steel Channel
Brakes .... Electric Standard
Tow Hitch .... As ordered c/w Safety Chains (2)
Pump .... Optional 2" Viking
Horizontal Wand Pumping System .... Optional
Shipping Weight .... 3,560 lbs.

Heated Material Output:
- material capacity: 360 US gallons — 360 gal. /hr x 85.0% **= 306 gal./hr**
- heat up time: 60 min's (1hr.) — 1,639.3 L /hr x 85.0% = **1,393.3 L/hr.**

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