Appendices

The pages following this page contain the following Appendices:

Appendix A: Wind Load Calculations

Wind Criteria & Calculated Variables

Wind Criteria		
Basic Wind Speed (V)	90 mph	figure 6-1C
Wind Exposure Category	B	
Occupancy Factor	II	
Importance Factor	1	table 6-1
Wind Directionality Factor (K_d)	0.85	table 6-4
Topographic factor (K_{zt})	1	sect 6.5.7.1-2
Number of Stories	9	
Building Height (Ft.)	94	
N-S Building Length (Ft.)	169.75	
E-W Building Length (Ft.)	133.5	
NE-SW Building Length (Ft.)	200.75	
NW-SE Building Length (Ft.)	210.75	
L/B in N-S Direction	1.27	
L/B in E-W Direction	0.79	
L/B in NE-SW Direction	1.05	

Gust Factor			
Variable	Wind Direction		
	N-S	E-W	NE-SW
Stiffness	Rigid	Rigid	Rigid
B (Feet)	133.50	169.75	210.75
L (Feet)	169.75	133.50	200.75
h (Feet)	94.00	94.00	94.00
c	0.30	0.30	0.30
Z	56.40	56.40	56.40
I_z	0.27	0.27	0.27
Lz	202.95	159.61	240.02
∈	0.33	0.33	0.33
Q	0.77	0.73	0.76
gQ & gv	3.40	3.40	3.40
G	0.80	0.77	0.79

	Wind Direction			
	N-S Direction	E-W Direction	NE-SW Direction	
C_p, Windward	0.8	0.8	0.8	figure 6-6
C_p, Leeward	-0.3	-0.5	-0.2	
Gust Factor	0.795	0.773	0.788	
GCpi	0.18	0.18	0.18	figure 6-5

Wind Pressures

Height (Feet)	K_z	q_z	Wind Pressures (psf)		
			N-S Windward	N-S Leeward	N-S Total
94	0.97	17.10	13.95	-7.16	21.11
90	0.96	16.92	13.81	-7.16	20.97
80	0.93	16.39	13.38	-7.16	20.53
70	0.89	15.69	12.80	-7.16	19.96
60	0.85	14.98	12.23	-7.16	19.38
50	0.81	14.28	11.65	-7.16	18.81
40	0.76	13.40	10.93	-7.16	18.09
30	0.7	12.34	10.07	-7.16	17.23
25	0.66	11.63	9.49	-7.16	16.65
20	0.62	10.93	8.92	-7.16	16.07
0-15	0.57	10.05	8.20	-7.16	15.36

Height (Feet)	K_z	q_z	Wind Pressures (psf)		
			E-W Windward	E-W Leeward	E-W Total
94	0.97	17.10	13.64	-9.68	23.32
90	0.96	16.92	13.50	-9.68	23.18
80	0.93	16.39	13.08	-9.68	22.76
70	0.89	15.69	12.52	-9.68	22.20
60	0.85	14.98	11.96	-9.68	21.64
50	0.81	14.28	11.39	-9.68	21.07
40	0.76	13.40	10.69	-9.68	20.37
30	0.7	12.34	9.85	-9.68	19.53
25	0.66	11.63	9.28	-9.68	18.96
20	0.62	10.93	8.72	-9.68	18.40
0-15	0.57	10.05	8.02	-9.68	17.70

Wind Story Force, Shear and Overturning Moment Spreadsheets

Wind (North-South)							
Level	Height (Feet)	Tributary Area (Feet)	Total (psf)	Story Force (Kips)	Story Shear (Kips)	Overturning Moment (k-ft)	
roof	90	9	21.00	25.28	25.28	2275.40	
8	80	10	20.54	27.71	53.00	4492.57	
7	70	10	19.97	27.04	80.04	6385.40	
6	60	10	19.39	26.27	106.31	7961.77	
5	50	10	18.82	25.51	131.82	9237.03	
4	40	10	18.10	24.64	156.46	10222.79	
3	30	10	17.23	23.58	180.04	10930.27	
2	20	10	16.37	21.85	201.90	11367.35	
1	10	10	15.36	20.51	222.40	11572.41	
ground	0	0	0.00	0.00	222.40	11572.41	Total

Wind (East-West)							
Level	Height (Feet)	Tributary Area (Feet)	Total (psf)	Story Force (Kips)	Story Shear (Kips)	Overturning Moment (k-ft)	
roof	90	9	23.28	35.54	35.54	3198.50	
8	80	10	22.78	39.03	74.56	6320.54	
7	70	10	22.21	38.19	112.75	8993.51	
6	60	10	21.65	37.23	149.98	11227.08	
5	50	10	21.09	36.28	186.25	13040.86	
4	40	10	20.38	35.20	221.45	14448.76	
3	30	10	19.54	33.88	255.33	15465.23	
2	20	10	18.7	31.73	287.07	16099.92	
1	10	10	17.71	30.06	317.13	16400.55	
ground	0	0	0	0.00	317.13	16400.55	Total

Appendix B: Seismic Load Calculations

Loads for SCBF

System-Specific Seismic Design Values and Coefficients

Seismic Criteria	
Occupancy Category	II
Importance Factor	1.000
Seismic Category	D
Site Class	C
Spectral Acceleration for Short Periods (Ss)	1.572
Spectral Acceleration for 1 Second Periods (S1)	0.617
Site Coefficient, Fa	1.000
Site Coefficient, Fv	1.300
Seismic Design Category	D
R Factor	6.000
S_{MS}	1.572
S_{M1}	0.802
S_{DS}	1.048
S_{D1}	0.535
Deflection Amplification Cd	5.00
Overstrength Factor	2.00

N-S Coefficient Variables		
Cu	1.400	table 12.8-1
T, min	0.720	Building period
Ta	0.604	Equation 12.8-7
T_L	8	ASCE 7-05 pg 228
Cs, min	0.175	Equation 12.8-2
	0.124	Equation 12.8-3
	1.376	Equation 12.8-4
Cs, larger than	0.051	Equation 12.8-6

E-W Coefficient Variables		
Cu	1.400	table 12.8-1
T, min	0.845	Section 12.8.2
Ta	0.604	Equation 12.8-7
T_L	8	ASCE 7-05 pg 228
Cs, min	0.175	Equation 12.8-2
	0.105	Equation 12.8-3
	0.998	Equation 12.8-4
Cs, larger than	0.051	Equation 12.8-6

Approximate Building Weight Calculations

These were used at the beginning of the design phase when all weights were not known once the structure was designed the actual weight was found and a verification was made to ensure the correct weight was in fact used.

Roof Weight					
Dead Load (psf)	Snow Load	Partition Load	Perimeter Wall Load	Perimeter Length	Roof Area
121	20<30 so NA.	-	47	760	14750
Total Roof Weight =	2145.08	kips			

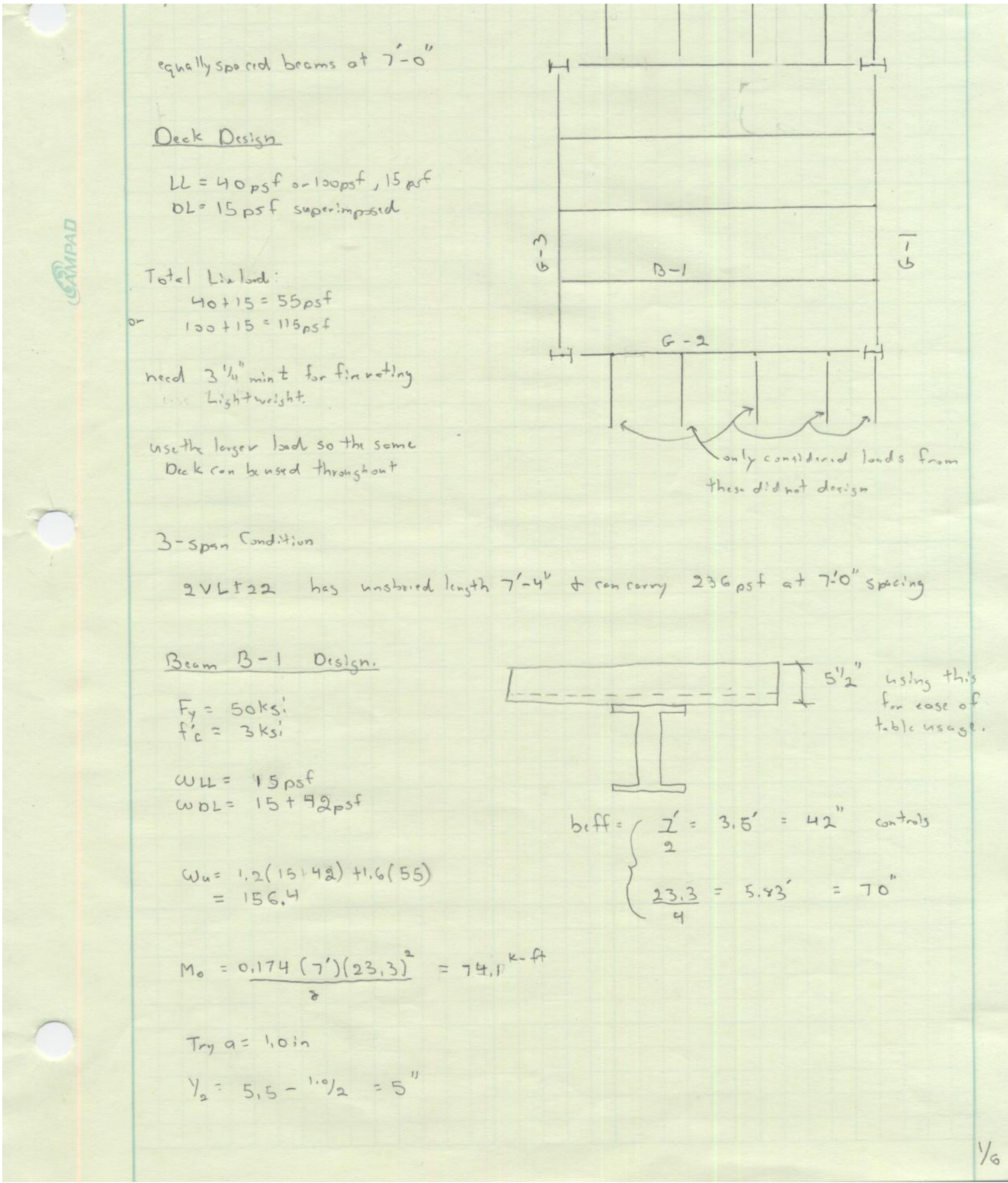
Typical Floor Weight Upper Floors					
Dead Load	Snow Load	Partition Load	Perimeter Wall Load	Perimeter Length	Floor Area
71	-	20	47	760	14750
Total Floor Weight =	1699.45	kips			

Typical Floor Weight Lower Floor					
Dead Load	Snow Load	Partition Load	Perimeter Wall Load	Perimeter Length	Floor Area
71	-	20	47	760	14750
Total Floor Weight =	1699.45	kips			

Appendix C: Gravity System Design

Sample Gravity Member Design

These were early designs to give a relative depth and see how the system will be. The final design has less beam as part of the optimization process but these calculations were not repeated for the relative nature between the two is reasonable.



equally spaced beams at 7'-0"

Deck Design

LL = 40 psf or 100 psf, 15 psf
DL = 15 psf superimposed

Total Live load:
40 + 15 = 55 psf
or 100 + 15 = 115 psf

need 3 1/4" min t for fire rating
Lightweight

use the larger load so the same Deck can be used throughout

3-span Condition

2VLI22 has unshored length 7'-4" & can carry 236 psf at 7'0" spacing

Beam B-1 Design

F_y = 50 ksi
f'_c = 3 ksi

ω_{LL} = 15 psf
ω_{DL} = 15 + 42 psf

ω_u = 1.2(15+42) + 1.6(55)
= 156.4

$M_o = \frac{0.174(7')(23.3)^2}{8} = 74.1^{k\text{-}ft}$

Try a = 1.0 in

Y_2 = 5.5 − 1.0/2 = 5"

From Table 3-19 pg. 1 W10x19 most econ.

$Y_2 = 5$

$\phi M_{pc} = 140$

$\Sigma q_n = 96.1$

check

$a = \frac{96.1}{0.85(3)(42'')} = 0.9 < 1.0$ so good.

Studs: 3/4" Stud L.W.C., 3 ksi

$Q_n = 17.2$ Deck ⊥ weak direction 1 stud

$\text{studs} = \frac{2(96.1)}{17.2} = 11.2 \rightarrow 12$ studs.

LL Deflection

$w_{LL} = 55$ psf

$\Delta = \frac{5(50)(7)(23.3)^4(1728)}{384(29000)(243)} = 0.36''$

Limit to $\ell/360$

$\frac{23.3(12)}{360} = 0.77''$

9/6

Girder G-1

LL = 40 + 100 psf, 15 psf

DL = 57 psf

2(17.6' x 28') = 985.6 > 400 ✓

$LL_{reduction} = L_o \left(0.25 + \frac{15}{\sqrt{986}}\right)$

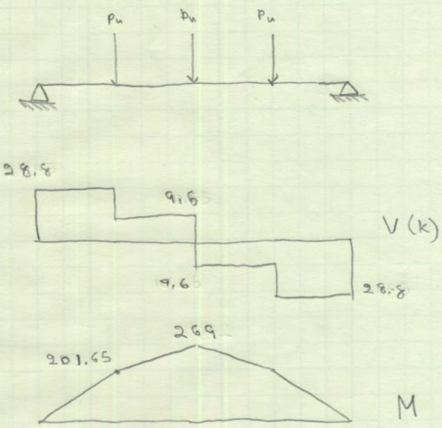
$= 0.73\ L_o$

$= 55\ (0.73) = 40.2$ psf

$= 115\ (0.73) = 84$ psf

$w_u = 1.2(57) + 1.6(84) = 203$ psf

$1.2(57) + 1.6(40.2) \quad 133$



$P_u = 0.133\ (7')\left(\frac{23.3'}{2}\right) +$

$0.203(7')(5.83')$

$= 19.2^k$

$M_u = 269\ ^{k}\text{-ft}$

Try $a = 1.0''$

$Y_2 = 5.5 - \frac{1}{2} = 5.0$ in

Table 3-19 pg 1: W16x36

b_{eff} = $\frac{17.6'}{2}(12) = 106''$; $\frac{28'(12)}{4} = 84''$ controls

$Y_2 = 5$

$\phi M_{pc} = 373$

$\Sigma q_n = 180$

check!

$a = \frac{180}{0.85\ (3)(84'')} = 0.84 < 1.0''$

3/6

Studs!

$Q_n = 21^k$

$$\text{studs} = \frac{2(180)}{21} = 17.2 \rightarrow 18 \text{ studs.}$$

LL Deflection

$\omega_{LL} = 55$ psf (ignoring the 100 due to very small area)

$$\Delta = \frac{5(55)(17.6')(28')^4(1728)}{384(29000)(897)} = 0.51''$$

$$\frac{l}{360} = \frac{28(12)}{360} = 1.13''$$

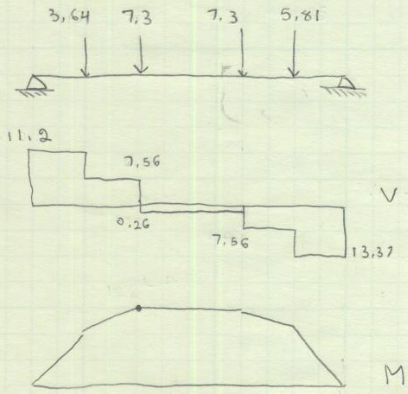
4/6

Girder G-2 Design

LL = 55 psf
DL = 57 psf

$\omega_u = 1.2(57) + 1.6(51) = 147$ psf

$P_u = 0.147(2.75')(9') = 3.64^k$
$P_u = 0.147(4.4)(9') = 5.81^k$
$P_u = 0.147(5.5')(9') = 7.3^k$



$M_u = 88^{k\text{-}ft.}$

Try $a = 1.0''$

$Y_2 = 5.5 - 1/2 = 5.0''$

Table 3-19 pg !! W14x26

choose high/deeper to ensure beams into it are shallower.

LL reduction $\left(0.25 + \frac{15}{\sqrt{500}}\right)$

$2(20 \times 12.5) = 500 > 400$

$Y_2 = 5$
$\phi M_{pc} = 224$
$\Sigma Q_n = 96.1$

$0.92 L_o$

$\omega LL = 51$ psf

check !
$a = \frac{96.1}{0.85(3)(42)} = 0.9 \leq 1''$

$b_{eff} = \begin{cases} \frac{7'}{2} = 42'' & \text{controls} \\ \frac{20(12)}{4} = 60'' \end{cases}$

Studs:

$Q_n = 17.2$

$\text{studs} = \frac{2(96.1)}{17.2} = 11.2 \rightarrow 12$ studs.

LL Deflection

$\omega_{LL} = 40$

$\Delta = \frac{5(55)(12)(23.5)^4(1727)}{384(29000)(465)} = 0.33$

$\frac{l}{360} = \frac{\_(12)}{360} = 0.78''$

5/6

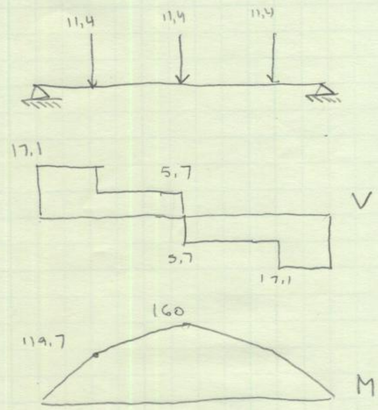
G-3 Design

LL = 55
DL = 57

LL reduction $= L_o\left(0.25 + \frac{15}{\sqrt{653}}\right) = 0.84$ $\qquad 2\left(28 \times \frac{23.3}{2}\right) = 653 > 400$

LL = 46.2

$P_u = (1.2(57) + 1.6(46.2))(7')(11.6') = 11.4^k$



$M_u = 160^{k\text{-}ft}$

Try $a = 1.0''$

$Y_2 = 5.5 - \frac{1}{2} = 5.0$

Table 3-19, pg ! : W12x26

Y_2 : 5
ϕM_{pc} : $204^{k\text{-}ft}$
ΣQ_n : 95.6^k

b_{eff} = Same as G1

42" controls.

Check: $\frac{95.6}{0.85(3)(42'')} = 0.89 < 1.0''$

Studs:

$Q_n = 21$

studs $= \frac{2(95.6)}{21} = 9.1 = 10$ studs.

LL Deflections

$\Delta = \frac{5(55)(11.6)(29)^4(1728)}{384(29000)(393)} = 0.77 < 1.13''$ so good

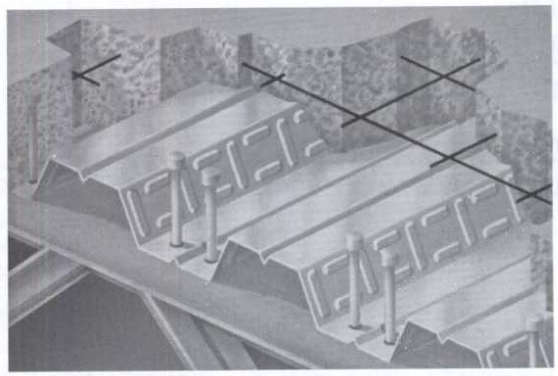
6/6

Composite Deck Details

VULCRAFT

SLAB INFORMATION

Total Slab Depth	Theo. Concrete Volume Yds./ 100 Sq. Ft.	Theo. Concrete Volume Cu. Ft./ Sq. Ft.	Recommended Welded Wire Fabric
5"	1.08	0.292	6x6-W1.4xW1.4
5 1/2"	1.23	0.333	6x6-W1.4xW1.4
6"	1.39	0.375	6x6-W1.4xW1.4
6 1/4"	1.47	0.396	6x6-W1.4xW1.4
6 1/2"	1.54	0.417	6x6-W2.1xW2.1
7"	1.70	0.458	6x6-W2.1xW2.1
7 1/4"	1.77	0.479	6x6-W2.1xW2.1
7 1/2"	1.85	0.500	6x6-W2.1xW2.1



(N=14) LIGHTWEIGHT CONCRETE (110 PCF)

Total Slab Depth	Deck Type	SDI Max. Unshored Clear Span 1 Span	2 Span	3 Span	Superimposed Live Load, PSF Clear Span (ft.-in.) 8'-0	8'-6	9'-0	9'-6	10'-0	10'-6	11'-0	11'-6	12'-0	12'-6	13'-0	13'-6	14'-0	14'-6	15'-0
	3VLI22	9'-1	11'-5	11'-5	141	127	115	83	75	67	60	54	49	45	40				
5"	3VLI21	9'-10	12'-4	12'-9	153	138	125	113	82	74	67	60	54	49	45	41			
	3VLI20	10'-6	13'-0	13'-5	163	147	133	121	110	102	72	65	59	54	49	44	40		
(t=2")	3VLI19	11'-10	14'-4	14'-10	185	166	150	136	124	114	105	97	68	62	57	52	47	43	
	3VLI18	13'-0	15'-4	15'-10	244	222	204	188	174	162	151	142	133	126	119	90	85	79	75
34 PSF	3VLI17	14'-0	16'-3	16'-6	262	238	218	201	185	172	161	150	141	133	126	119	113	85	80
	3VLI16	14'-5	16'-11	16'-11	277	254	234	217	202	189	177	166	157	149	141	134	127	99	94
	3VLI22	8'-5	10'-6	10'-6	161	121	107	95	85	77	69	62	56	51	46	42			
5 1/2"	3VLI21	9'-5	11'-10	12'-2	175	157	142	105	94	84	76	69	62	56	51	47	42		
	3VLI20	10'-0	12'-6	12'-11	186	167	151	138	126	91	82	74	67	61	56	51	46	42	
(t=2 1/2")	3VLI19	11'-3	13'-9	14'-3	211	189	171	155	142	130	120	86	78	71	65	59	54	49	45
	3VLI18	12'-4	14'-8	15'-2	278	253	232	214	198	184	172	161	152	118	110	103	97	91	85
39 PSF	3VLI17	13'-4	15'-7	16'-0	299	272	248	229	211	196	183	171	161	152	143	110	103	97	91
	3VLI16	14'-0	16'-5	16'-5	316	289	267	247	230	215	202	190	179	170	161	153	146	114	107
	3VLI22	7'-9	9'-9	9'-9	154	136	120	107	96	86	78	70	63	57	52	47	43		
6"	3VLI21	9'-0	11'-4	11'-6	196	176	160	118	106	95	86	77	70	64	58	52	48	43	
	3VLI20	9'-7	12'-0	12'-5	209	188	170	155	114	103	93	84	76	69	63	57	52	47	43
(t=3")	3VLI19	10'-9	13'-3	13'-8	237	212	192	174	159	146	107	97	88	80	73	67	61	56	51
	3VLI18	11'-9	14'-2	14'-8	312	284	261	240	223	207	193	181	142	133	124	116	109	102	96
43 PSF	3VLI17	12'-9	15'-1	15'-7	335	305	279	257	237	221	206	192	181	170	132	124	116	109	102
	3VLI16	13'-5	15'-10	16'-0	354	325	299	277	258	241	226	213	201	190	181	143	135	128	121
	3VLI22	7'-6	9'-5	9'-5	162	143	127	113	101	91	82	74	67	60	55	50	45	41	
6 1/4"	3VLI21	8'-10	11'-1	11'-1	207	186	140	125	112	100	90	82	74	67	61	55	50	46	42
	3VLI20	9'-5	11'-10	12'-2	221	198	179	134	120	108	98	88	80	73	66	60	55	50	46
(t=3 1/4")	3VLI19	10'-6	13'-0	13'-6	250	224	202	184	168	154	113	102	93	84	77	70	64	59	54
	3VLI18	11'-6	13'-11	14'-5	329	300	275	253	235	218	204	191	150	140	131	122	115	108	101
46 PSF	3VLI17	12'-5	14'-10	15'-3	354	322	294	271	250	233	217	203	191	150	140	131	122	115	108
	3VLI16	13'-2	15'-6	15'-10	374	343	316	293	272	254	239	225	212	201	190	151	143	135	128
	3VLI22	7'-3	9'-1	9'-1	171	150	134	119	107	96	86	78	70	64	58	52	47	43	
6 1/2"	3VLI21	8'-7	10'-9	10'-9	218	196	147	131	117	106	95	86	78	71	64	58	53	48	44
	3VLI20	9'-2	11'-7	12'-0	232	209	189	141	127	114	103	93	84	77	70	63	58	53	48
(t=3 1/2")	3VLI19	10'-4	12'-10	13'-3	263	236	213	193	176	131	119	108	98	89	81	74	68	62	57
	3VLI18	11'-4	13'-8	14'-2	346	316	289	267	247	230	215	170	158	147	138	129	121	113	107
48 PSF	3VLI17	12'-2	14'-7	15'-0	372	338	310	285	263	245	228	214	201	158	147	138	129	121	114
	3VLI16	12'-11	15'-3	15'-7	393	360	332	308	286	268	251	236	223	211	169	159	150	142	134
	3VLI22	6'-7	8'-3	8'-3	196	173	153	137	122	110	99	89	81	73	66	60	55	49	45
7 1/4"	3VLI21	7'-10	9'-9	9'-9	216	190	169	151	135	121	109	99	90	81	74	67	61	55	50
	3VLI20	8'-8	11'-1	11'-2	267	240	182	163	146	131	118	107	97	88	80	73	66	61	55
(t=4 1/4")	3VLI19	9'-9	12'-2	12'-7	302	271	244	222	168	151	137	124	112	102	93	85	78	71	65
	3VLI18	10'-8	13'-0	13'-6	398	362	332	306	284	264	211	196	182	169	158	148	139	130	123
55 PSF	3VLI17	11'-6	13'-10	14'-4	400	388	355	327	302	281	262	245	195	181	169	158	148	139	131
	3VLI16	12'-2	14'-7	15'-1	400	400	381	353	329	307	288	271	256	207	194	183	173	163	154

Notes:
1. Minimum exterior bearing length required is 2.5 inches. Minimum interior bearing length required is 5.0 inches. If these minimum lengths are not provided, web crippling must be checked.
2. Always contact Vulcraft when using loads in excess of 200 psf. Such loads often result from concentrated, dynamic, or long term load cases for which reductions due to bond breakage, concrete creep, etc. should be evaluated.
3. All fire rated assemblies are subject to an upper live load limit of 250 psf.
4. Inquire about material availability of 17, 19 & 21 gage.

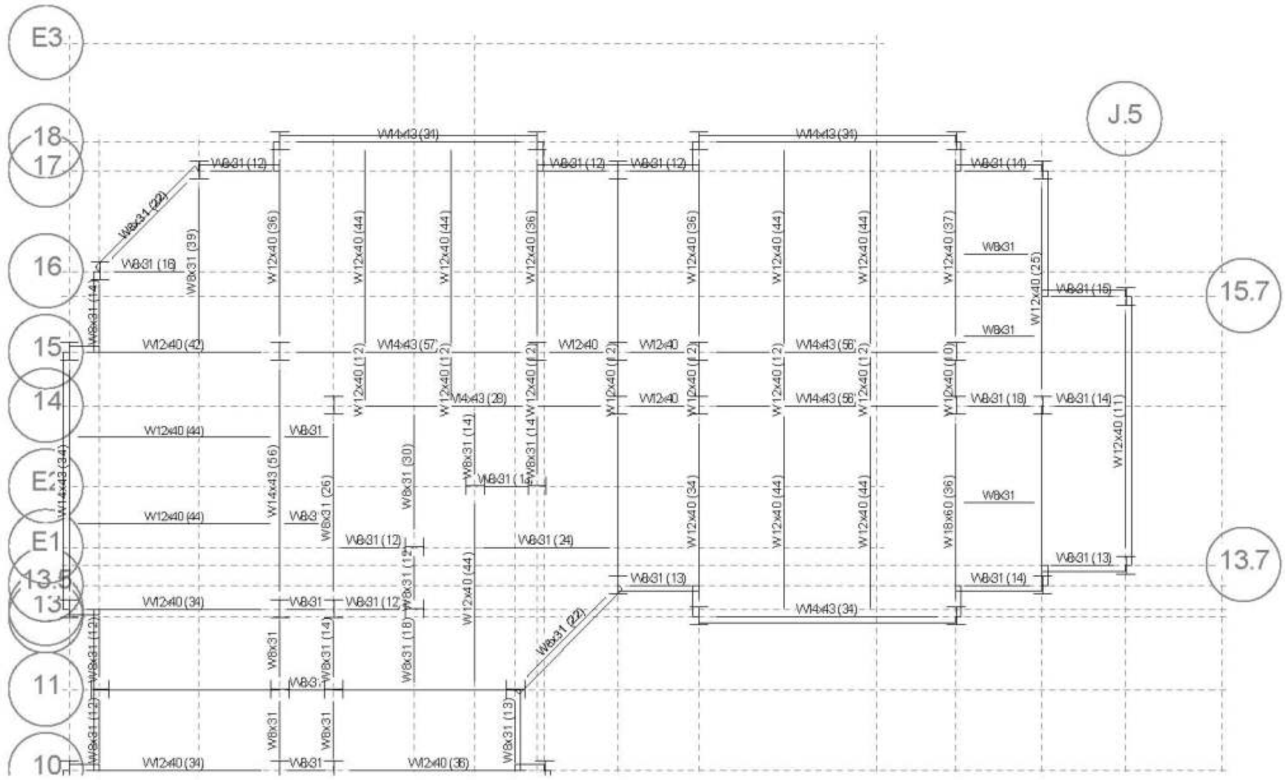
Restrained Assembly Rating	Type of Protection	Concrete Thickness & Type (1)	U.L. Design No. (2,3,4)	Classified Deck Type		Unrestrained Beam Rating
				Fluted Deck	Cellular Deck (5)	
2 Hr. (continued)	Sprayed Fiber	2" NW&LW	859 *	2VLI,3VLI	2VLP, 3VLP	1,1.5,2,3 Hr.
		2 1/2" NW&LW	822 *	2VLI,3VLI	2VLP, 3VLP	1 Hr.
			825 *	1.5VLI,2VLI,3VLI	2VLP, 3VLP	1,1.5,2 Hr.
			831 *	2VLI,3VLI	2VLP, 3VLP	1,1.5,2 Hr.
			832 *	1.5VLI,2VLI,3VLI	1.5VLP, 2VLP, 3VLP	1,1.5,2,3 Hr.
			833 *	1.5VLI,2VLI,3VLI	2VLP, 3VLP	1.5 Hr.
			847 *	2VLI,3VLI	3VLP	1,1.5,3 Hr.
			858 *	2VLI,3VLI	2VLP, 3VLP	1,1.5,2,4 Hr.
			861 *	12VLI,3VLI		1,1.5 Hr.
			870 *	1.5VLI,2VLI,3VLI	1.5VLP, 2VLP, 3VLP	1,2 Hr.
			871 *	2VLI,3VLI	2VLP, 3VLP	1,1.5,2,3 Hr.
		2 1/2" LW	862 *	2VLI,3VLI		1 Hr.
		2 1/2" NW	864 *	3VLI	3VLP	1.5 Hr.
		3 1/4" LW	860 *	2VLI,3VLI		1,1.5,2 Hr.
	Unprotected Deck	3 1/4" LW	733 #	1.5VL,1.5VLI,2VLI,3VLI	1.5VLP, 2VLP, 3VLP	1,1.5Hr.
			826 #	1.5VL,1.5VLI,2VLI,3VLI	1.5VLP, 2VLP, 3VLP	1,1.5,2 Hr.
			840 #	1.5VL,1.5VLI,2VLI,3VLI	1.5VLP, 2VLP, 3VLP	1,1.5 Hr.
			902 #	1.5VL,1.5VLI,2VLI,3VLI	1.5VLP, 2VLP, 3VLP	1,1.5 Hr.
			907 #	1.5VL,1.5VLI,2VLI,3VLI	1.5VLP, 2VLP, 3VLP	1,2 Hr.
			913 #	1.5VL,1.5VLI,2VLI,3VLI	1.5VLP, 2VLP, 3VLP	1 Hr.
			916 #	1.5VL,1.5VLI,2VLI,3VLI	1.5VLP, 2VLP, 3VLP	1,1.5,2,3 Hr.
			918 #	1.5VL,1.5VLI,2VLI,3VLI	1.5VLP, 2VLP, 3VLP	1,1.5 Hr.
			919 #	1.5VL,1.5VLI,2VLI,3VLI	1.5VLP, 2VLP, 3VLP	1,1.5 Hr.
			920 #	2VLI,3VLI	2VLP, 3VLP	1.5 Hr.
		4 1/2" NW	902 #	1.5VL,1.5VLI,2VLI,3VLI	1.5VLP, 2VLP, 3VLP	1,1.5 Hr.
			916 #	1.5VL,1.5VLI,2VLI,3VLI	1.5VLP, 2VLP, 3VLP	1,1.5,2,3 Hr.
			918 #	1.5VL,1.5VLI,2VLI,3VLI	1.5VLP, 2VLP, 3VLP	1,1.5 Hr.
			919 #	1.5VL,1.5VLI,2VLI,3VLI	1.5VLP, 2VLP, 3VLP	1,1.5 Hr.

Ram Optimization Design

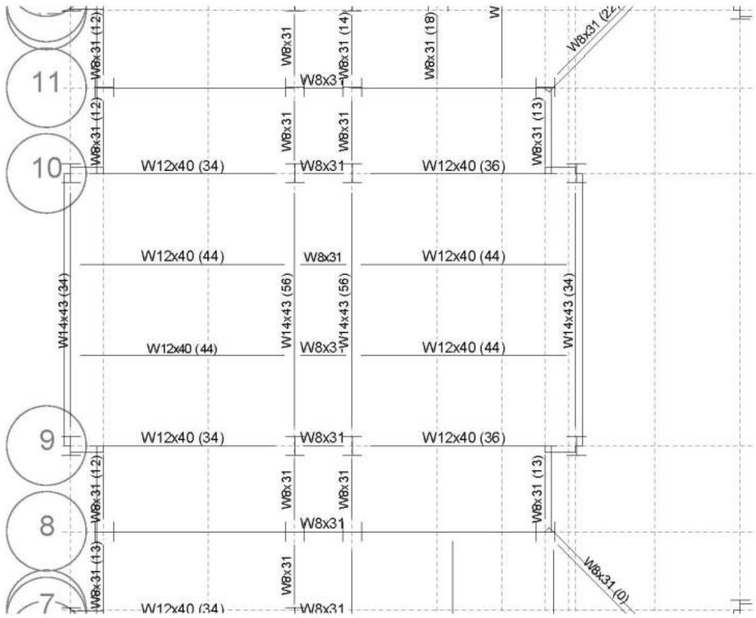
It should be noted that these design are the final but certain small changes were made to the typical bay in the report per this authors judgments based on minimum sizes, this mainly is around the W8x10's in the corridors.

Typical Floor

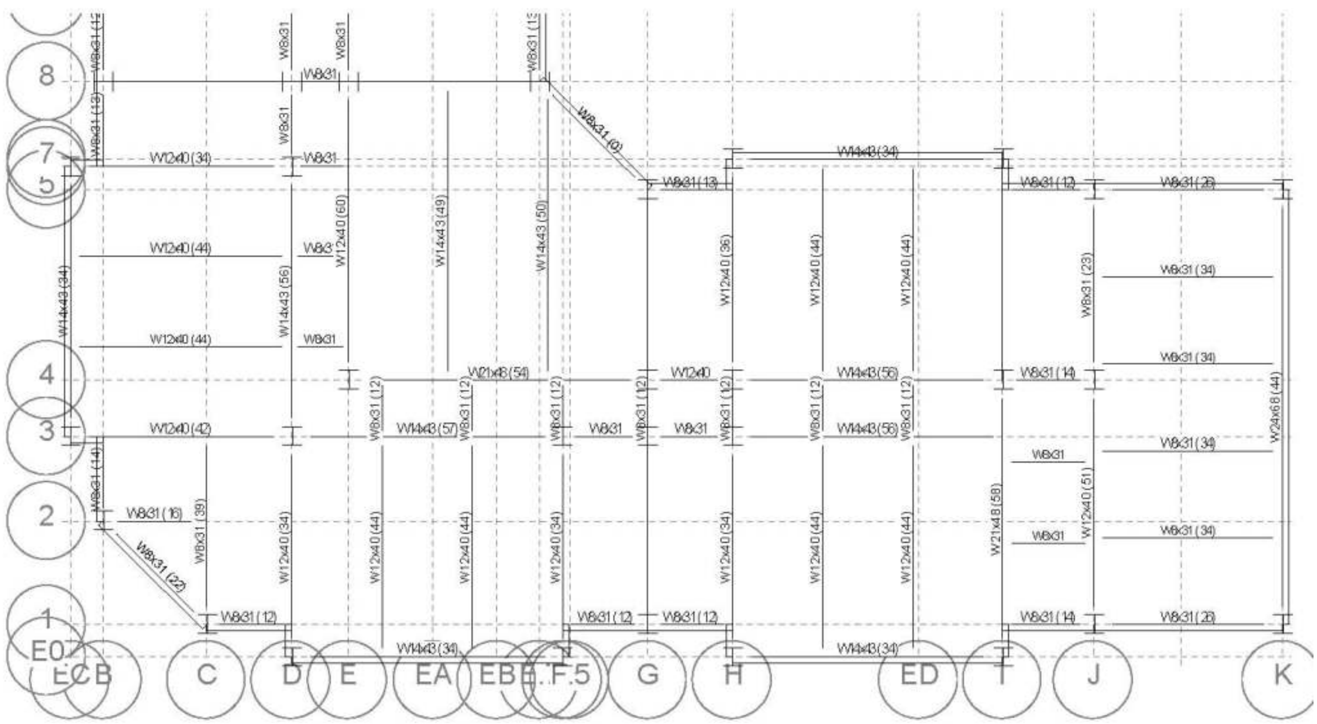
Floor Type: Typical



Floor Type: Typical

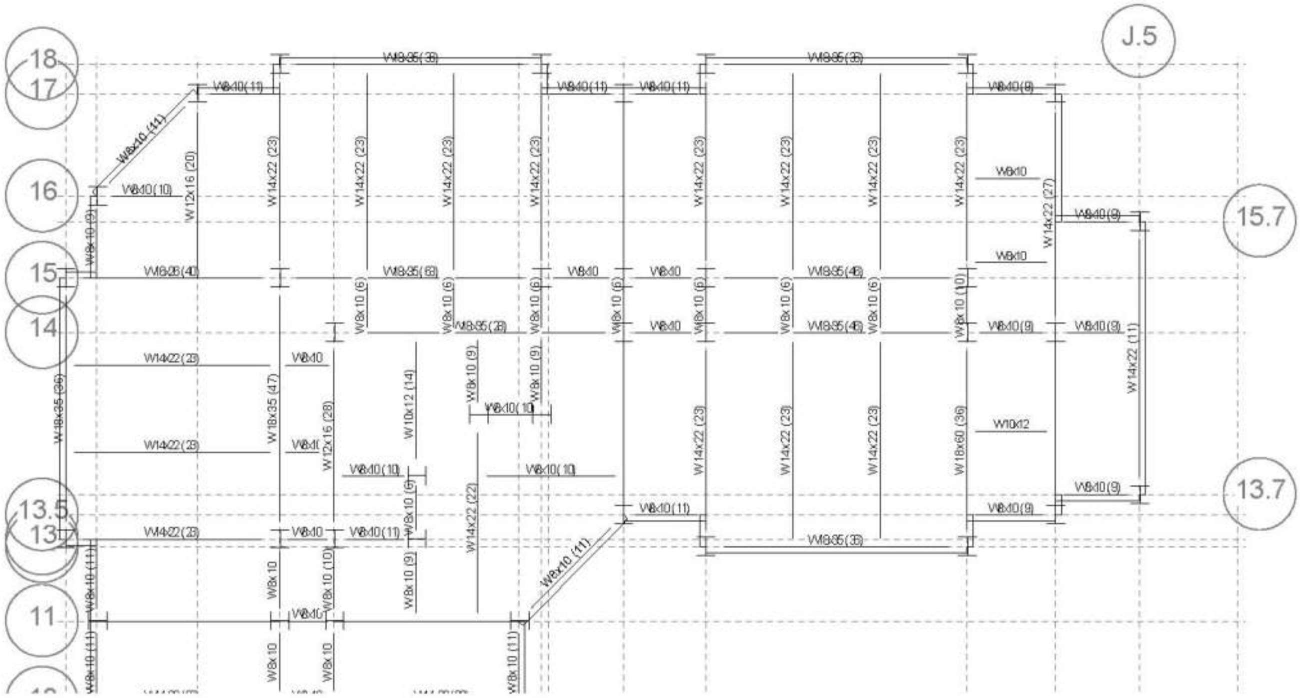


Floor Type: Typical

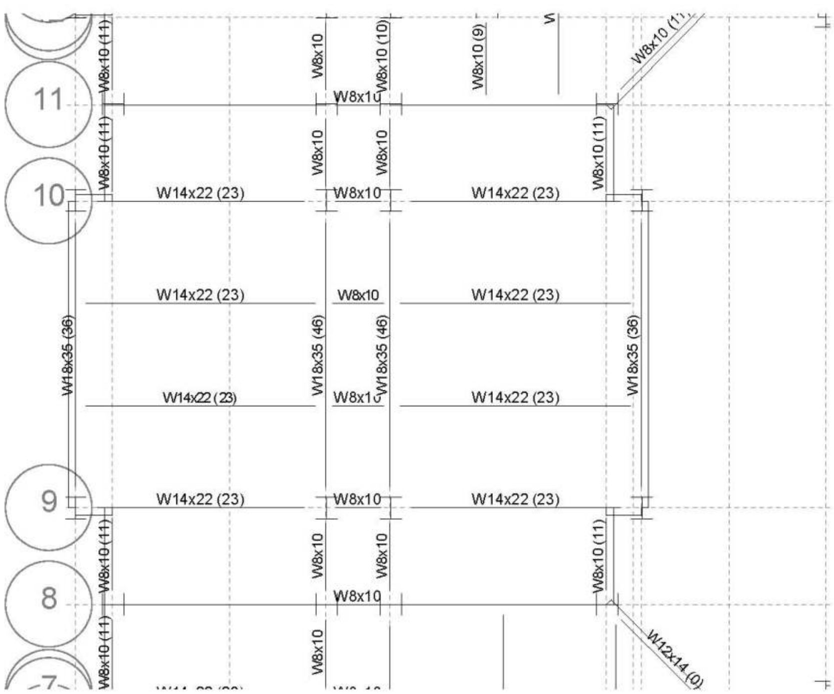


Roof Level

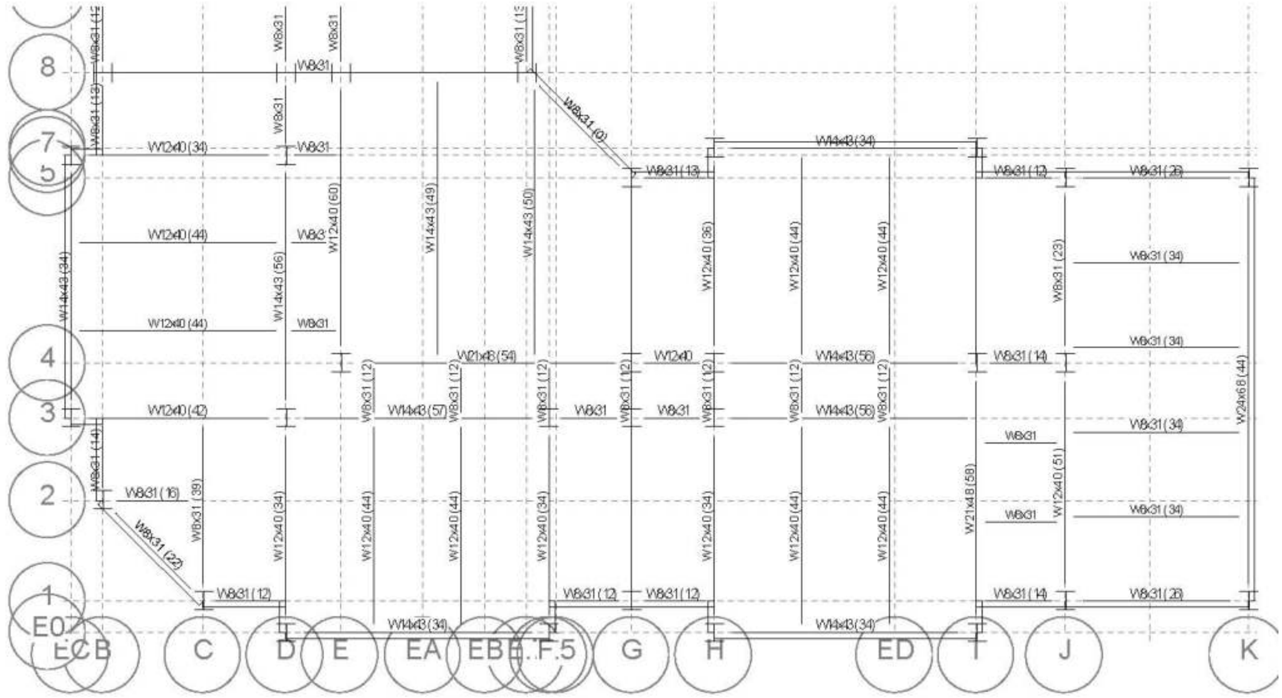
Floor Type: Roof



Floor Type: Roof



Floor Type: Typical



Beam to Girder Connection

Beam	W12x50		
	tw	0.37	in
	Fy	50	ksi
	Fu	65	ksi
	T	9.25	in
	Ag	14.6	in2
	Ho	10.5	in

Single Row of Bolts

Vu	18.2 kips		
# of bolts	1.14	use	2

1 **Eccentric Shear of the Bolt group**

Shear
ϕRn 15.9 kips

Bearing
ϕRn 29.3625 kips

Tearout
ϕRn 21.41016 kips

e 4.38

Table 7-7

S	3	in spacing
n	2	# of bolts
	4	1.67
	4.38	1.57625
	5	1.42

ϕVn 25.06238 kips > 18.2

2 **Max Plate Thickness**

t 0.4375 > tp and tw
Leh 1.5 ok

3	Plate shear Yielding			
	L	6 in		
	ϕVn	48.6	>	18.2
4	plate shear rupture			
	ϕVn	41.59688	>	18.2
5	Block Shear			
	Table 9-3a	46.2		
	Table 9-3b	72.9		
	Table 9-3c	76.7		
	ϕRn	44.6625 kips	>	18.2
6	Beam Web			
	tp>tw			
	shear yield			
	ϕRn	438		
	shear rupture			
	ϕRn	408.1106		
7	Plate Flexure yield			
	a	2.875		
	Mu	52.325		
	fv	8.987654321		
	Fcr	35.6235461		
	ϕMn	108.2065213	> Mu	ok

Plate				Bolts			
	Fy	36	ksi		dia	0.75	in
	Fu	58	ksi		Grade	A325-N	
	t	0.375	in		Shear Str.	15.9	ksi

8 **Flexural Rupture of the plate**

Zplate	2.390625	
ϕMn	103.9922	>Mu

8 **Flexural Rupture of the plate**

λ	0.663643	< 0.7

8 **weld size**

tweld	3.75 sixteenths	use 4/16"

Girder to Column Connection

Girder	W14x53	
	tw	0.37
	Fy	50
	Fu	65
	tf	0.66
	Ag	15.6
	d	13.9

Single Row of Bolts

Vu	24.5	kips		
# of bolts	1.54		use	6

1 **Eccentric Shear of the Bolt group**

Shear
ϕRn 15.9 kips

Bearing
ϕRn 29.3625 kips

Tearout
ϕRn 21.41016 kips

e 7.38

Table 7-7

S	3	in spacing
n	2	# of bolts
	7	1.99
	7.38	1.91125
	8	1.78

ϕVn 30.38888 kips > 24.5

2 **Max Plate Thickness**

t	0.4375	> tp and tw
Leh	1.5	ok

3 **Plate shear Yielding**

L	9 in			
ϕVn	72.9	>	24.5	ok

4 **plate shear rupture**

ϕVn	70.95938	>	24.5	ok

5 **Block Shear**

Table 9-3a	51.8		
Table 9-3b	117		
Table 9-3c	132		
ϕRn	63.3 kips	>	24.5

6 **Beam Web**

tp>tw

shear yield

ϕRn 468

shear rupture

ϕRn 437.3606

7 **Plate Flexure yield**

a	5.875		
Mu	143.9375		
fv	8.065844		
Fcr	35.66234		
ϕMn	243.7298	> Mu	ok

Plate			Bolts		
Fy	36		dia	0.75	in
Fu	58		Grade	A325-N	
t	0.375	in	Shear Str.	15.9	kips

8 Flexural Rupture of the plate

Zplate	6.609375	
ϕMn	287.5078	>Mu

9 Plate Buckling

λ	1.209347	> 0.7
ϕFcr	24.37314	
ϕMn	161.0912	>Mu

10 weld size

tweld	3.75 sixteenths	use 4/16"

Appendix D: Lateral System Design

Center of Mass and Rigidity

Center of Rigidity for SCBF		
Story	X Direction	Y Direction
Roof	73.14	84.53
8	73.12	84.53
7	73.25	84.53
6	73.54	84.53
5	73.97	84.52
4	74.54	84.52
3	74.66	84.52
2	75.01	84.51
1	72.53	84.49

Center of Mass for SCBF		
Story	X Direction	Y Direction
Roof	54.00	81.76
8	53.95	81.94
7	53.95	81.94
6	53.91	81.95
5	53.86	81.95
4	53.88	81.95
3	53.89	81.95
2	53.88	81.94
1	58.11	72.98

Amplification Factor

Amplification Factor, Ao in the N-S Direction for SCBF							
Story	δA (in)	δB (in)	δavg (in)	δmax (in)	Ax	% torsion Δ	Torsion Irreg.
Roof	3.8	2.99	3.395	3.8	0.87	1.12	Good
8	3.21	2.53	2.87	3.21	0.87	1.13	Good
7	2.63	2.08	2.355	2.63	0.87	1.12	Good
6	2.11	1.67	1.89	2.11	0.87	1.13	Good
5	1.59	1.27	1.43	1.59	0.86	1.12	Good
4	1.18	0.95	1.06475	1.18	0.85	1.11	Good
3	0.74	0.6	0.67	0.74	0.85	1.12	Good
2	0.41	0.34	0.375	0.41	0.83	1.10	Good
1	0.11	0.095	0.1025	0.11	0.80	1.07	Good

Amplification Factor, Ao in the E-W Direction for SCBF							
Story	δA (in)	δB (in)	δavg (in)	δmax (in)	Ax	% torsion Δ	Torsion Irreg.
Roof	3.63	3.865	3.7475	3.865	0.74	1.02	Good
8	3.06	3.27	3.165	3.27	0.74	1.04	Good
7	2.52	2.685	2.6025	2.685	0.74	1.03	Good
6	2.01	2.14	2.075	2.14	0.74	1.03	Good
5	1.51	1.61	1.56	1.61	0.74	1.04	Good
4	1.12	1.185	1.1525	1.185	0.73	1.02	Good
3	0.69	0.74	0.715	0.74	0.74	1.03	Good
2	0.39	0.42	0.405	0.42	0.75	1.07	Good
1	0.26	0.25	0.255	0.26	0.72	1.02	Good

Inherent Torsion

Inherent Torsion in the N-S Direction with SCBF					
Story	COM	COR	Eccentricity	Story Force (k)	Torsion (ft-k)
Roof	81.76	84.53	2.77	398.08	1103
8	81.94	84.53	2.59	280.44	726
7	81.94	84.53	2.59	245.39	636
6	81.95	84.53	2.58	210.33	543
5	81.95	84.52	2.57	175.28	450
4	81.95	84.52	2.57	140.22	360
3	81.95	84.52	2.57	105.17	270
2	81.94	84.51	2.57	70.11	180
1	72.98	84.49	11.51	35.06	404
				Total	4672

Inherent Torsion in the E-W Direction with SCBF					
Story	COM	COR	Eccentricity	Story Force (k)	Torsion (ft-k)
Roof	54.00	73.14	19.14	398.08	7619
8	53.95	73.12	19.17	280.44	5376
7	53.95	73.25	19.3	245.39	4736
6	53.91	73.54	19.63	210.33	4129
5	53.86	73.97	20.11	175.28	3525
4	53.88	74.54	20.66	140.22	2897
3	53.89	74.66	20.77	105.17	2184
2	53.88	75.01	21.13	70.11	1481
1	58.11	72.53	14.42	35.06	506
				Total	32453

Accidental Torsion

Accidential Torsion in the N-S Direction for SCBF					
Story	Width Bx (Ft)	5% Bx (Ft)	Story Force (K)	Ax Factor	Torsion (Ft-K)
Roof	130	6.5	467.4	1.00	3038.2
8	130	6.5	329.3	1.00	2140.4
7	130	6.5	288.1	1.00	1872.8
6	130	6.5	247.0	1.00	1605.2
5	130	6.5	205.8	1.00	1337.7
4	130	6.5	164.6	1.00	1070.2
3	130	6.5	123.5	1.00	802.6
2	130	6.5	82.3	1.00	535.1
1	130	6.5	41.2	1.00	267.5

Accidential Torsion in the E-W Direction for SCBF					
Story	Width By (Ft)	5% By (Ft)	Story Force (K)	Ax Factor	Torsion (Ft-K)
Roof	167	8.35	398.1	1.00	3323.97
8	167	8.35	280.4	1.00	2341.67
7	167	8.35	245.4	1.00	2049.01
6	167	8.35	210.3	1.00	1756.26
5	167	8.35	175.3	1.00	1463.59
4	167	8.35	140.2	1.00	1170.84
3	167	8.35	105.2	1.00	878.17
2	167	8.35	70.1	1.00	585.42
1	167	8.35	35.1	1.00	292.75

Lateral Design Spot Check

Lateral SCBF Spot Check, Brace.

SCBF Brace Design

$P_D = 16.4^k$

$P_L = 10$

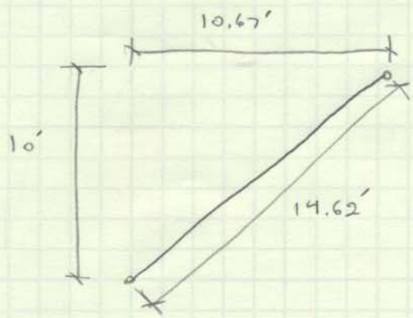
$P_{QE} = 285^k$

$\Omega = 2.0$

$\rho = 1.3$

$S_{DS} = 1.048$

$F_y = 46$



$\frac{10.67}{14.62}(285) = 207.99$ Tension

max compressive force

$P_u = (1.2 + 0.2 S_{DS}) P_D + \rho P_{QE} + 0.5 P_L$

$P_u = (1.2 + 0.2(1.048))(16.4) + 1.3(285) + 0.5(10)$

$= 398.6$

max tension force

$T_u = (0.9 - 0.2 S_{DS}) P_D + \rho P_{QE}$

$= (0.9 - 0.2(1.048))(16.4) + 1.3(-285)$

$= -359.2$

Unbraced Length

$L = \sqrt{10^2 + 10.67^2}$

$= 14.62'$

Try HSS 10"x10"x5/8"

$A_g = 21 \text{ in}^2$
$b = 10"$
$t_{nom} = 0.581"$
$r = 3.8$

Using table 1-6 the section meets local buckling requirements.

Check Slenderness

$$\frac{kL}{r} \le 4.0\sqrt{\frac{E}{F_y}}$$

use $k = 1.0$ Per Table C-C2.2.

$$\frac{kL}{r} = \frac{1.0(14.62)(12)}{3.8} = 46.2$$

$$4.0\sqrt{\frac{E}{F_y}} = 4\sqrt{\frac{29000}{46}} = 100$$

since $46.2 < 100$ then good.

Determine Compression Strength.

Section E3 spec.

$$4.71\sqrt{\frac{E}{F_y}}$$

$$4.71\sqrt{\frac{29000}{46}} = 118.3 > 46.2$$ then use,

$$F_{cr} = \left[0.658^{F_y/F_e}\right] F_y$$

$$F_e = \frac{\pi^2 E}{\left(\frac{kL}{r}\right)^2}$$

$$= \frac{\pi^2(29000)}{46.2^2}$$

$$= 134.1 \text{ ksi}$$

21

$$F_{cr} = \left[0.658^{\frac{46}{134.1}}\right] 46$$

$$= 39.8 \text{ ksi}$$

$$\phi P_n = 0.9 F_{cr} A_g$$

$$= 0.9(39.8)(21)$$

$$= 753.1 \text{ kips}$$

$P_u = 398.6 < 753.1^k$ so o.k.

Determine Tension Strength

yielding on the section.

$$P_n = F_y A_g$$

$$\phi P_n = 0.9(46)(21)$$

$$= 869.4^k$$

$P_u = 357.2 < 869.4^k$ so! ok

Seismic Connections Calculations

Column Splice

Column	W14x176		Plate		
	Fy	50		W	6
	d	13.1		t	1
	tf	1.11		L	12
	tw	0.71			
	Z	85.4		weld	0.375
				Fy	36

1 **Splice demands**

Vu	231.744	kips
Mu	2135	k-in

2 **Plate shear strength**

Vn 116.64 per plate total 233.28 note greater than demand found in Ram

3 **splice weld strength**

C1	1		
L	12		
kL	5	k	0.416667
		x	0
ex,al	0		
a	0		
		C	
	0.4	5.29	
	0.42	5.38	
	0.5	5.85	

4 **Required weld D**

1.793678 sixteenths use 3/16"

Brace to Beam to Column

Brace	HSS9x9x5/8			Beam	W18x65	
	Ag	18.7	in2		d	18.4
	r	3.4			k des	1.17
	tnom	0.625			tw	0.48
	D	10			tf	0.77
	tdes	0.581			Fy	50
	Fy	46	ksi		Fu	65
	Fu	58	ksi		N	
	Length act	11	ft			

gusset plate clip 1 in

1 **Expected tensile Strength of the Brace**

Ry 1.6

Tu 1376.32 kips

2 **Expected max compression strength of the brace**

KL/r 38.82353 ≤ 118.2608

so:

Fe 189.7

Fcr 41.5604

nominal Compressive Strength

Pn 1367.836

3 **Interface Forces**

Pu	1372.078	kips			
Vc	682.8203	kips	eb	9.25	in
Hc	177.5333	kips	ec	6.5	in
Hb	826.2125	kips	β	25	in
Vb	252.6435	kips	α	30.25	in
R	50.23569				

4	coulmn to Gusset weld Design				
	fv	27.31281			
	fa	7.101331			
	favg	28.22			
	fr	35.27611			
	D min	12.67102	use	13	sixteenths
5	yielding of the gusset plate				
	ϕrn	45	>	fv and fa so ok	
6	column web yielding				
	ϕrn	32.25	>	ru = fa so ok	
7	column web crippling				
	N	0.77			
	rn	545.8825			
	ϕrn	409.4119	>	Huc so ok	
8	beam to Gusset weld Design				
	fv	27.31281			
	fa	8.351851			
	favg	28.56			
	fr	35.70152			
	D min	12.82382		13	sixteenths
9	beam web yielding				
	ϕrn	24	>ru	so ok	
10	beam web crippling				
	N	30.25			
	rn	581.6507			
	ϕrn	436.238	>	Vub so ok	

Column		Plate	A 36		
d	14.7		Fy	50	
k des	1.63		Fu	65	
tw	0.645		t	1.5	
tf	1.03				
Fy	50	Bolts			
Fu	65		dia	0.75	in
N			Grade	A325-N	
			Shear Str.	15.9	kips

11 **beam connection**

Flange Connection

use CJP welds

Shear tab

Vu	50		
# of bolts	3.14	use	4

Plate length	11.5		
Plate Thickness	0.239464	use	0.25

Gross Shear
ϕVn 62.1 > Vu so ok

Block Shear
ϕVn 53.05 > Vu so ok

Bolt Shear, bearing, and tearout

table 10-9a allows 52.2 kips > Vu so ok

Weld Size
Dmin 2.5 use 3 sixteenths

Brace to Beam Mid-Span

Brace	HSS9x9x5/8			Beam	W18x60		
	Ag	18.7	in2		d	18.4	in
	r	3.68			k des	1.15	
	tnom	0.625	in		tw	0.45	in
	D	9	in		tf	0.75	in
	tdes	0.581	in		Fy	50	ksi
	Fy	46	ksi		Fu	65	ksi
	Fu	58	ksi		N	35.2	
	Length act	11	ft				

1 **Expected tensile Strength of the Brace**

Ry	1.6	
Tu	1376.32	kips

2 **Brace to Gusset weld Design**

max fillet weld size

D≤	10.91	try	10	/sixteenths

minimum length of 4 welds

lw≥	24.7	Use(L)	25	in

min gusset plate thickness

tmin	0.007521	use	1.5	in

3 **Shear lag check of the brace**

Ae req	26.36628	18.7	so not good
An	16.66875 in^2		
Aecp	9.697534 in^2		
so reinforcing plates		2, 5/8" by 8" plate	
w Dmin	0.5625 use 9	sixteenths	

4 **Determine brace forces**

KL/r	35.86957 ≤	118.2608
so:		
Fe	222.2312	
Fcr	42.18248	

nominal Compressive Strength

Pn	1388.31

5 **Determine forces at gusset beam interface**

Shear Force

V	1954.888	kips

Tension Force

T	8.478069	kips

Moment

M	17984.97	k-in

6 **Design weld at the gusset beam interface**

Gusset plate length	69.75	in		
Sw	810.8438	in3/in		
fv	28.02707	kip/in		
fa	-0.12155	kip/in		
fb	22.18057	kip/in		
fpeak	35.66675	kips/in		
favg	35.74218	kips/in		
fp/fa	0.99789 <		1.25	
so:				
fr	44.67773	kips/in		

min weld size

D ≥	16.04803	use	CJP

Plate	A 36		
	Fy	50	ksi
	Fu	65	ksi

7 Compression buckling of gusset plate check

plate t	1.5 (from part 2)				
buckling length	19	in			
r	0.433013	in			
KL/r	52.65434				
ϕFcr	26.3	table 4-22			
whitmore width					
lw	25	in			
Lw	37.84982	in			
ϕRn	1493.175	kips	>	1388.31	so ok

8 tension yielding of gusset

ϕRn	2554.863	kips	>	1376.32	so ok

9 **beam web local buckling**

max comp load per length of gusset
fc 22.05902 kip/in

max tens load per length of gusset
ft 22.30212 kip/in

length of gusset subject to tensile forces

Lt 35.06611 in

ϕFywtw	30.25	>	22.05902	so ok

10 **Beam web Crippling**

Ru	382.5462 kips			
Rn	923.5717			
ϕRn	692.6788 kips	>	382.5462	so ok

11 **free edge buckling of gusset plate**

max free edge length

Lfg max 27.09359 in

outer edge to brace

Lfg	24.82226 in	<	27.09359	so ok

inner brace to brace(one stiffner)

Lfg	34.1629 in	>	27.09359	so ng

inner brace to brace(two stiffner)

Lfg	13.45811	<	27.09359	so ok

Inverted V

Brace	HSS9x9x5/8			Beam	W36x282		
	Ag	18.7	in2		d	37.1	in
	r	3.4			bf	16.6	in
	tnom	0.625	in2		tw	0.885	in
	D	10	in2		tf	1.57	in
	tdes	0.581	in2		Fy	50	ksi
	Fy	46	ksi		Fu	65	ksi
	Fu	58	ksi		Ag	82.9	in2
	Length act	11	ft		weight	0.282	klf
					Ix	17900	in4
					Zx	1200	in3
					rx	15.3	
					Ry	3.76	
					Sx	92	in3

1 assumed force in the tension brace

Ry	1.6
Pt	1376.32

2 assumed force in the compression brace

KL/r	38.8 <	118.2608

so:

Fe	189.7
Fcr	41.5604
Pn	777.1796
ϕPn	699.4616
Pc	233.1539

3 determine the unbalanced vertical load on the beam

Pty	1251.2	kips
Pcy	211.9581	kips
Qb	1039.242	kips

4 Determine axial force in the beam

Pty	1376.32	kips
Pcy	233.1539	kips

	Pu	804.7369	kips
5	**Determine moment in the beam**		
	Mqe	5715.831	
	Mu	5715.831	
6	**check element slenderness**		
	λf	5.286624	
	λp	9.151612	
	λw	38.2	
	λp	90.55279	
6	**check unbraced length**		
	Lp	12.2	manual table 3-2
	Lb	10.36667	
7	**Determine Flexural Strength**		
	Mn	5000	
	ϕMn	4500	

Story height	10	ft
frame width	22	ft
.5 frame w	11	ft

Coumn

dc 15.2 in

8 Determine Compression Strength

Klx/rx 17.2549
Kly/ry 35.10638

From Manual

ϕFcr 39.2 ksi
ϕcPn 3249.68 kips

9 Consider second-order effects

B1	1.01	Pel	73434.89
B2	1.0		

Pr 804.7369
Mrx 5779.162

10 Check Combined Loading

Pr/Pc	0.207406 <.2	Pc	3880
		Mc	4240

so
1.066713 < 1.0

11 Determine Shear in the beam

Vqe 1039.242

Vu 1039.242

12 Check Shear Strength

table 3-2
ϕVn = ϕRv1 1110 > 1039.242 so ok

Appendix E: Green Roof Study

Existing LEED Score Card

UMCP Bldg 7 -- LEED 2.2 Checklist & Responsibility Matrix									
			Attempt?				Responsible for Analysis and/or Documentation	Documentation Pending / Documentation Completed	50% CD 100% CD Constr Post Con
CREDIT	CRITERIA	INTENT AND REQUIREMENT	Y	N	?	# of Points			
Sustainable Sites						8		Notes	Status
Pre-requisite	Construction Activity Pollution Prevention	Prevent loss of soil during construction by storm water runoff and/or wind erosion, including protecting topsoil by stockpiling for reuse. Prevent sedimentation of storm sewer or receiving streams and/or pollution with dust and particulate matter. Erosion control plan conforms to 2003 EPA Construction General Permit, or local Erosion and Sedimentation Control standards, whichever is more stringent.				—	AMT		100% CD
Credit SS 1.0	Site Selection	Avoid the development of inappropriate sites (e.g.- prime agricultural land, flood plains, previous parkland, wetlands) and reduce the environmental impact from the location of a building on a site.	1			1	DCI	Provide a written narrative and plan of the existing site to verify that it is a predeveloped area.	Done
Credit SS 2.0	Development Density & Community Connectivity	Construct on a previously developed site AND within a 1/2 mile of a dense residential zone (average of 10 units per acre) AND within 1/2 mile of 10 basic services AND with pedestrian access between the building and the services.	1			1	DCI	Overlay a 1/2 mile radius on a Google map and highlight the locations of services and outline / calculate the residential density.	Done
Credit SS 3.0	Brownfield Redevelopment	Rehabilitate damaged sites where development is complicated by real or perceived environmental contamination, reducing pressure on undeveloped land.		1					
Credit SS 4.1	Alternative Transport. - Public	Locate building within 1/4 mile of a commuter rail, lite rail, or subway station OR 1/4 mile of 2 or more bus lines.	1			1	DCI / AMT	Document the 2 nearest stops on any 2 separate routes of the UM Shuttle, within	Done
Credit SS 4.2	Alternative Transport. - Bike Storage	Provide suitable means for securing bicycles, in a covered location, for 15% or more of building occupants.	1			1	DCI/UMCP/CMC	Documented the locations in the Mowatt Garage. Need to provide cut-sheets of the proposed racks to verify the capacity of 55 bikes.	100% CD
Credit SS 4.3	Alternative Transport. - Low-Emitting Vehicles	Provide preferred parking for low-emitting or fuel-efficient vehicles for 5% of the total parking capacity of the site	1			1	UMCP/DCI/AMT	The submitted CIR was answered favorably. We need to upload actual Green Sticker Program info to site. UMCP to provide.	100% CD
Credit SS 4.4	Alternative Transport. - Parking	Provide no new on-site parking	1			1	DCI	Residents will park in existing Mowatt Garage	Done
Credit SS 5.1	Site Development - Protect or Restore Habitat	On greenfield sites, limit site disturbance including earthwork and clearing of vegetation to 40 feet beyond the building perimeter, 5 feet beyond primary roadway curbs, walkways, and main utility branch trenches, and 25 feet beyond pervious paving areas that require additional staging areas in order to limit compaction in the paved area. On previously developed sites, restore a minimum of 50% of the remaining open area by planting native or adapted vegetation		1					
Credit SS 5.2	Site Development - Maximize Open	Reduce the development footprint to exceed the local zoning's open space requirement for the site by 25%.		1					
Credit SS 6.1	Stormwater Design - Quantity Control	No net increase in the rate or quantity of stormwater runoff from existing to developed conditions		1				Calcs did not appear favorable.	
Credit SS 6.2	Stormwater Design - Quality Control	Treatment systems designed to remove 80% of the average annual post development total suspended solids by implementing Best Management Practices.		1				Calcs did not appear favorable	
Credit SS 7.1	Heat Island Effect - Non-Roof	Provide shade or a high-SRI on at least 50% of non-roof impervious surfaces on the site, including parking lots, walkways, plazas.							
Credit SS 7.2	Heat Island Effect - Roof	Use ENERGY STAR Roof compliant, high-reflectance AND high emissivity roofing (initial reflectance of at least .65 and three-year-aged reflectance of at least .5 when tested in accordance with ASTM E408) for a minimum of 75% of the roof surface OR install a green vegetated roof for at least 50% of the roof area.	1			1	DCI	This credit could be achieved with a white TPO roof membrane	100% CD

UMCP Bldg 7 -- LEED 2.2 Checklist & Responsibility Matrix

CREDIT	CRITERIA	INTENT AND REQUIREMENT	Attempt? Y	N	?	# of Points	Responsible for Analysis and/or Documentation	Documentation Pending / Documentation Completed	50% CD 100% CD Constr Post-Con
Credit SS 8.0	Light Pollution Reduction	Do not exceed Illuminating Engineering Society of North America (IESNA) footcandle level requirements AND design interior and exterior lighting such that zero direct-beam illumination leaves the building site. (e.g. must be full cut-off luminaires and no up-lighting)	1			1	BKM	Verify compliance with required security lighting	100% CD
Water Efficiency						3			
Credit WE 1.1	Water Efficient Landscaping - Reduce by 50%	Use high-efficiency irrigation technology such as micro-irrigation systems, moisture sensors, and weather database controllers.	1			1	MRA/BKM	Credit information has been uploaded and marked complete	Done
Credit WE 1.2	Water Efficient Landscaping - No Potable Water Use or No Irrigation	Use only captured rain water for at additional 50% reduction in potable water for irrigation needs OR do not install permanent landscape irrigation systems.							
Credit WE 2.0	Innovative Wastewater Technologies	Reduce the use of municipally provided potable water for building sewage conveyance by a minimum of 50% OR treat 100% of wastewater on site to tertiary standards.		1					
Credit WE 3.1	Water Use Reduction - 20% Reduction	Employ strategies that in aggregate use 20% less water than the water use calculated for the building (not including irrigation) after meeting the Energy Policy Act of 1992 fixture performance requirements. (e.g. waterless urinals, low-flow fixtures).	1			1	DCI/BKM	Utilize water flow-restrictors in all faucets and showers. Utilize "low flush" toilets in apartments.	100% CD
Credit WE 3.2	Water Use Reduction - 30%	Exceed the potable water use reduction by an additional 10% (30% total efficiency increase).	1			1	DCI/BKM	Utilize newer "ultra-low dual flush" toilets in apartments?	100% CD
Energy and Atmosphere						5			
Pre-requisite	Fundamental Building Systems Commissioning	Verify and ensure that fundamental building elements and systems are designed, installed and calibrated to operate as intended through best practice commissioning procedures.				—	WT/BKM/CDC	Need to engage a commissioning agent	Post-Con
Pre-requisite	Minimum Energy Performance	Design to meet building energy efficiency and performance as required by ASHRAE/IESNA 90.1-2004 or the local energy code, whichever is more stringent. Analyze expected baseline building performance using the				—	BKM/WT		
Pre-requisite	Fundamental Refrigerant Management	Zero use of CFC-based refrigerants in new building HVAC&R systems.				—	BKM/WT		
Credit EA 1.1 - 1.5	Optimize Energy Performance	Exceed the requirements of ASHRAE 90.1-2004 by 14%, demonstrated by whole building simulation	2			2	DCI/BKM/WT	15-SEER furnaces, consider water heating options	100% CD
Credit EA 2.0	Renewable Energy	Use of on-site renewable energy systems.		1					
Credit EA 3.0	Additional Commissioning	Implement comprehensive best practice commissioning procedures which at a minimum includes third party quality control assurance.	1			1			
Credit EA 4.0	Enhanced Refrigerant	Install base building level HVAC and refrigeration equipment and fire suppression systems that do not contain HCFCs or Halon.	1			1	BKM	Energy Modeler suggested this as an easy credit. BKM agrees.	100% CD
Credit EA 5.0	Measurement & Verification	Comply with the installed equipment requirements for continuous metering as stated in Option B: Methods by Technology of the US DOE's International Performance Protocol (IMPVP) for the following: lighting and systems, cooling loads, building specific process energy efficiency	1			1	BKM/WT	Post-commissioning study in lieu of a metering plan compliant with the IMPVP requirements.	100% CD
Credit EA 6.0	Green Power	Encourage the development and use of grid-source, renewable energy technologies on a net zero pollution basis.		1					
Materials and Resources						4			
Pre-requisite	Storage & Collection of Recyclables	Provide an easily accessible area that serves the entire building that is dedicated to the separation, collection and storage of materials for recycling including (at a min) paper, glass, plastics and metal.				—	DCI/WT/CMC	Individual bins on each floor and collection in the main trash room, as typical SCC buildings operate.	Done
Credit MR 1.1	Building Reuse - 75%	Maintain at least 75% of existing building structure and shell. This is calculated in square feet.		1					

UMCP Bldg 7 -- LEED 2.2 Checklist & Responsibility Matrix

CREDIT	CRITERIA	INTENT AND REQUIREMENT	Attempt? Y	N	?	# of Points	Responsible for Analysis and/or Documentation	Documentation Pending / Documentation Completed	50% CD 100% CD Constr Post-Con
Credit MR 1.2	Building Reuse - 100%	Maintain an additional 25% (100% total) of existing building structure and shell (exterior skin and framing excluding window assemblies). This is		1					
Credit MR 1.3	Building Reuse - 50%	Maintain 50% of existing building interior		1					
Credit MR 2.1	Construction Waste Management - Divert 50% from	Develop a waste management plan. Recycle and/or salvage 50% (by weight) of construction, demolition, and land clearing waste (total waste-stream).	1			1	WT	Will keep track of tickets	Post-Con
Credit MR 2.2	Construction Waste Management - Divert 75% from	Recycle and/or salvage an additional 25% (75% total by weight) of the construction, demolition, and land clearing debris (total waste-stream).	1			1	WT	Will keep track of tickets	Post-Con
Credit MR 3.1	Materials Reuse - 5%	Specify salvaged or refurbished materials for 5% of building materials. This is calculated by dollar value.		1					
Credit MR 3.2	Materials Reuse - 10%	Specify salvaged or refurbished materials for 10% of building materials. This is calculated by dollar value.		1					
Credit MR 4.1	Recycled Content - 10%	Use materials with recycled content such that the sum of the post-consumer + 1/2 pre-consumer constitutes at least 10% of total value of materials in the project. This is calculated by dollar value.	1			1	DCI/WT	Look at steel, concrete, carpet, tile, exterior cladding, etc.	Post-Con
Credit MR 4.2	Recycled Content - 20%	Use materials with recycled content such that the sum of the post-consumer + 1/2 pre-consumer constitutes at least 20% of total value of materials in the project. This is calculated by dollar value.		1					
Credit MR 5.1	Regional Materials - 10%	Specify a minimum of 10% building materials that are extracted, harvested, and manufactured within a radius of 500 miles. This is			1		DCI/WT	Look at concrete, brick, gypsum board, etc.	Post-Con
Credit MR 5.2	Regional Materials - 20%	Specify a minimum of 20% building materials that are extracted, harvested, and manufactured within a radius of 500 miles. This is calculated by dollar value.		1					
Credit MR 6.0	Rapidly Renewable Materials	Specify rapidly renewable building materials for 5% of total building materials. This is calculated by dollar value.		1					
Credit MR 7.0	Certified Wood	Use a minimum of 50% of wood-based materials certified in accordance with the Forest Steward Council guidelines for wood building components including framing, flooring finishes, furnishings, and non-rented temporary construction applications such as bracing, concrete formwork and	1			1	DCI/WT	Must also consider casework, base moulding and all interior wood doors.	Post-Con
Indoor Environmental Quality (IEQ)						**12**			
Pre-requisite	Minimum IAQ Performance	Meet the minimum requirements of voluntary consensus standard ASHRAE 62.1-2004, Ventilation for Acceptable Indoor Air Quality and approved Addenda. (e.g. Locate building outdoor air intakes away from loading areas, building exhaust fans, cooling towers, and other sources of contamination).				—	BKM		
Pre-requisite	Environmental Tobacco Smoke Control	Prevent exposure of building occupants and systems to Environmental Tobacco Smoke (ETS). Zero exposure of nonsmokers to ETS by prohibition of smoking in the building or within 25' of the building entrance.				—	UMCP/CMC	UMCP buildings are non-smoking and smoking is prohibited within 25' of entrances	Done
Credit EQ 1.0	Outdoor Air Delivery Monitoring	Install a permanent carbon dioxide (CO2) monitoring system that provides feedback on space ventilation performance in a form that affords operational adjustments.		1					
Credit EQ 2.0	Increased Ventilation Effectiveness	For mechanically ventilated buildings, design ventilation systems that result in an air change effectiveness greater than 30% above the minimum as determined by ASHRAE 62.1-2004. For naturally ventilated spaces demonstrate compliance with the reccommendations of the Carbon Trust Good Practice Guide 237 (1998)		1					

UMCP Bldg 7 -- LEED 2.2 Checklist & Responsibility Matrix

CREDIT	CRITERIA	INTENT AND REQUIREMENT	Attempt? Y	N	?	# of Points	Responsible for Analysis and/or Documentation	Documentation Pending / Documentation Completed	50% CD 100% CD Constr Post-Con
Credit EQ 3.1	Construction IAQ Management Plan - During Construction	Develop and implement an Indoor Air Quality Management Plan such that during construction, meet or exceed the minimum requirements of the Sheet Metal and Air Conditioning National ECls Association (SMACNA) IAQ Guideline for Occupied Buildings under Construction 1995 (applied to 5 areas: HVAC protection, source control, pathway interruption, housekeeping, and scheduling), AND protect stored on-site or installed absorptive materials from moisture damage, AND replace all filtration media immediately prior to occupancy w/ MERV 13	1			1	WT	Requires MERV 8 filtration during construction and MERV 13 filtration to be installed at end of construction. BKM research indicates we can comply.	Post-Con
Credit EQ 3.2	Construction IAQ Management Plan - Before Occupancy	Conduct a building flushout with new filtration media at 14,000cf outside air for each square foot of floor area, after construction ends and prior to occupancy, OR conduct a baseline indoor air quality testing procedure consistent with current EPA protocol.	1			1	WT	Depending on scheduling and time-of-year, this may need to be achieved in various ways	Post-Con
Credit EQ 4.1	Low-Emitting Materials - Adhesives & Sealants	Adhesives and sealants must meet or exceed the VOC limits of South Coast Air Quality Management District Rule # 1168.	1			1	DCI/WT	Specs and submittal verification	100% CD
Credit EQ 4.2	Low-Emitting Materials - Paints & Coatings	Paints and coating must meet or exceed the VOC and chemical component limits of Green Seal requirements.	1			1	DCI/WT	Specs and submittal verification	100% CD
Credit EQ 4.3	Low-Emitting Materials - Carpet Systems	Carpet systems must meet the Carpet and Rug Institute Green Label Indoor Air Quality Test Program.	1			1	DCI/WT	Specs and submittal verification	100% CD
Credit EQ 4.4	Low-Emitting Materials - Composite Wood & Agrifiber Products	Composite wood products must contain no added urea-formaldehyde resins.	1			1	DCI/WT	Specs and submittal verification	100% CD
Credit EQ 5.0	Indoor Chemical and Pollutant Source Control	Employ a permanent entryway system (i.e., grills or grates) to keep dirt from entering the building at high volume entryways, AND provide areas with deck to deck partitions with separate exhaust air and negative pressure for chemical use, housekeeping and copying/printing rooms, AND drains plumbed for approp. disposal of liquid chemical concentrate waste.	1			1	DCI/BKM/WT	Provide entrance mats in both building vestibules and separate the janitor closets	100% CD
Credit EQ 6.1	Controllability of Systems - Lighting	Provide individual lighting controls for a minimum of 90% of building occupants AND for all shared multi-occupant spaces	1			1	DCI/BKM		100% CD
Credit EQ 6.2	Controllability of Systems - Thermal Comfort	Provide controls for each individual for airflow, temperature, and lighting for 50% of regularly occupied areas (or provide operable windows) AND provide system controls for all shared multi-occupant spaces	1			1	DCI/BKM		100% CD
Credit EQ 7.1	Thermal Comfort - Design	Provide for a thermally comfortable environment that supports the productive and healthy performance of the building occupants by complying with ASHRAE Standard 55-2004 for thermal comfort standards including humidity control within established ranges per climate zone.	1			1	BKM		100% CD
Credit EQ 7.2	Thermal Comfort - Verification	Implement a survey of residents regarding thermal comfort performance and effectiveness of humidification and/or dehumidification systems in the building.	1			1	BKM/CMC		Post-Con
Credit EQ 8.1	Daylight and Views - 75%	Achieve a minimum Daylight Factor of 2% (excluding all direct sunlight penetration) in 75% of all space occupied for critical visual tasks, not including copy rooms, storage areas, mechanical, laundry, and other low occupancy support areas.		1				Calcs did not achieve required Daylight Factor	
Credit EQ 8.2	Daylight and Views - 90%	Direct line of sight to vision glazing while seated from 90% of all regularly occupied spaces, not including copy rooms, storage areas, mechanical, other low occupancy support areas.	1			1	DCI	Preliminary calcs completed - will add to templates on USGBC site	100% CD

UMCP Bldg 7 -- LEED 2.2 Checklist & Responsibility Matrix

CREDIT	CRITERIA	INTENT AND REQUIREMENT	Attempt? Y	N	?	# of Points	Responsible for Analysis and/or Documentation	Documentation Pending / Documentation Completed	50% CD 100% CD Constr Post-Con
Innovation in Design						5			
	Innovation in Design	Provide design teams and projects the opportunity to be awarded points for exceptional performance above requirements set by the LEED Rating System and/or innovative performance in categories not specifically							
Credit ID 1.1	Possible Innovation Credit 1	Campus-wide Transportation Management Plan	1			1	UMCP/DCI	Describe the university's programs of ride-sharing, encouraged bike use, flex-vehicles to minimize the impacts of vehicles on campus. Alternative	Done
Credit ID 1.2	Possible Innovation Credit 2	Heat Island Effect (Non-Roof) Exemplary Performance (100%)	1			1	DCI/MRA/WT	Use high-albedo paving for all new hardscape surfaces	100% CD
Credit ID 1.3	Possible Innovation Credit 3	Green Cleaning Program	1			1	UMCP/CMC	Use only "green" products for general cleaning and disinfecting of interior spaces	100% CD
Credit ID 1.4	Possible Innovation Credit 4	Education of Campus Community About Building	1			1	UMCP/CMC	Develop a program or curriculum which teaches the community about the "green" aspects of the building	100% CD
Credit ID 2.0	LEED Accredited Professional	Support and encourage the design integration process required by a LEED Green Building project and streamline the application and certification process by having at least one principal participant of the project team who has successfully completed the LEED Accredited	1			1	DCI/BKM/WT		Done
		TOTAL POINTS (including Innovation Credits)	37	19	1	37			
		LEED Certified = 26-32, Silver = 33-38, Gold = 39-51, Platinum = 52 or more							

Water Collection Design Calculations

Locations	Roof Area (SF)	Rain (inches)	Cubic Ft of Rain	Gallons of Water
College Park, MD	14,750.00	44	54,083.33	404,543.33
San Diego, CA	14,750.00	5	6,145.83	45,970.83

Locations	Water Comsumed by green roof (inch per month)	Excess water for Sanitary System (Gallons)	Average Supply per month to tank (Gallons)	Required Tank Size (Cubic Feet)	Provided Tanks Sizes (Gallons)
College Park, MD	2	386,155.00	32,179.58	4,302.08	2 @ 1000
San Diego, CA	0.125	44,821.56	3,735.13	499.35	1 @ 500

Drain Sizing

Sizing and Placement of MIFAB Roof Drains

CHART B:
HORIZONTAL STORM DRAIN CAPACITY IN GPM FOR SLOPES GIVEN WITH MAXIMUM SERVICEABLE ROOF AREA IN SQUARE FEET BASED ON SYSTEM CAPACITY

	1/8 INCH PER FOOT SLOPE		1/4 INCH PER FOOT SLOPE		1/2 INCH PER FOOT SLOPE	
DRAIN PIPE SIZE (INCHES)	DRAIN CAPACITY (GPM)	MAXIMUM ROOF AREA (SQUARE FEET)	DRAIN CAPACITY (GPM)	MAXIMUM ROOF AREA (SQUARE FEET)	DRAIN CAPACITY (GPM)	MAXIMUM ROOF AREA (SQUARE FEET)
3	34	822	48	1160	69	1644
4	78	1880	110	2650	157	3760
5	139	3340	197	4720	278	6680
6	223	5350	315	7550	446	10700
8	479	11500	679	16300	958	23000
10	863	20700	1217	29200	1725	14100
12	1388	33300	1958	47000	2775	66600
15	2479	59500	3500	84000	4958	11900

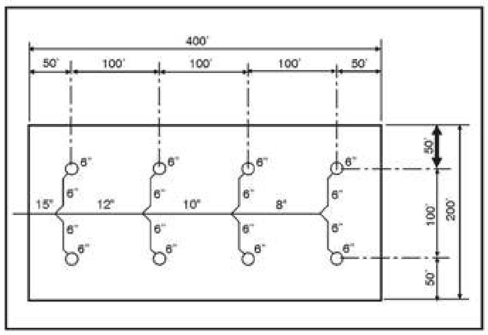
Roof Drain Sizing - Example

A warehouse is being built in a geographical area where the maximum hourly rainfall (See Page RD-6) is 2.8 inches per hour. The building will be 200'x400' and have a flat roof with no appreciable vertical surfaces.

CALCUATIONS:

- Total area to be drained (200 x 400) — **80,000 Sq. ft.**
- Number of drains required (From sizing rule, one drain per 10,000 sq. Ft.) — **8**
- Rainfall conversion from in. per hour to GPM (0.0104 x 2.8 x 80,000) — **2330**
- Expected flow from drain (GPM÷number of drains) (2330÷8) — **292**
- Size of leader (from Chart A) — **6 inch vertical**
- Size of horizontal storm sewers (from Chart B 1/4/ foot slope, combined flow of vertical leaders) — **8,10,12,15 inches**

Roof Drainage System Layout indicated by the sizing example



Roof Drain Sizing: Other Considerations

• OVERFLOW DRAINAGE
Overflow scuppers and drains, as essential components of the roof drainage system, are employed to prevent potentially damaging overloading of roof structures. They must be installed in conformance with local codes. Generally, scuppers are installed in adjacent parapet walls no more than 5 inches above the low point of the roof at a ratio of at least one scupper per 20,000 sq. ft. of roof area. Overflow drains of the same size as the roof drains having above roof inlet elevation as specified by code, connected to drain lines independent from the roof drains, may be installed in lieu of scuppers.

• VERTICAL WALLS
Finally, vertical walls that project above and permit storm water to drain on the roof area to be drained must be considered when planning the roof drainage system. An acceptable rule to follow in sizing roof drains, leaders, and horizontal drainage piping is to add one half of the area of any vertical wall that diverts rainwater to the roof to the projected area of that roof. By multiplying the area thus obtained by the GPM/sq. ft. conversion of inches per hour rainfall, the new total GPM discharge requirement is determined for the roof.

ix B

Appendix F: Acoustic Study

Space Noise and Listening Requirements

Type of Space (and Listening Requirements)	Preferred Range of Noise Criteria	Equivalent dBA Level*
Concert halls, opera houses, broadcasting and recording studios, large auditoriums, large churches, recital halls (for excellent listening conditions)	< NC-20	< 30
Small auditoriums, theaters, music practice rooms, large meeting rooms, teleconference rooms, audiovisual facilities, large conference rooms, executive offices, small churches, courtrooms, chapels (for very good listening conditions)	NC-20 to NC-30	30 to 38
Bedrooms, sleeping quarters, hospitals, residences, apartments, hotels, motels (for sleeping, resting, relaxing)	NC-25 to NC-35	34 to 42
Private or semiprivate offices, small conference rooms, classrooms, libraries (for good listening conditions)	NC-30 to NC-35	38 to 42
Large offices, reception areas, retail shops and stores, cafeterias, restaurants, gymnasiums (for moderately good listening conditions)	NC-35 to NC-40	42 to 47
Lobbies, laboratory work spaces, drafting and engineering rooms, general secretarial areas, maintenance shops such as for electrical equipment (for fair listening conditions)	NC-40 to NC-45	47 to 52
Kitchens, laundries, school and industrial shops, computer equipment rooms (for moderately fair listening conditions)	NC-45 to NC-55	52 to 61

* Do not use A-weighted sound levels (dBA) for specification purposes. Spectrum shapes and noise characteristics can vary widely for background noises with identical A-weighted sound levels (see Chap. 1).

Air Space Transmission Loss

	Improvement in TL (dB)					
Airspace (in)	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
2	5	7	19	25	30	30
4	10	12	24	30	35	35

Floor and Roof Assembly constructions for STC and IIC

TL DATA FOR COMMON BUILDING ELEMENTS*

Building Construction	Transmission Loss (dB) 125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	STC Rating	IIC Rating†
Walls[2-6]‡								
Monolithic:								
1. 3/8-in plywood (1 lb/ft²)	14	18	22	20	21	26	22	
2. 26-gauge sheet metal (1.5 lb/ft²)	12	14	15	21	21	25	20	
3. 1/2-in gypsum board (2 lb/ft²)	15	20	25	31	33	27	28	
4. 2 layers 1/2-in gypsum board, laminated with joint compound (4 lb/ft²)	19	26	30	32	29	37	31	
5. 1/32-in sheet lead (2 lb/ft²)	15	21	27	33	39	45	31	
6. Glass-fiber roof fabric (37.5 oz/yd²)	6	9	11	16	20	25	16	
Interior:								
7. 2 by 4 wood studs 16 in oc with 1/2-in gypsum board both sides (5 lb/ft²)	17	31	33	40	38	36	33	
8. Construction no. 7 with 2-in glass-fiber insulation in cavity	15	30	34	44	46	41	37	
9. 2 by 4 staggered wood studs 16 in oc each side with 1/2-in gypsum board both sides (8 lb/ft²)	23	28	39	46	54	44	39	
10. Construction no. 9 with 2 1/4-in glass-fiber insulation in cavity	29	38	45	52	58	50	48	
11. 2 by 4 wood studs 16 in oc with 5/8-in gypsum board both sides, one side screwed to resilient channels. 3-in glass-fiber insulation in cavity (7 lb/ft²)	32	42	52	58	53	54	52	
12. Double row of 2 by 4 wood studs 16 in oc with 3/8-in gypsum board on both sides of construction. 9-in glass-fiber insulation in cavity (4 lb/ft²)	31	44	55	62	67	65	54	
13. 6-in dense concrete block, 3 cells, painted (34 lb/ft²)	37	36	42	49	55	58	45	
14. 8-in lightweight concrete block, 3 cells, painted (38 lb/ft²)	34	40	44	49	59	64	49	
15. Construction no. 14 with expanded mineral loose fill in cells	34	40	46	52	60	66	51	
16. 6-in lightweight concrete block with 1/2-in gypsum board supported by resilient metal channels on one side, other side painted (26 lb/ft²)	35	42	50	64	67	65	53	
17. 2 1/2-in steel channel studs 24 in oc with 5/8-in gypsum board both sides (6 lb/ft²)	22	27	43	47	37	46	39	
18. Construction no. 17 with 2-in glass-fiber insulation in cavity	26	41	52	54	45	51	45	
19. 3 5/8-in steel channel studs 16 in oc with 1/2-in gypsum board both sides (5 lb/ft²)	26	36	43	51	48	43	43	
20. Construction no. 19 with 3-in mineral-fiber insulation in cavity	28	45	54	55	47	54	48	
21. 2 1/2-in steel channel studs 24 in oc with two layers 5/8-in gypsum board one side, one layer other side (8 lb/ft²)	28	31	46	51	53	47	44	
22. Construction no. 21 with 2-in glass-fiber insulation in cavity	31	43	55	58	61	51	51	
23. 3 5/8-in steel channel studs 24 in oc with two layers 5/8-in gypsum board both sides (11 lb/ft²)	34	41	51	54	46	52	48	
24. Construction no. 23 with 3-in mineral-fiber insulation in cavity	38	52	59	60	56	62	57	
Exterior:								
25. 4 1/2-in face brick (50 lb/ft²)	32	34	40	47	55	61	45	
26. Two wythes of 4 1/2-in face brick, 2-in airspace with metal ties (100 lb/ft²)	37	37	47	55	62	67	50	
27. Two wythes of plastered 4 1/2-in brick, 2-in airspace with glass-fiber insulation in cavity	43	50	52	61	73	78	59	
28. 2 by 4 wood studs 16 in oc with 1-in stucco on metal lath on outside and 1/2-in gypsum board on inside (8 lb/ft²)	21	33	41	46	47	51	42	
29. 6-in solid concrete with 1/2-in plaster both sides (80 lb/ft²)	39	42	50	58	64	67	53	
Floor-Ceilings[2,3]								
30. 2 by 10 wood joists 16 in oc with 1/2-in plywood subfloor under 25/32-in oak on floor side, and 5/8-in gypsum board nailed to joists on ceiling side (10 lb/ft²)	23	32	36	45	49	56	37	32

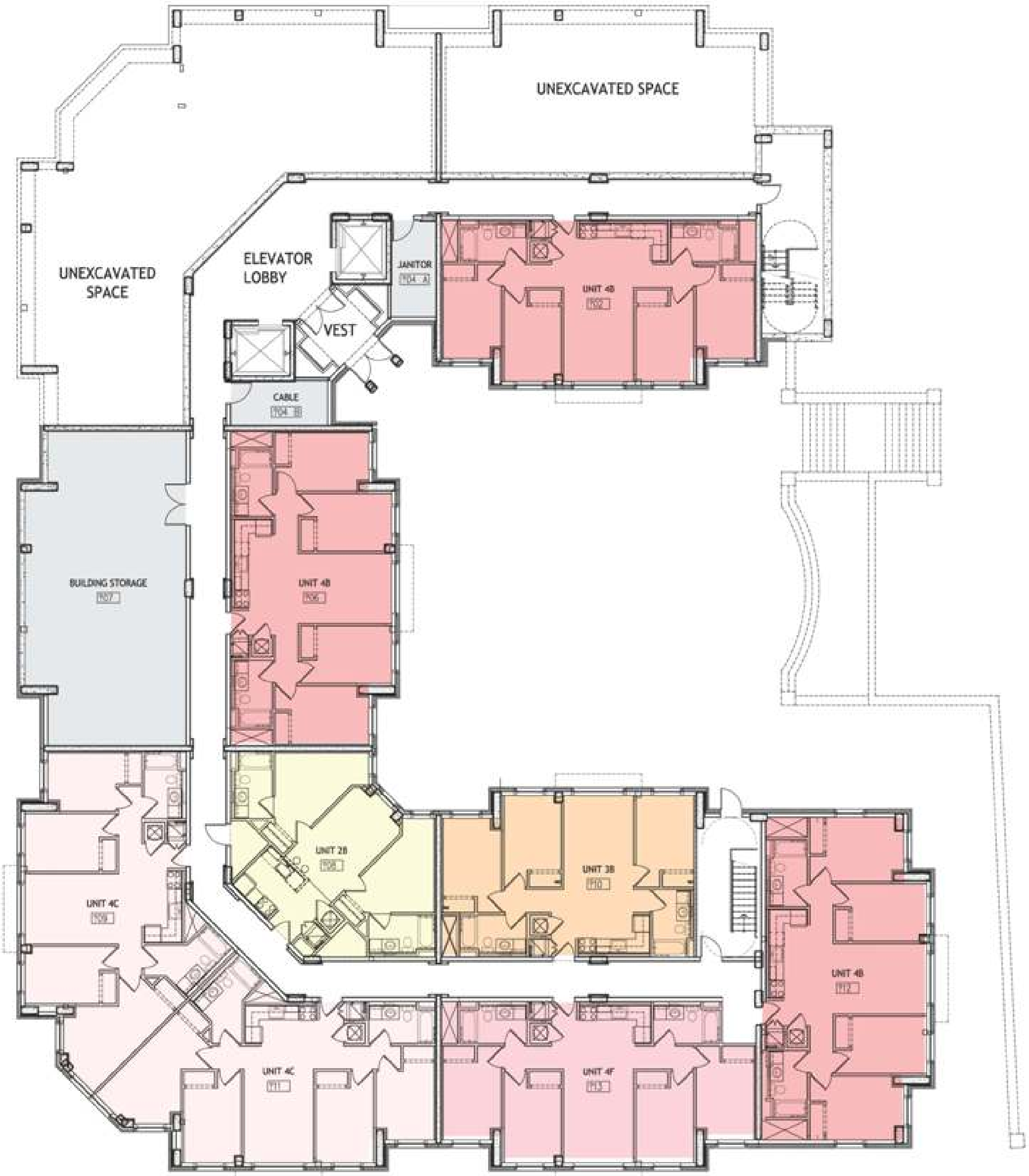
204 SOUND ISOLATION

Building Construction	Transmission Loss (dB) 125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	STC Rating	IIC Rating†
31. Construction no. 30 with 5/8-in gypsum board screwed to resilient channels spaced 24 in oc perpendicular to joists	30	35	44	50	54	60	47	39
32. Construction no. 31 with 3-in glass-fiber insulation in cavity	36	40	45	52	58	64	49	46
33. 4-in reinforced concrete slab (54 lb/ft²)	48	42	45	56	57	66	44	25
34. 14-in precast concrete tees with 2-in concrete topping on 2-in slab (75 lb/ft²)	39	45	50	52	60	68	54	24
35. 6-in reinforced concrete slab (75 lb/ft²)	38	43	52	59	67	72	55	34
36. 6-in reinforced concrete slab with 3/4-in T&G wood flooring on 1 1/2 by 2 wooden battens floated on 1-in glass fiber (83 lb/ft²)	38	44	52	55	60	65	55	57
37. 18-in steel joists 16 in oc with 1 5/8-in concrete on 5/8-in plywood under heavy carpet laid on pad, and 5/8-in gypsum board attached to joists on ceiling side (20 lb/ft²)	27	37	45	54	60	65	47	62
Roofs‡								
38. 3 by 8 wood beams 32 in oc with 2 by 6 T&G planks, asphalt felt built-up roofing, and gravel topping	29	33	37	44	55	63	43	
39. Construction no. 38 with 2 by 4s 16 in oc between beams, 1/2-in gypsum board supported by metal channels on ceiling side with 4-in glass-fiber insulation in cavity	35	42	49	62	67	79	53	
40. Corrugated steel, 24 gauge with 1 3/8-in sprayed cellulose insulation on ceiling side (1.8 lb/ft²)	17	22	26	30	35	41	30	
41. 2 1/2-in sand and gravel concrete (148 lb/ft³) on 28 gauge corrugated steel supported by 14-in-deep steel bar joists with 1/2-in gypsum plaster on metal lath attached to metal furring channels 13 1/2 in oc on ceiling side (41 lb/ft²)	32	46	45	50	57	61	49	
Doors‡								
42. Louvered door, 25 to 30% open	10	12	12	12	12	11	12	
43. 1 3/4-in hollow-core wood door, no gaskets, 1/4-in air gap at sill (1.5 lb/ft²)	14	19	23	18	17	21	19	
44. Construction no. 43 with gaskets and drop seal	19	22	25	19	20	29	21	
45. 1 3/4-in solid-core wood door with gaskets and drop seal (4.5 lb/ft²)	29	31	31	31	39	43	34	
46. 1 3/4-in hollow-core 16 gauge steel door, glass-fiber filled, with gaskets and drop seal (7 lb/ft²)	23	28	36	41	39	44	38	
Glass‡								
47. 1/8-in monolithic float glass (1.4 lb/ft²)	18	21	26	31	33	22	26	
48. 1/4-in monolithic float glass (2.9 lb/ft²)	25	28	31	34	30	37	31	
49. 1/2-in insulated glass: 1/8- + 1/8-in double glass with 1/4-in airspace (3.3 lb/ft²)	21	26	24	33	44	34	28	
50. 1/4- + 1/8-in double glass with 2-in airspace	18	31	35	42	44	44	39	
51. Construction no. 50 with 4-in airspace	21	32	42	48	48	44	43	
52. 1/4-in laminated glass, 30-mil plastic interlayer (3.6 lb/ft²)	25	28	32	35	36	43	35	
53. Double glass: 1/4-in laminated + 3/16-in monolithic glass with 2-in airspace (5.9 lb/ft²)	25	34	44	47	48	55	45	
54. Double glass: 1/4-in laminated + 3/16-in monolithic glass with 4-in airspace (5.9 lb/ft²)	36	37	48	51	50	58	48	
55. Double glass: 1/4-in laminated + 1/4-in laminated with 1/2-in airspace (7.2 lb/ft²)	21	30	40	44	46	57	42	

† IIC (*impact isolation class*) is a single-number rating of the impact sound transmission performance of a floor-ceiling construction tested over a standard frequency range. The higher the IIC, the more efficient the construction will be for reducing impact sound transmission. INR (*impact noise rating*) previously was used as the single-number rating of impact noise isolation. To convert the older INR data to IIC, add 51 to the INR number.
‡ A wide range of TL and STC performance can be achieved by gypsum wallboard constructions. Refer to ASTM E 90 laboratory report and literature from manufacturers for specific details such as type of gypsum board; gauge, width, and spacing of steel studs; glass-fiber or mineral-fiber insulation thickness and density; and complete installation recommendations.

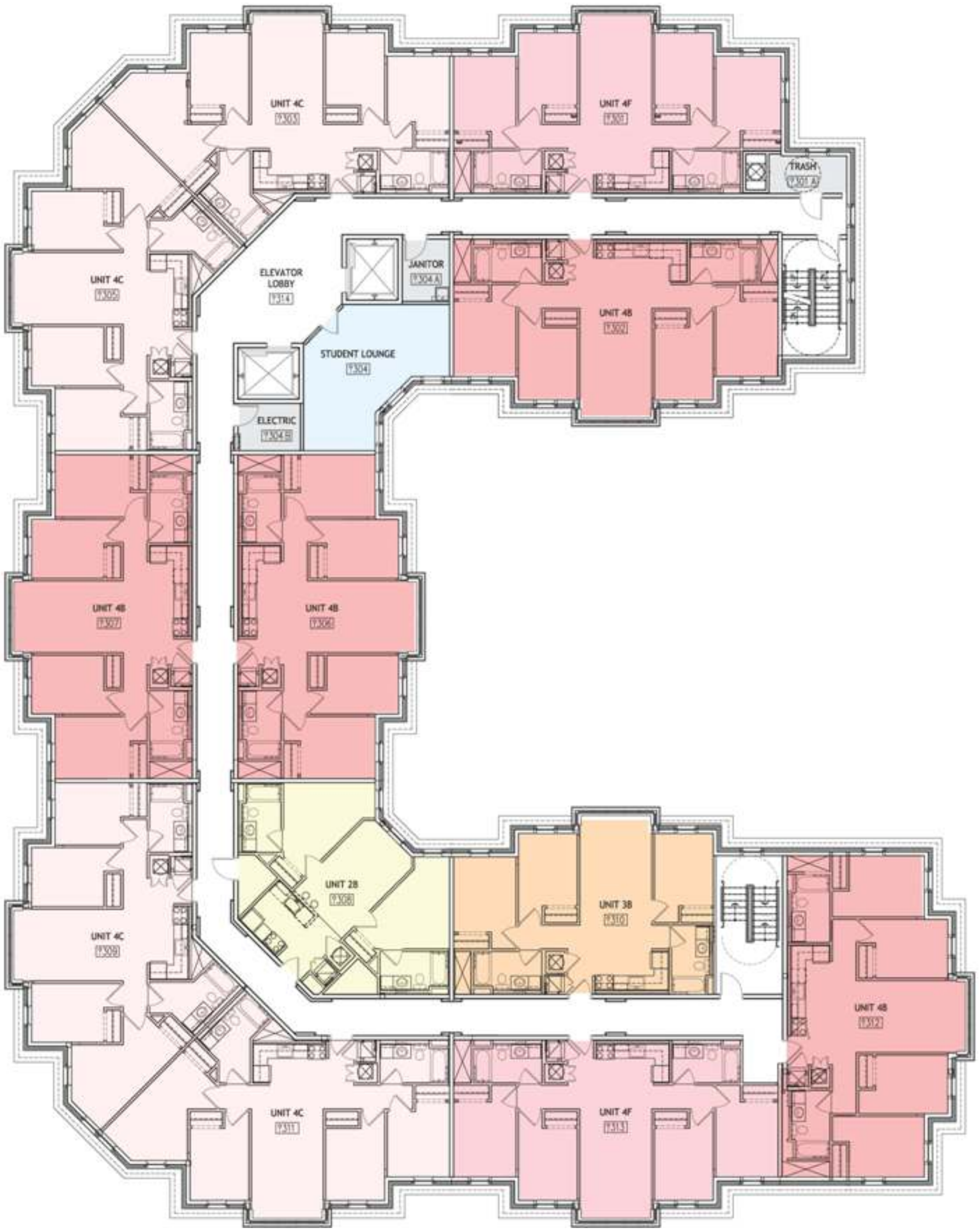
Appendix G: Building Plans

Terrace/Ground Floor Plan



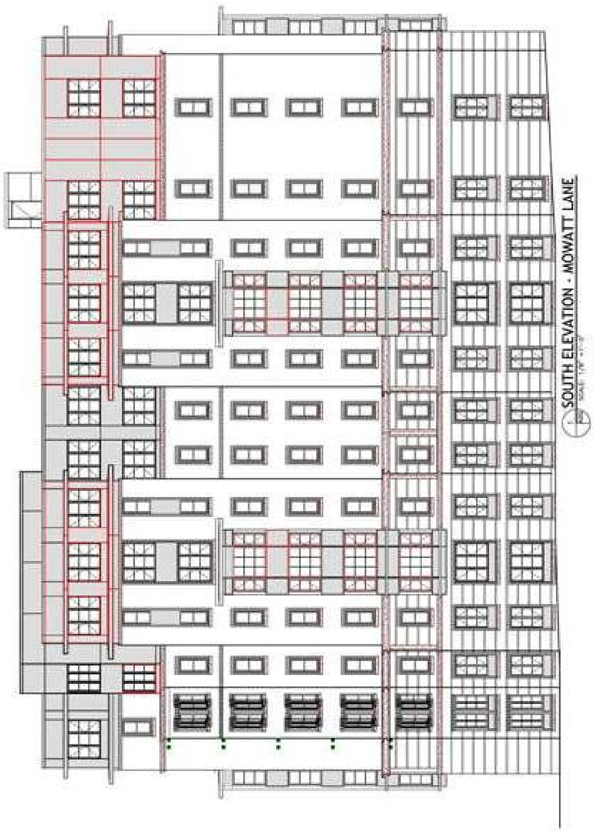
First Floor Plan

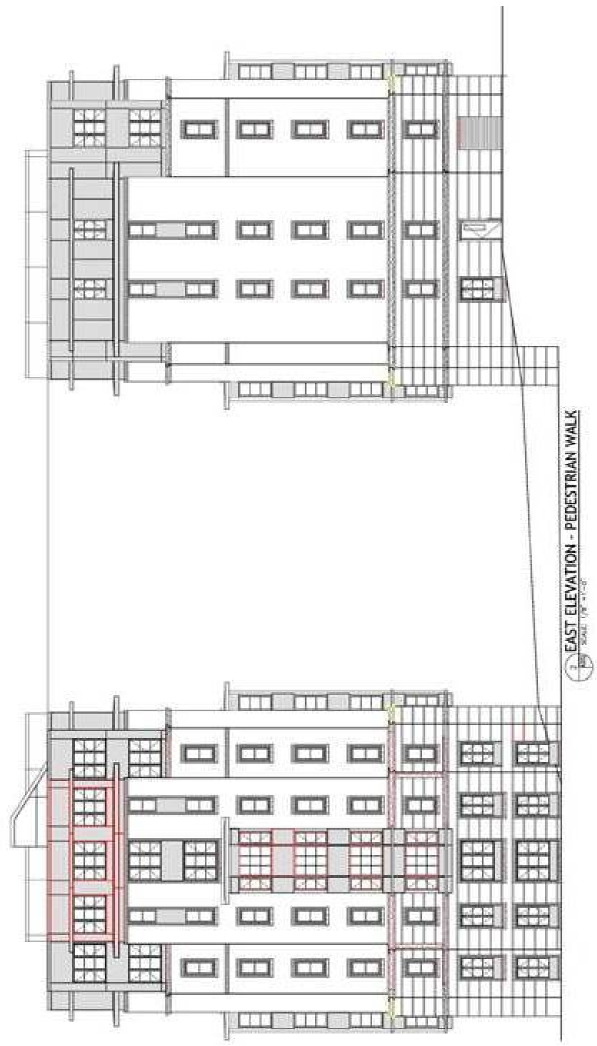
Typical Upper Floor Plan



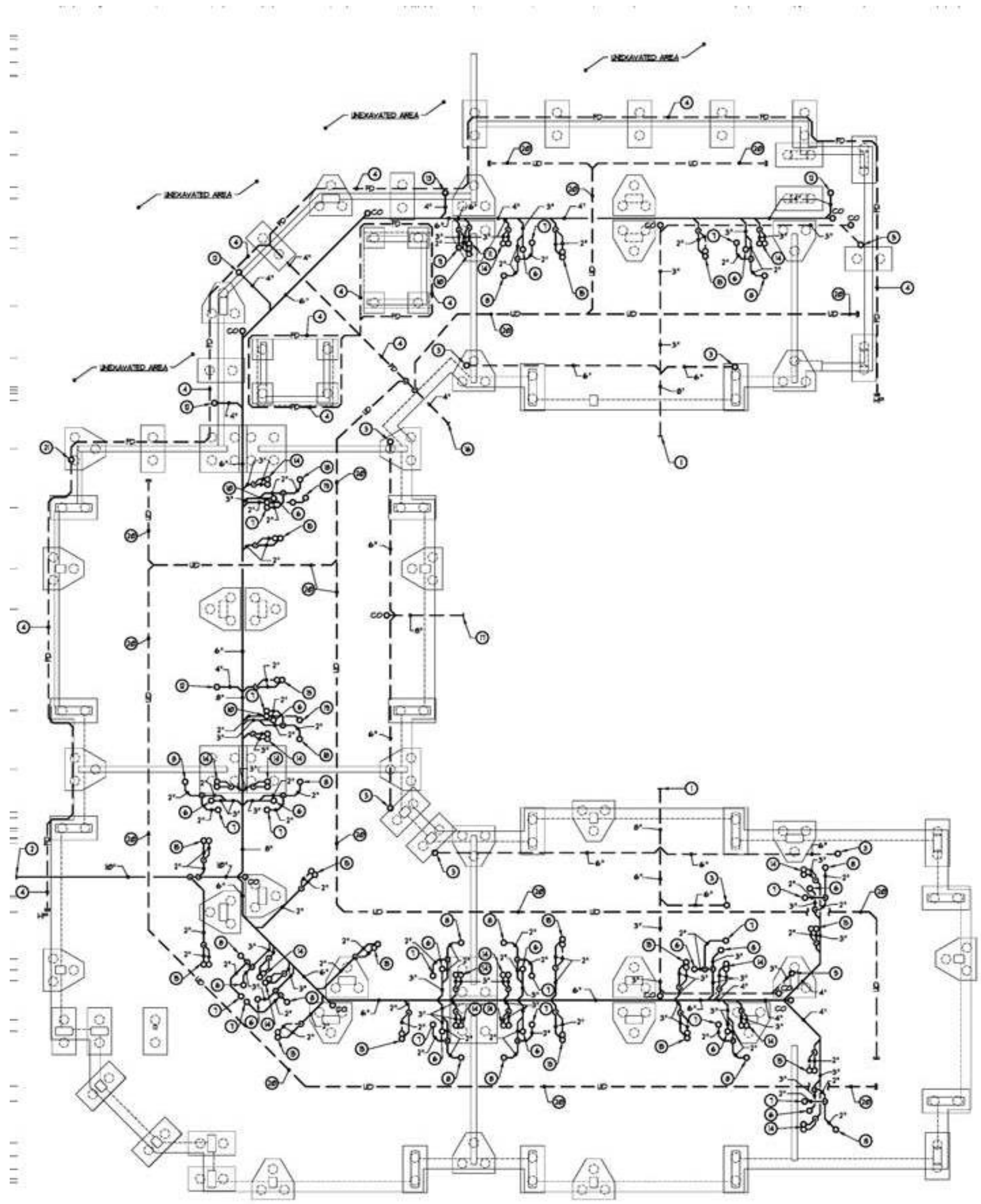
North and West Elevations

East and South Elevations



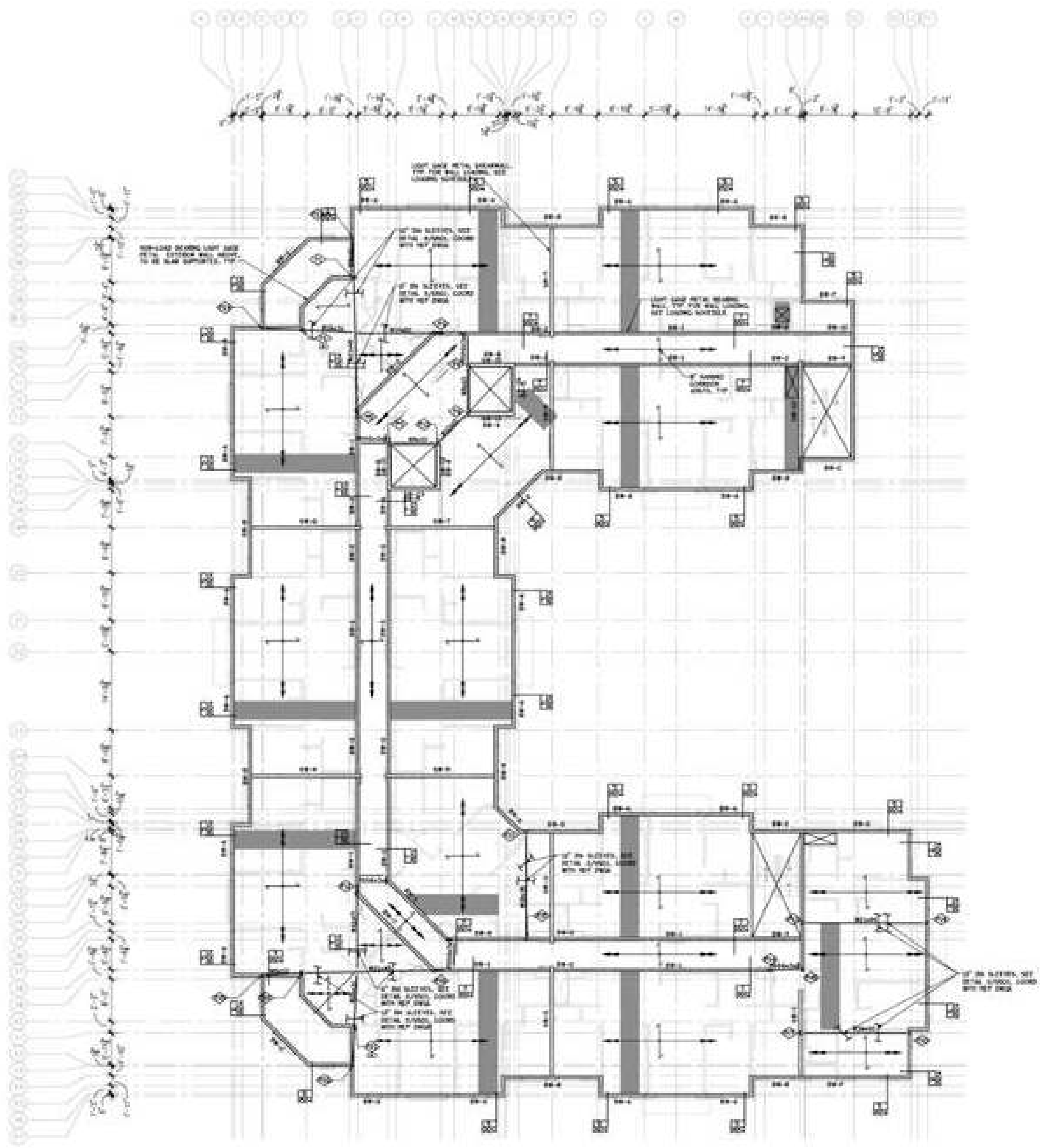


Foundation Plan

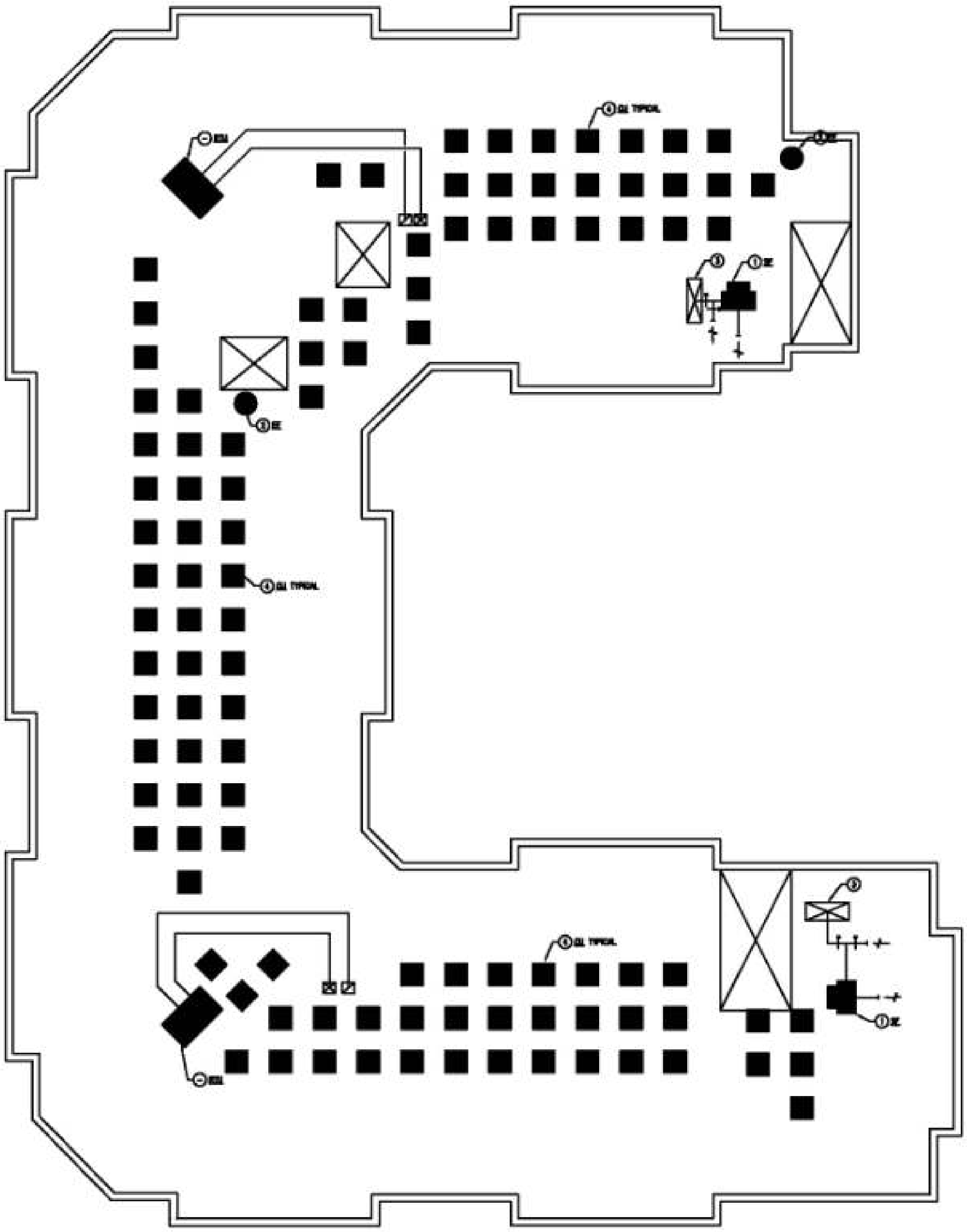


1 P1.01 FOUNDATION PLAN – PLUMBING
SCALE: 1/8" = 1'-0"

Typical Structural Plan



Roof Mechanical Plan



Appendix H: Bibliography

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