

Appendix A: Composite Deck Design

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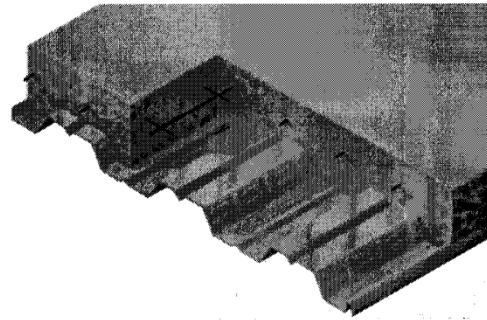
VULCRAFT

FLOOR-CEILING ASSEMBLIES WITH COMPOSITE DECK

Vulcraft Decks have been tested by Underwriters Laboratories Inc. for their Fire Resistance Ratings. In as much as new listings are continually being added, please contact the factory if your required design is not listed below. The cellular decks listed comply with U.L. 209 for use as Electrical Raceways.

COMPOSITE

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)	
¼ Hr.	Unprotected Deck	2 ½" LW	D914 #	1.5VL, 1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1 Hr.
			D916 #	1.5VL, 1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1,1.5,2,3 Hr.
1 Hr.	Exposed Grid	2 ½" NW	D216 +	1.5VL, 1.5VLI, 2VLI, 3VLI	2VLP, 3VLP	2,3 Hr.
			D743 *	2VLI, 3VLI	2VLP, 3VLP	1,1.5,2,3 Hr.
	Cementitious	2 ½" NW&LW	D703 *	1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1.5 Hr.
			D712 *	3VLI	3VLP	2 Hr.
			D722 *	2VLI, 3VLI	2VLP, 3VLP	1,1.5,2 Hr.
			D739 *	1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1,1.5,2,3,4 Hr.
			D759	1.5VL, 1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1,1.5,2,3 Hr.
			D859 *	2VLI, 3VLI	2VLP, 3VLP	1,1.5,2,3 Hr.
	Sprayed Fiber	2 ½" NW&LW	D832 *	1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1,1.5,2,3 Hr.
			D847 *	2VLI, 3VLI	3VLP	1,1.5,3 Hr.
			D858 *	2VLI, 3VLI	2VLP, 3VLP	1,1.5,2,4 Hr.
			D871 *	2VLI, 3VLI	2VLP, 3VLP	1,1.5,2,3 Hr.
			D902 #	1.5VL, 1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1,1.5 Hr.
			D914 #	1.5VL, 1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1 Hr.
	Unprotected Deck	2 ½" LW	D916 #	1.5VL, 1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1,1.5,2,3 Hr.
			D918 #	1.5VL, 1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1,1.5 Hr.
			D919 #	1.5VL, 1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1,1.5 Hr.
			D902 #	1.5VL, 1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1,1.5 Hr.
			D916 #	1.5VL, 1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1,1.5,2,3 Hr.
			D918 #	1.5VL, 1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1,1.5 Hr.
D919 #			1.5VL, 1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1,1.5 Hr.	
D902 #			1.5VL, 1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1,1.5 Hr.	
D916 #			1.5VL, 1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1,1.5,2,3 Hr.	
D918 #			1.5VL, 1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1,1.5 Hr.	
1½ Hr.	Gypsum Board	2 ½" NW	D502 *	1.5VL, 1.5VLI, 2VLI, 3VLI	2VLP, 3VLP	1.5,2 Hr.
			D743 *	2VLI, 3VLI	2VLP, 3VLP	1,1.5,2,3 Hr.
	Cementitious	2 ½" NW&LW	D703 *	1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1.5 Hr.
			D712 *	3VLI	3VLP	2 Hr.
			D722 *	2VLI, 3VLI	2VLP, 3VLP	1,1.5,2 Hr.
			D739 *	1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1,1.5,2,3,4 Hr.
			D759	1.5VL, 1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1,1.5,2,3 Hr.
			D859 *	2VLI, 3VLI	2VLP, 3VLP	1,1.5,2,3 Hr.
	Sprayed Fiber	2 ½" NW&LW	D832 *	1.5VLI, 2VLI, 3VLI	3VLP	1,1.5,2,3 Hr.
			D847 *	2VLI, 3VLI	3VLP	1,1.5,3 Hr.
			D858 *	2VLI, 3VLI	2VLP, 3VLP	1,1.5,2,4 Hr.
			D871 *	2VLI, 3VLI	2VLP, 3VLP	1,1.5,2,3 Hr.
			D902 #	1.5VL, 1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1,1.5 Hr.
			D916 #	1.5VL, 1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1,1.5,2,3 Hr.
	Unprotected Deck	3" LW	D919 #	1.5VL, 1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1,1.5 Hr.
			D902 #	1.5VL, 1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1,1.5 Hr.
			D916 #	1.5VL, 1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1,1.5,2,3 Hr.
			D918 #	1.5VL, 1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1,1.5 Hr.
		4" NW	D919 #	1.5VL, 1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1,1.5 Hr.
			D916 #	1.5VL, 1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1,1.5,2,3 Hr.
D918 #			1.5VL, 1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1,1.5 Hr.	
D919 #			1.5VL, 1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1,1.5 Hr.	
2 Hr.	Exposed Grid	2 ½" NW	D216 +	1.5VL, 1.5VLI, 2VLI, 3VLI	2VLP, 3VLP	2,3 Hr.
			D502 +	1.5VL, 1.5VLI, 2VLI, 3VLI	2VLP, 3VLP	1.5,2 Hr.
	Cementitious	2 ½" NW&LW	D743 *	2VLI, 3VLI	2VLP, 3VLP	1,1.5,2,3 Hr.
			D746 *	1.5VLI		1,1.5,2,3 Hr.
			D752 *	1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1,1.5,2 Hr.
			D703 *	1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1.5 Hr.
			D712 *	3VLI	3VLP	2 Hr.
			D716 *	1.5VLI, 2VLI, 3VLI	2VLP, 3VLP	1.5,2 Hr.
			D722 *	2VLI, 3VLI	2VLP, 3VLP	1,1.5,2 Hr.
			D739 *	1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1,1.5,2,3,4 Hr.
			D745 *	2VLI, 3VLI		1,1.5,2 Hr.
			D750 *	1.5VLI, 2VLI, 3VLI		1.5,2 Hr.
			D755	1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1,1.5,2,3 Hr.
			D759	1.5VL, 1.5VLI, 2VLI, 3VLI	1.5VLP, 2VLP, 3VLP	1,1.5,2,3 Hr.
D760 *	2VLI, 3VLI		1,1.5,2,3,4 Hr.			
D730 *	2VLI, 3VLI	2VLP, 3VLP	1.5,2 Hr.			
D742 *	1.5VLI, 2VLI, 3VLI		1,1.5 Hr.			



SLAB INFORMATION

Total Slab Depth, in.	Theo. Concrete Volume		Recommended Welded Wire Fabric
	Yd ³ / 100 ft ²	ft ³ / ft ²	
4	0.93	0.250	6x6 - W1.4xW1.4
4 1/2	1.08	0.292	6x6 - W1.4xW1.4
5	1.23	0.333	6x6 - W1.4xW1.4
5 1/4	1.31	0.354	6x6 - W1.4xW1.4
5 1/2	1.39	0.375	6x6 - W2.1xW2.1
6	1.54	0.417	6x6 - W2.1xW2.1
6 1/4	1.62	0.438	6x6 - W2.1xW2.1
6 1/2	1.70	0.458	6x6 - W2.1xW2.1

(N=14.15) LIGHTWEIGHT CONCRETE (110 PCF)

TOTAL SLAB DEPTH	DECK TYPE	SDI Max. Unshored Clear Span			Superimposed Live Load, PSF														
		1 SPAN	2 SPAN	3 SPAN	Clear Span (ft.-in.)														
					6'-0	6'-6	7'-0	7'-6	8'-0	8'-6	9'-0	9'-6	10'-0	10'-6	11'-0	11'-6	12'-0	12'-6	13'-0
4.00 (t=2.00) 30 PSF	2VLI22	8'-1	10'-3	10'-7	238	209	186	167	152	120	108	98	90	82	75	69	64	59	55
	2VLI20	9'-6	11'-8	12'-1	268	235	209	187	169	153	140	129	101	92	84	78	72	66	61
	2VLI19	10'-10	13'-0	13'-2	297	260	230	206	185	168	153	141	130	121	93	86	79	73	68
	2VLI18	11'-7	13'-7	13'-7	324	285	253	227	205	187	171	158	146	136	127	119	92	86	80
4.50 (t=2.50) 35 PSF	2VLI16	12'-3	14'-3	14'-4	377	330	292	261	235	214	195	179	165	153	143	133	118	98	91
	2VLI22	7'-8	9'-10	10'-2	276	243	216	194	155	139	126	114	104	96	88	81	75	69	64
	2VLI20	9'-0	11'-3	11'-7	312	273	243	217	196	178	163	128	117	107	98	90	83	77	72
	2VLI19	10'-3	12'-5	12'-9	346	302	268	239	215	195	178	164	151	118	108	100	92	85	79
5.00 (t=3.00) 39 PSF	2VLI18	11'-2	13'-1	13'-1	376	331	294	264	238	217	199	183	170	158	147	116	107	100	93
	2VLI16	11'-7	13'-8	13'-10	400	384	340	303	273	248	227	208	192	178	166	155	123	114	106
	2VLI22	7'-4	9'-5	9'-9	315	277	247	197	176	159	143	130	119	109	100	92	85	79	73
	2VLI20	8'-7	10'-9	11'-2	355	312	276	248	224	203	161	146	133	122	112	103	95	88	82
5.25 (t=3.25) 42 PSF	2VLI19	9'-9	11'-11	12'-4	394	345	305	272	245	223	203	187	147	135	124	114	105	97	90
	2VLI18	10'-9	12'-9	12'-9	400	377	335	300	272	247	227	209	193	180	143	132	122	114	106
	2VLI16	11'-0	13'-1	13'-5	400	400	387	346	311	283	258	237	219	203	189	151	140	130	121
	2VLI22	7'-2	9'-3	9'-7	334	294	262	209	187	168	152	138	126	116	106	98	90	84	78
5.50 (t=3.50) 44 PSF	2VLI20	8'-5	10'-7	10'-11	377	331	293	263	237	190	171	155	142	130	119	110	101	94	87
	2VLI19	9'-6	11'-8	12'-1	400	366	324	289	260	236	216	198	156	143	131	121	111	103	95
	2VLI18	10'-6	12'-7	12'-7	400	400	355	319	288	263	241	222	205	191	151	140	130	121	113
	2VLI16	10'-9	12'-10	13'-3	400	400	400	367	330	300	274	252	232	215	173	160	148	138	128
6.25 (t=4.25) 51 PSF	2VLI22	7'-0	9'-1	9'-5	353	311	277	222	198	178	161	147	134	122	113	104	96	89	82
	2VLI20	8'-3	10'-4	10'-9	399	350	310	278	251	201	181	165	150	137	126	116	107	99	92
	2VLI19	9'-4	11'-6	11'-10	400	387	342	306	275	250	228	182	165	151	139	128	118	109	101
	2VLI18	10'-3	12'-5	12'-5	400	400	376	337	305	278	254	234	217	174	160	148	138	128	119
6.25 (t=4.25) 51 PSF	2VLI16	10'-6	12'-7	13'-0	400	400	400	388	350	317	290	266	246	228	184	170	157	146	136
	2VLI22	6'-8	8'-7	8'-11	400	362	291	258	231	208	188	171	156	143	131	121	112	103	96
	2VLI20	7'-0	9'-10	10'-2	400	400	364	323	260	234	211	192	175	160	147	135	125	115	107
	2VLI19	8'-9	10'-11	11'-3	400	400	398	356	320	291	233	212	193	176	162	149	137	127	118
51 PSF	2VLI18	9'-8	11'-10	11'-11	400	400	400	392	355	323	296	273	220	202	187	173	160	149	139
	2VLI16	9'-11	12'-0	12'-5	400	400	400	400	400	369	337	310	253	232	214	198	183	170	158

COMPOSITE

- Notes: 1. Minimum exterior bearing length required is 2.00 inches. Minimum interior bearing length required is 4.00 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.



Appendix B: Wind Calculations

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Table 2a - Wind Variables			ASCE 7-05 References
Basic Wind Speed	V	95 mph	(Fig. 6-1)
Directionality Factor	k_d	0.85	(Table 6-4)
Importance Factor	I	1.15	(Table 6-1)
Exposure Category		B	(Sec. 6.5.6.3)
Topographic Factor	K_{zt}	1	(Sec. 6.5.7.1)
Velocity Pressure Exposure Coefficient evaluated at Height z	K_z	Varies	(Table 6-3)
Velocity Pressure at Height z	q_z	Varies	(Eq. 6-15)
Velocity Pressure at Mean Roof Height (North/South)	q_h	25.29 psf	(Eq. 6-15)
Velocity Pressure at Mean Roof Height (East/West)	q_h	24.62 psf	(Eq. 6-15)
Equivalent Height of Struture	z	94.6'	(Table 6-2)
Intensity of Turbulence	I_z	0.252	(Eq. 6-5)
Integral Length Scale of Turbulence	L_z	454.6'	(Eq. 6-7)
Background Response Factor (East/West)	Q	0.794	(Eq. 6-6)
Background Response Factor (North/South)	Q	0.786	(Eq. 6-6)
Gust Effect Factor (East/West)	G	0.878	(Eq. 6-4)
Gust Effect Factor (North/South)	G	0.873	(Eq. 6-4)
External Pressure Coefficient (Windward)	C_p	0.8	(Fig. 6-6)
External Pressure Coefficient (E/W Leeward)	C_p	-0.47	(Fig. 6-6)
External Pressure Coefficient (N/S Leeward)	C_p	-0.5	(Fig. 6-6)

Table 2c-Wind Loads (East/West) B=247'-3" L=282'-4"														
Floor	Height Above Ground-z (ft)	Story Height (ft)	Kz	qz	Wind Pressure (psf)		Total Pressure (psf)	Force (k) of Windward only	Force (k) of Total Pressure	Story Shear Windward (k)	Story Shear Total (k)	Factored Story Force (k)	Factored Story Shear (k)	
					Windward	Leeward								
Roof	144	13.33	1.10	24.84	21.90	-14.59	36.49	46.52	77.50	46.52	77.50	124.01	124.01	
Mech Mez.	130.66	18.66	1.06	23.94	21.27	-14.59	35.86	63.37	106.84	109.89	184.34	170.94	294.95	
8	112	16	1.02	23.04	20.64	-14.59	35.23	81.65	139.37	191.54	323.71	222.99	517.94	
7	96	16	0.98	22.13	20.01	-14.59	34.60	79.16	136.87	270.70	460.59	219.00	736.94	
6	80	16	0.93	21.00	19.22	-14.59	33.81	76.04	133.76	346.74	594.34	214.01	950.95	
5	64	16	0.87	19.65	18.27	-14.59	32.86	72.29	130.01	419.03	724.36	208.02	1158.97	
4	48	16	0.80	18.07	17.17	-14.59	31.76	67.93	125.64	486.95	850.00	201.03	1360.00	
3	32	16	0.71	16.03	15.75	-14.59	30.34	62.31	120.03	549.26	970.03	192.04	1552.04	
2	16	16	0.58	13.10	13.70	-14.59	28.29	54.20	111.92	603.46	1081.94	179.07	1731.11	
1	0	0	0.00	0.00	0.00	0	0.00	0.00	0.00	603.46	1081.94	0.00	1731.11	
Σ Story Shear (Windward) = 603.46 k					Σ Story Shear (Total) = 1081.94 k					Factored Story Force = 1731.11				

Table 2b-Wind Loads (North/South) B=282'-4" L=247'-3"														
Floor	Height Above Ground-z (ft)	Story Height (ft)	Kz	qz	Wind Pressure (psf)		Total Pressure (psf)	Force (k) of Windward only	Force (k) of Total Pressure	Story Shear Windward (k)	Story Shear Total (k)	Factored Story Force (k)	Factored Story Force (k)	
					Windward	Leeward								
Roof	162	14.33	1.13	25.52	22.38	-15.59	37.97	73.00	123.86	73.00	123.86	198.17	198.17	
Mech Mez.	148.66	18.66	1.11	25.07	22.06	-15.59	37.65	98.11	167.44	171.10	291.30	267.90	466.07	
8	130	16	1.07	24.17	21.43	-15.59	37.02	96.80	167.22	267.90	458.52	267.56	733.63	
7	114	16	1.03	23.26	20.80	-15.59	36.39	93.95	164.37	361.85	622.90	263.00	996.63	
6	98	16	0.98	22.13	20.01	-15.59	35.60	90.39	160.81	452.24	783.71	257.30	1253.93	
5	82	16	0.94	21.23	19.38	-15.59	34.97	87.54	157.96	539.78	941.67	252.74	1506.67	
4	66	16	0.87	19.65	18.27	-15.59	33.86	82.55	152.97	622.33	1094.65	244.76	1751.43	
3	50	16	0.81	18.29	17.33	-15.59	32.92	78.28	148.70	700.60	1243.35	237.92	1989.35	
2	34	16	0.72	16.26	15.91	-15.59	31.50	71.86	142.29	772.47	1385.63	227.66	2217.01	
1	18	18	0.6	13.55	14.02	-15.59	29.61	71.23	150.45	843.69	1536.09	240.73	2457.73	
B1	0	0	0	0.00	0.00	0	0.00	0.00	0.00	843.69	1536.09	0.00	2457.73	
Σ Story Shear (Windward) = 843.69 k					Σ Story Shear (Total) = 1536.09 k					Factored Story Force = 2259.56				

Wind Calculations

ASCE 7-05 Method 2 - Analytical Procedure

V = 95 mph Occupancy Classification: Cat III

I_w = 1.15 Exposure Category: BK_z

Level	Height (ft)	K _z (Interpolated)
B ₁	0	0
1	18	0.6
2	34	0.72
3	50	0.81
4	66	0.87
5	82	0.94
6	98	0.98
7	114	1.03
8	130	1.07
Mech Mezz.	148.66	1.11
Roof	162	1.13

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

$$q_z = 0.00256 \underbrace{K_z}_{\text{Varies at levels}} (1.0)(0.85)(95)^2(1.15)$$

$$q_h = 0.00256 K_h K_{zt} K_d V^2 I$$

N/S: $q_h = 0.00256 (1.12)(1.0)(0.85)(95)^2(1.15) = \boxed{25.29 \text{ psf}}$
 $\rightarrow h = 157.66 \text{ (N/S)}$

ELW: $q_h = 0.00256 (1.09)(1.0)(0.85)(95)^2(1.15) = \boxed{24.62 \text{ psf}}$
 $\rightarrow h = 139.66 \text{ (ELW)}$

Gust Effect Factors, $G \neq G_F$

$$n_1 = 100/H = 100/157.66 = 0.63 < 1 \text{ Hz} \quad \therefore \underline{\text{Flexible}}$$

$$g_R = g_v = 3.7$$

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

$$g_R = \sqrt{2 \ln(3600(0.63))} + \frac{0.577}{\sqrt{2 \ln(3600(0.63))}} = 4.08$$

$$\bar{z} = 0.6h = 0.6(157.66) = 94.6' > z_{\min} = 30'$$

$$I_{\bar{z}} = C \left(\frac{33}{\bar{z}} \right)^{1/6} = 0.30 \left(\frac{33}{94.6} \right)^{1/6} = 0.252$$

$$L_{\bar{z}} = L \left(\frac{\bar{z}}{33} \right)^{2} = 320 \left(\frac{94.6}{33} \right)^{2.0} = 454.6'$$

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

$$N/S: B = 282.33' \quad L = 247.25' \quad E/W: B = 247.25' \quad L = 282.33'$$

$$Q_{N/S} = 0.786$$

$$Q_{E/W} = 0.794$$

$$\bar{V}_{\bar{z}} = \bar{V} \left(\frac{\bar{z}}{33} \right)^{\bar{x}} V \left(\frac{88}{60} \right) = 0.45 \left(\frac{94.6}{33} \right)^{1.4} (95) \left(\frac{88}{60} \right) = 81.59$$

$$N_1 = \frac{n_1 L_{\bar{z}}}{\bar{V}_{\bar{z}}} = \frac{0.63(454.6)}{81.59} = 3.51$$

$$R_n = \frac{7.47 N_1}{(1 + 10.3 N_1)^{5/3}} = \frac{7.47(3.51)}{(1 + 10.3(3.51))^{5/3}} = 0.0634$$

$$R_B = \frac{1}{n} - \frac{1}{2n^2} (1 - e^{-2n}) \quad \text{for } n > 0$$

$$\eta = 4.6 n_1 B / \sqrt{z}$$

$$N/S: \eta = 4.6 (0.63) (282.33) / 81.59 = 10.03$$

$$E/W: \eta = 4.6 (0.63) (247.25) / 81.59 = 8.78$$

$$R_{B N/S} = \frac{1}{10.03} - \frac{1}{2(10.03)^2} (1 - e^{-2(10.03)}) = 0.0947$$

$$R_{B E/W} = \frac{1}{8.78} - \frac{1}{2(8.78)^2} (1 - e^{-2(8.78)}) = 0.0569$$

$$R_h = \frac{1}{\eta} - \frac{1}{2\eta^2} (1 - e^{-2\eta}) \quad \text{for } \eta > 0$$

$$\eta = 4.6 n_1 h / \sqrt{z} = 4.6 (0.63) (157.66) / 81.59 = 5.6$$

$$R_h = \frac{1}{5.6} - \frac{1}{2(5.6)^2} (1 - e^{-2(5.6)}) = 0.163$$

$$R_L = \frac{1}{\eta} - \frac{1}{2\eta^2} (1 - e^{-2\eta}) \quad \text{for } \eta > 0$$

$$\eta = 15.4 n_1 L / \sqrt{z}$$

$$N/S: \eta = 15.4 (0.63) (247.25) / 81.59 = 29.4$$

$$E/S: \eta = 15.4 (0.63) (282.33) / 81.59 = 33.57$$

$$R_{L N/S} = \frac{1}{29.4} - \frac{1}{2(29.4)^2} (1 - e^{-2(29.4)}) = 0.0334$$

$$R_{L E/S} = \frac{1}{33.57} - \frac{1}{2(33.57)^2} (1 - e^{-2(33.57)}) = 0.0293$$

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

$$\beta = 2\% \text{ (concrete)}$$

$$R_{N/S} = 0.0163 \quad R_{E/W} = 0.0126$$

$$G_F = 0.925 \left(\frac{1 + 1.7 I_z \sqrt{g^2 Q^2 + g^2 R^2}}{1 + 1.7 g \sqrt{I_z}} \right)$$

$$G_F N/S = 0.925 \left(\frac{1 + 1.7(0.252) \sqrt{3.4^2 (0.786)^2 + 4.08^2 (0.063)^2}}{1 + 1.7(3.4)(0.252)} \right)$$

$$G_F N/S = 0.873$$

$$G_F E/W = 0.925 \left(\frac{1 + 1.7(0.252) \sqrt{3.4^2 (0.794)^2 + 4.08^2 (0.102)^2}}{1 + 1.7(3.4)(0.252)} \right)$$

$$G_F E/W = 0.878$$

Wind Calculations Cont. - MWFRS

Enclosed Building

Parapet Pressure

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

$$K_z @ 167.33 = 1.14 \quad (N/S)$$

↳ Parapet ht N/S

$$q_p = 0.00256 (1.14)(1.0)(0.85)(95^2)(1.15)$$

$$q_p = 25.75 \text{ psf} \quad (N/S)$$

$$q_p = 0.00256 (1.10)(1.0)(0.85)(95^2)(1.15)$$

$$K_z @ 146.33 = 1.10$$

↳ Parapet ht E/W

$$q_p = 24.90 \text{ psf}$$

$$G_{Cpn} = +1.5 \quad (\text{windward})$$

$$G_{Cpn} = -1.0 \quad (\text{leeward})$$

$$P_p = q_p G_{Cpn}$$

N/S:

$$\text{Windward: } P_p = 25.75(1.5) = 38.63 \text{ psf}$$

$$\text{Leeward: } P_p = 25.75(-1.0) = -25.75 \text{ psf}$$

E/W:

$$\text{Windward: } P_p = 24.90(1.5) = 37.35 \text{ psf}$$

$$\text{Leeward: } P_p = 24.90(-1.0) = -24.90 \text{ psf}$$

Wind Calculations Cont.

Pressure coefficient C_p (Fig 6-6)

N/S:

Windward: $C_p = 0.8$

Leeward: $L/B = 247.25/282.33 = 0.876$

$C_p = -0.5$

E/W:

Windward: $C_p = 0.8$

Leeward: $L/B = 282.33/247.25 = 1.14$

$C_p = -0.47$

Pressure:

$$P_z = q_z G F C_p - q_h (G C_{pi}) \text{ (Windward)}$$

$$P_h = q_h G F C_p - q_h (G C_{pi}) \text{ (Leeward)}$$

$W/G C_{pi} = +0.18, -0.18$ for enclosed bldgs (Fig 6-5)

N/S:

Windward $P_z = (q_z)(0.873)(0.8) - 25.29(-0.18)$

$$P_z = (q_z)(0.6984) + 4.552$$

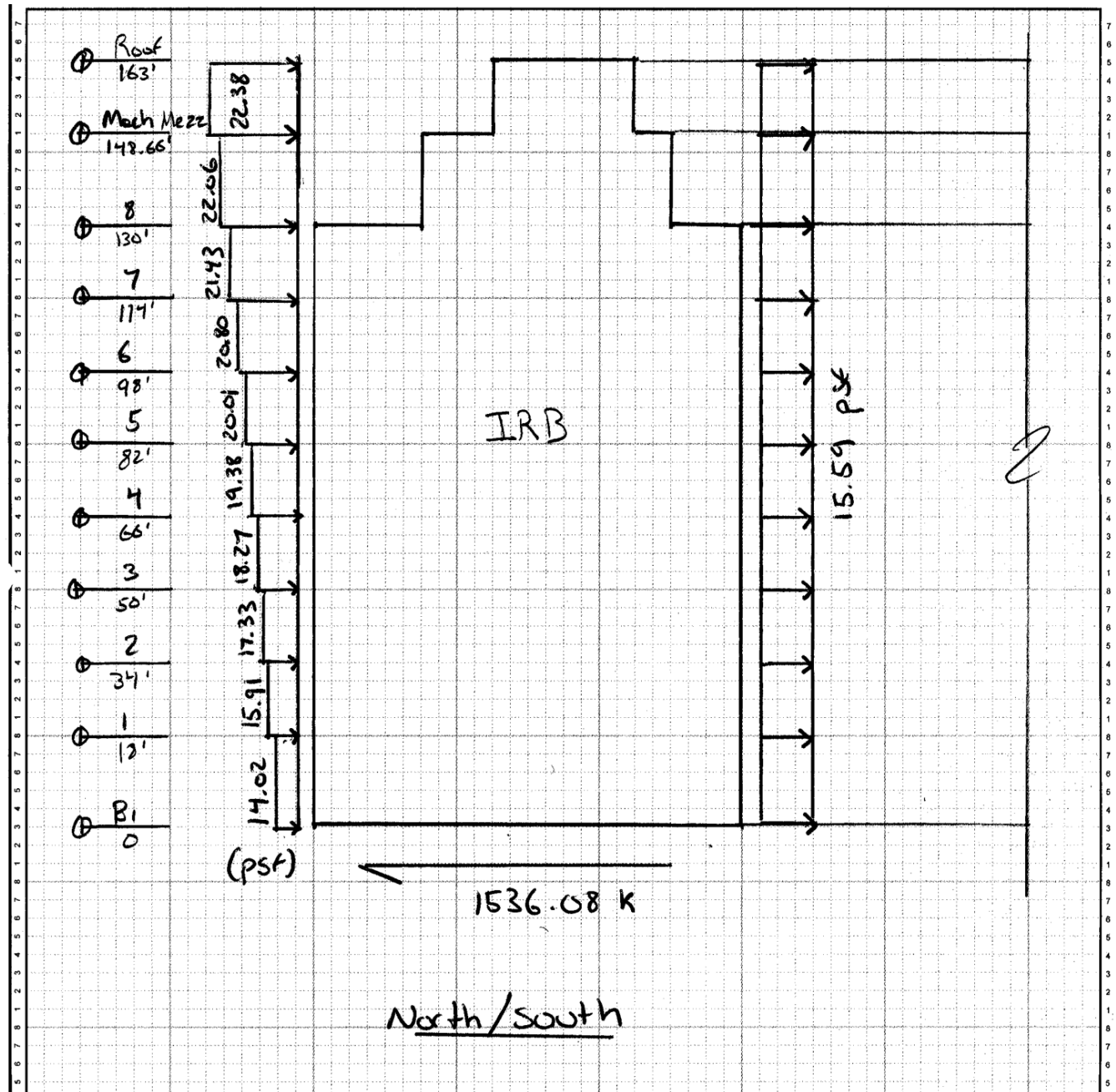
Leeward $P_h = (25.29)(0.873)(-0.5) - 4.552 = -15.59 \text{ psf}$

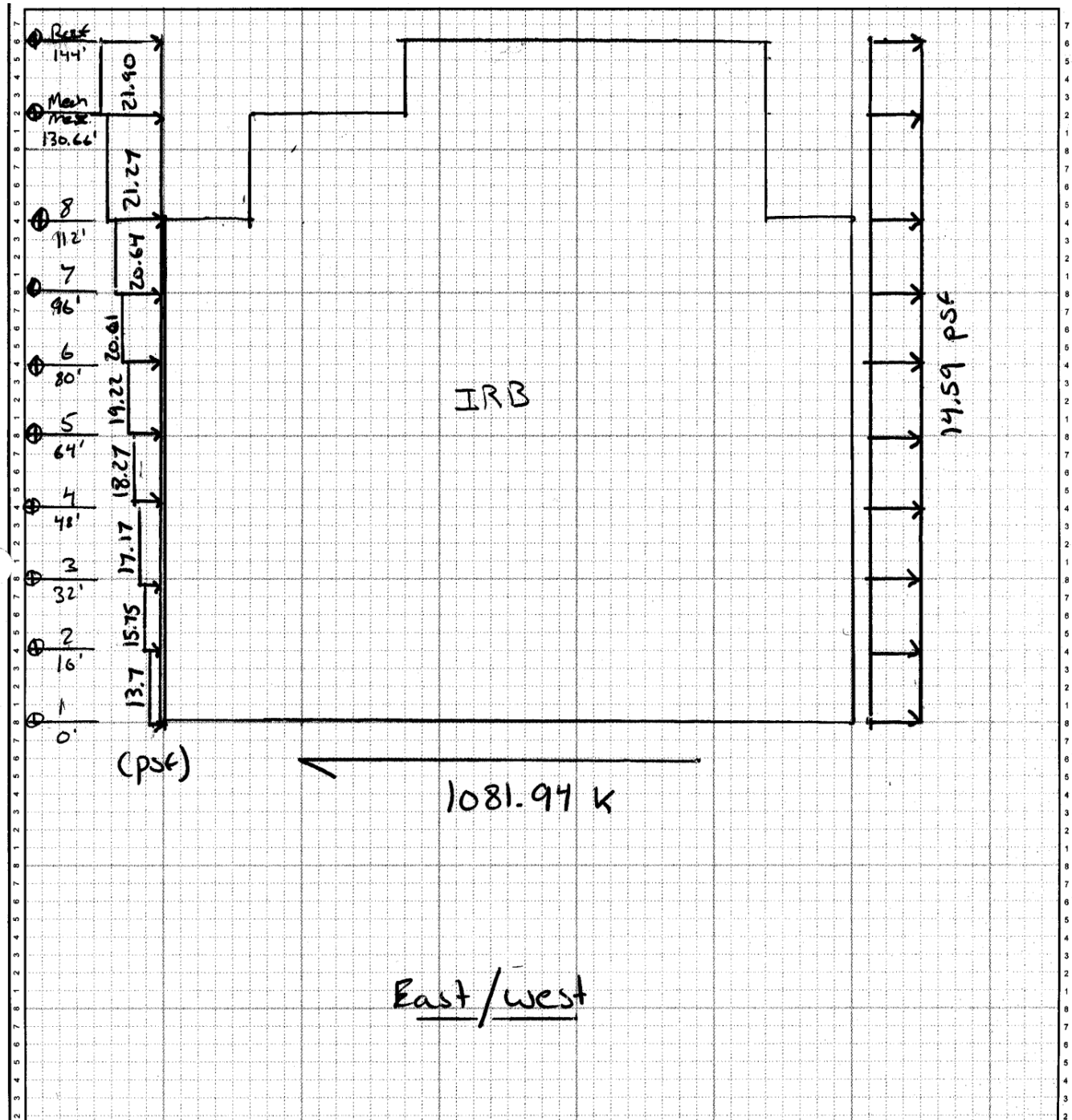
E/W:

Windward $P_z = (q_z)(0.878)(0.8) - 24.62(-0.18)$

$$P_z = (q_z)(0.7024) + 4.43$$

Leeward $P_h = (24.62)(0.878)(-0.47) - 4.43 = -14.59 \text{ psf}$





Appendix C: Seismic Calculations

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Table 3a - Seismic Design Variables			ASCE 7-05 References
Site Class		C	(Table 20.3-1)
Occupancy		III	(Table 1-1)
Importance Factor		1.25	(Table 11.5-1)
Structural System		Building Frame Sytem: Ordinary Reinforced Concrete Shear Wall	(Table 12.2-1)
Spectral Response Acceleration, short	S_s	0.209 g	(USGS)
Spectral Response Acceleration, 1 s	S_1	0.081g	(USGS)
Site Coefficient	F_a	1.2	(Table 11.4-1)
Site Coefficient	F_v	1.7	(Table 11.4-2)
MCE Spectral Response Acceleration, short	S_{MS}	0.251	(Eq. 11.4-1)
MCE Spectral Response Acceleration, 1 s	S_{M1}	0.092	(Eq.11.4-2)
Design Spectral Acceleration, short	S_{DS}	0.167	(Eq. 11.4-3)
Design Spectral Acceleration, 1s	S_{D1}	0.092	(Eq. 11.4-4)
Seismic Design Category	SDC	B	(Eq. 11.6-2)
Response Modification Coefficient	R	5	(Table 12.2-1)
Approximate Period Parameter	C_t	0.02	(Table 12.8-2)
Building Height (above grade)	h_n	162	
Approximate Period Parameter	x	0.75	(Table 12.8-2)
Calculated Period Upper Limit Coefficient	C_u	1.7	(Table 12.8-1)
Approximate Fundamental Period	T_a	0.92 s	(Eq. 12.8-7)
Fundamental Period Max	T_{max}	1.56	(Sec. 12.8.2)
Long Period Transition Period	T_L	8 g	(Fig. 22-15)
Seismic Response Coefficient	C_s	0.025	(Eq. 12.8-2)
Structural Period Exponent	k	1.21	(Sec. 12.8.3)

Table 3b - Total Redesign Building Weight for Seismic						
Floor	Area (sf)	Composite Deck (3 psf)	NonComposite Deck (5psf)	Slab LWC (115 pcf)	Superimposed DL (Partion's, finishes, MEP) (25psf)	Total Weight (k)
Penthouse Roof	13473.70	0.00	67.37	336.84	336.84	741.05
Lower Penthouse	22224.10	0.00	111.12	2555.77	555.60	3222.49
PH/Roof	34824.70	104.47	0.00	4004.84	870.62	4979.93
7.00	34824.70	104.47	0.00	4004.84	870.62	4979.93
6.00	34824.70	104.47	0.00	4004.84	870.62	4979.93
5.00	34824.70	104.47	0.00	4004.84	870.62	4979.93
4.00	34824.70	104.47	0.00	4004.84	870.62	4979.93
3.00	34824.70	104.47	0.00	4004.84	870.62	4979.93
2.00	34824.70	104.47	0.00	4004.84	870.62	4979.93
1.00	33226.20	99.68	0.00	3821.01	830.66	4751.35
					Total (Non-Structural Steel)=	43574.42
					Structural Steel =	3242.43
					Exterior Walls =	2884.49
					Total Weight =	49701.33

Table 3c- Seismic Loads							
Level	Story Weight W_x (k)	Height h_x (ft)	h_x^k	$w_x h_x^k$	C_{vx}	Lateral Force F_x (k)	Story Shear V_x (k)
Roof	876.45	162	471.53	413276.12	0.04	42.99	0.00
Mech Mez.	3452.93	148.66	424.97	1467380.25	0.15	152.65	42.99
8.00	5341.01	130	361.30	1929722.44	0.19	200.75	195.64
7.00	5341.01	114	308.22	1646183.56	0.17	171.25	396.39
6.00	5341.01	98	256.67	1370903.68	0.14	142.61	567.65
5.00	5341.01	82	206.88	1104938.62	0.11	114.95	710.26
4.00	5341.01	66	159.09	849711.61	0.09	88.40	825.21
3.00	5341.01	50	113.70	607263.39	0.06	63.17	913.60
2.00	5341.01	34	71.30	380813.98	0.04	39.62	976.78
1.00	5095.87	18	33.03	168305.41	0.02	17.51	1016.39

Seismic Calculations (Steel Redesign)

$$S_s = 0.209g \quad S_1 = 0.081g \quad (\text{USGS. gov})$$

$$F_a = 1.2 \quad F_v = 1.7 \quad \text{Site Class C}$$

$$S_{ms} = F_a S_s = 1.2(0.209) = 0.251 \quad I_s = 1.25$$

$$S_{m1} = F_v S_1 = 1.7(0.081) = 0.138 \quad \text{Occ Cat III}$$

$$S_{DS} = \frac{2}{3} S_{ms} = \frac{2}{3}(0.251) = 0.167g$$

$$S_{D1} = \frac{2}{3} S_{m1} = \frac{2}{3}(0.138) = 0.092g$$

$$\text{Seismic Design Category (SDC)} = B$$

→ Determine Structure Fundamental Period, T

$$T_s = S_{D1} / S_{DS} = 0.092 / 0.167 = 0.551$$

$$T_L = 8g$$

$$T_a = C_e h_n^x = 0.02(162)^{0.75} = 0.92 \text{ s}$$

↳ SCBF's

$$T = T_a = 0.92 < T_{max} = C_u T_a = 1.7(0.92) = 1.56 \text{ s}$$

$$T = 0.92 < 3.5 T_s = 3.5(0.551) = 1.93$$

From Tech 1 → Type 2 Horizontal Irregularities

ASCE 7-05 Requires modal Response Spectrum Analysis
or seismic response history procedure

$$C_s = \min \left[\begin{array}{l} S_{DS} / (R/I) = 0.167 / (6/1.25) = 0.0348 \\ S_{D1} / T(R/I) = 0.092 / 0.92 (6/1.25) = \underline{0.0208} > 0.01 \\ S_{D1} T_L / T^2 (R/I) = 0.092(8) / (0.92)^2 (6/1.25) = 0.181 \end{array} \right.$$

$$V = C_s W = 0.0208(49,705.68) = 1033.9^k$$



PROJECT NAME UNC-IRB

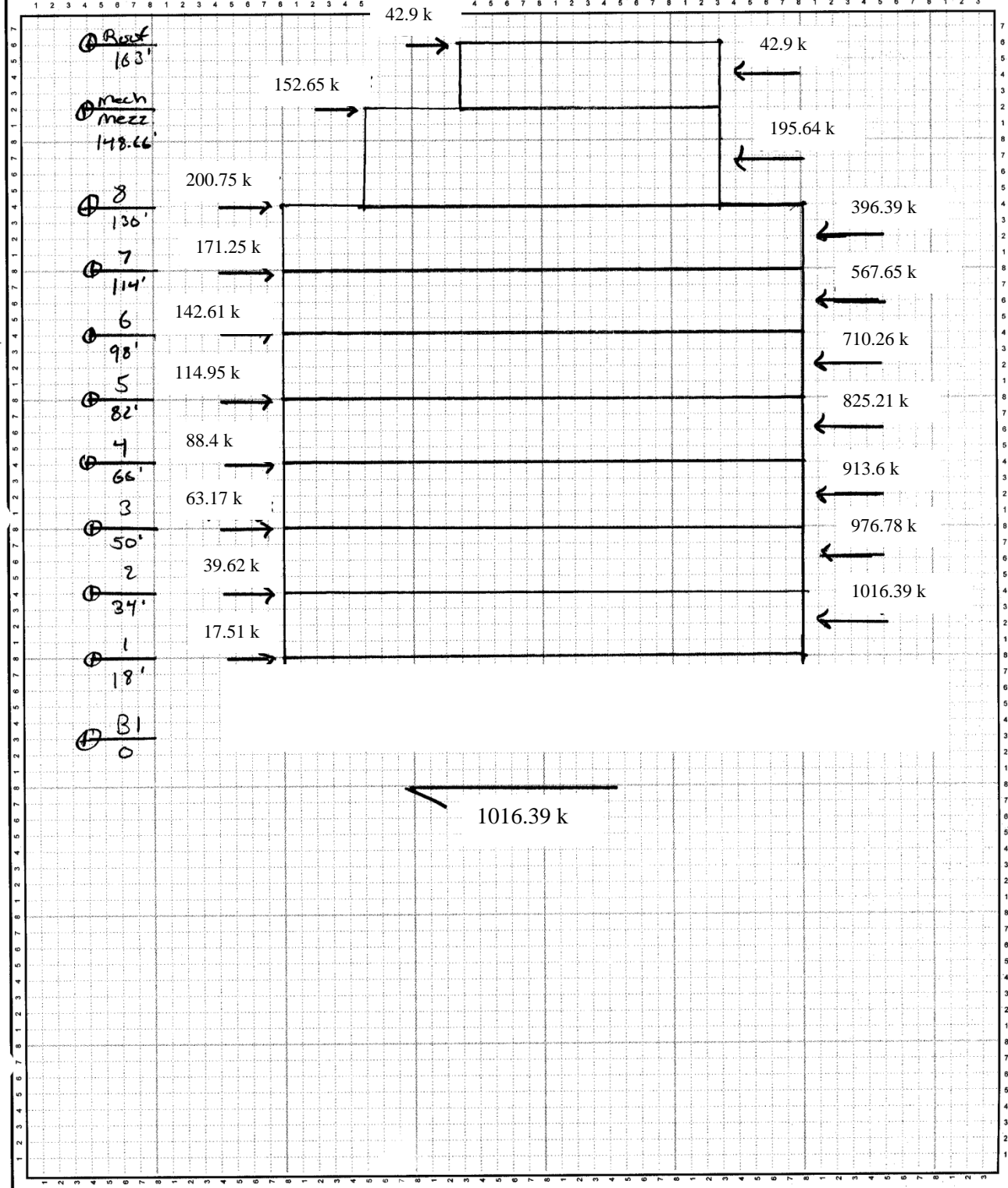
PROJECT NO. _____ SHEET 1 OF 1

P.O. Box 33127 • Raleigh, NC 27636-3127

SUBJECT Seismic Calcs

Phone: (919) 851-1912 • Fax: (919) 851-1918

PREPARED BY DRH DATE 12/1/09 CHECKED BY _____ DATE _____

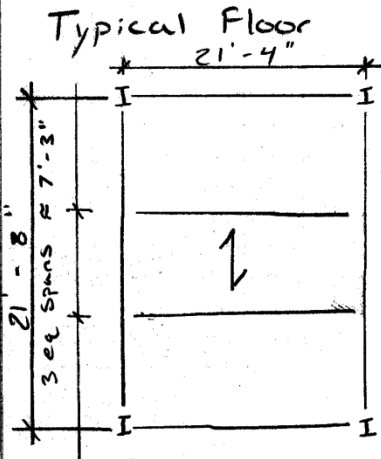


ME-02

Appendix D: Gravity Beams & Girders Calculations

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Typical Composite Beam Spot Check



Design Loads

$$L = 100 \text{ psf}$$

$$SD = 25 \text{ psf}$$

$$\text{Deck \& Slab} = 53.3 \text{ psf}$$

Deck \& Slab

Lightweight Concrete 115 pcf, $f_c = 3 \text{ ksi}$

2" VLI, 20 gage Deck w/ 7.25" Slab

$$\text{Max Unshored Length} = 16.17'$$

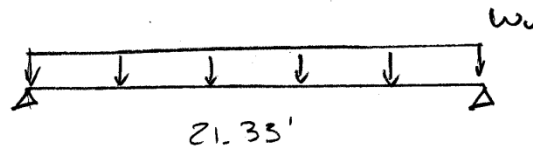
Beam Design

$$\text{Trib Area} = (7.22')(21.33') = 154.07 \text{ SF}$$

$$\text{Influence Area} = 2A_T = 2(154.07) = 308.15 \text{ SF}$$

$$L = L_0 \left(0.25 + \frac{15}{\sqrt{308}} \right) = L_0 1.10 \Rightarrow \text{No Reduction}$$

$$L = 100 \text{ psf}$$



$$w_u = \text{Dead} = (25 + 53.3)(7.22') = 565.33 \text{ plf}$$

$$\text{Live} = (100 \text{ psf})(7.22') = 722 \text{ plf}$$

$$\text{Strength} = 1.2D + 1.6L = 1.83 \text{ k/ft}$$

$$M_u = \frac{w_u l^2}{8} = \frac{(1.83)(21.33)^2}{8}$$

$$M_u = 104.31 \text{ 'K}$$

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Deflection:

$$\Delta_H \leq \frac{21.33(12)}{360} = 0.71" = \frac{(5)(0.722)(21.22)^4 1728}{384(29,000)(I_{req})}$$

$$\Rightarrow I_{req} = 159.97 \text{ in}^4$$

$$\Delta_T \leq \frac{21.33(12)}{240} = 1.07" = \frac{(5)(1.29)(21.22)^4 1728}{384(29,000)(I_{req})}$$

$$\Rightarrow I_{req} = 189.27 \text{ in}^4 \leftarrow \text{controls}$$

$$\Delta_{pc} \leq \frac{21.33(12)}{360} = 0.71" = \frac{(5)(0.385)(21.22)^4 1728}{384(29,000)(I_{req})}$$

$$\Rightarrow I_{req} = 85.27 \text{ in}^4$$

Size Comparison

Composite For $Y_2 = 6 - \frac{a}{2} = 5.5$ $Q_n = 17.6$ } (2" deck)
assume $a=1$ (deck)

Mem	I_x	ϕM_p	ΣQ_n	#	
W14x22	199	189	81.2	(5)	$\leftarrow I_x > I_{req}$
W12x26	207	208	95.6	(6)	
W14x26	245	227	96.1	(6)	

W14x22 w/ 10 studs

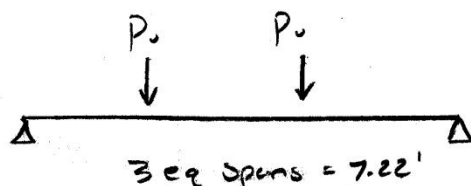
* Member selection is consistent w/ RAM

Girder Design

$$\text{Tri.b Area} = (21.33)(21.66) = 462 \text{ SF}$$

$$\text{Influence Area} = 2A_T = 924 \text{ SF}$$

$$L_e = L_0 \left(0.25 + \frac{15}{\sqrt{924}} \right) = L_0 (0.74) \Rightarrow L_e = 74 \text{ psf}$$



$$P_u = \text{Dead} = (53.3 + 25) (21.33)(7.22) = 12.1 \text{ k}$$

$$\text{Live} = (74) (21.33)(7.22) = 11.4 \text{ k}$$

Strength

$$1.2D + 1.6L = 32.76 \text{ k} = P_u$$

$$M_U = (32.76)(7.22) = 236.5 \text{ k}$$

Deflection

$$\Delta L_e \leq \frac{(21.66)(12)}{360} = 0.722''$$

$$A_{\text{max}} = \frac{Pl^3}{288EI} \Rightarrow 0.722 = \frac{11.4 (21.66)^3 (1728)}{28 (29,000)(I_{\text{reqd}})}$$

$$I_{\text{reqd}} \Rightarrow 341.6 \text{ in}^4$$

$$\Delta_T \leq \frac{(21.66)(12)}{240} = 1.08''$$

$$A_{\text{max}} = \frac{Pl^3}{288EI} \Rightarrow 1.08 = \frac{23.5 (21.66)^3 (1728)}{28 (29,000)(I_{\text{reqd}})}$$

$$I_{\text{reqd}} \Rightarrow 470.6'' \leftarrow \text{Controls}$$

$$P_{re} \text{ Composite } I_x = (53.3 \text{ psf})(7.22)(21.33) = 8.2^4 = f_u$$

$$\Delta_{pc} \leq \frac{(21.66)(12)}{360} = 0.722''$$

$$\Delta_{max} = 0.722 = \frac{(8.2)(21.66)^3(1728)}{28(29,000)(I_{req})}$$

$$\Rightarrow I_{req} = 245.6 \text{ in}^4$$

Member Selection

Composite Assume $a=1''$ $y_2=5.5''$ $Q_n=17.1$

Limit Depth 18''

<u>Mem</u>	<u>I_x</u>	<u>ϕM_p</u>	<u>ΣQ_n</u>	<u>#</u>
W18x40	612	428	147	9
W18x35	510	367	129	8 $\leftarrow I_x > I_{req}$
W16x40	518	396	147	9

W18x35 w/ (18) studs

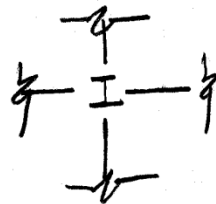
Member Selection Consistent w/ RAM

CAMPAD

Appendix E: Gravity Column Calculations

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Spot Check

Typical Interior Column Design

KL=16'

K=1

$$L_c = 100 \text{ psf}$$

$$\text{Trib Area} = (20.833)(21.33)$$

$$= 444.4 \text{ SF}$$

$$\text{Influence Area} = 4A_t = 1777.6 \text{ SF}$$

$$L_c = L_o \left(0.25 + \frac{15}{\sqrt{1777.6}} \right) = 0.61 L_o$$

$$L_c = 61 \text{ psf}$$

$$P_{\text{Live}} = (61)(444.4) = 27.1 \text{ psf}$$

From RAM

$$\text{Dead} \rightarrow 155.45 \text{ k}$$

$$\text{Live} \rightarrow 126.89 \text{ k}$$

$$\text{Strength } 1.2D + 1.6L + 0.5RF$$

$$P_u = 389.55$$

Moment Negligible for Interior Column

Try W10 x 49

$$\phi P_n = 428 \text{ k} > P_u \therefore \text{ok}$$

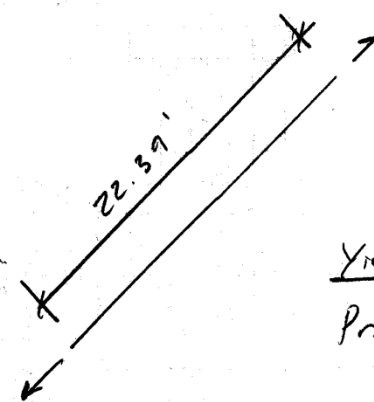
Member Selection Consistent w/ RAM

Appendix F: Lateral Calculations and Frame Elevations

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Lateral Braces | Spot Check

HSS 10 x 10 x 1/2"



$$P_u = 80.7 \text{ k} \quad (\text{From RAM})$$

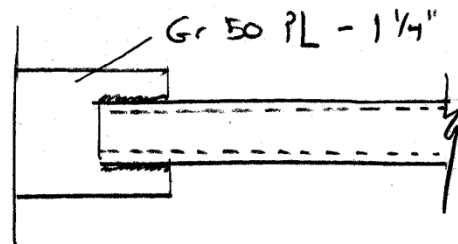
$$\text{Slenderness} \rightarrow \frac{L}{r} < 300$$

$$= \frac{22.39(12)}{3.86} = 69.61$$

Yielding

$$P_n = F_y A_g = 36(17.2) = 619.2 \text{ k}$$

$$P_u < P_n \therefore \text{OK}$$

Rupture

From Table D3.1...

$$U = 1 - \bar{x}/l = 1 - \frac{3.75}{256} = 0.99$$

$$\bar{x} = \frac{b^2 + 2BH}{4(B+H)}$$

$$\bar{x} = \frac{10^2 + 2(10)(10)}{4(10+10)} = 3.75$$

$$P_n = F_u A_e$$

$$A_e = A_n U$$

For slotted HSS welded to a Gusset PL...

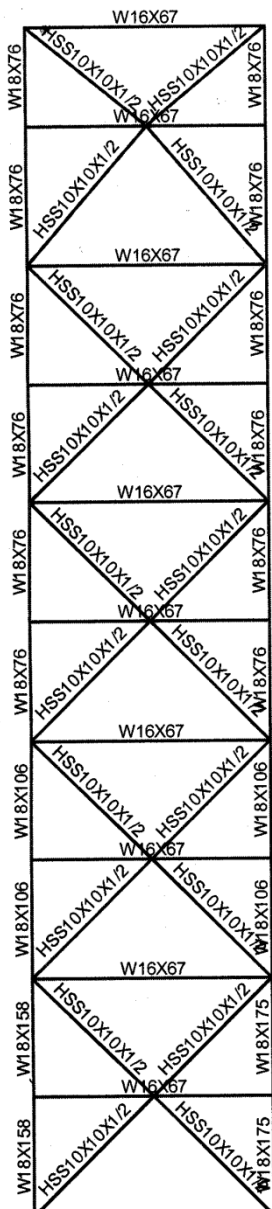
$$A_n = A_g - [(1.25)(0.465)(2)]$$

$$= 17.2 - 1.1625 = 16.04$$

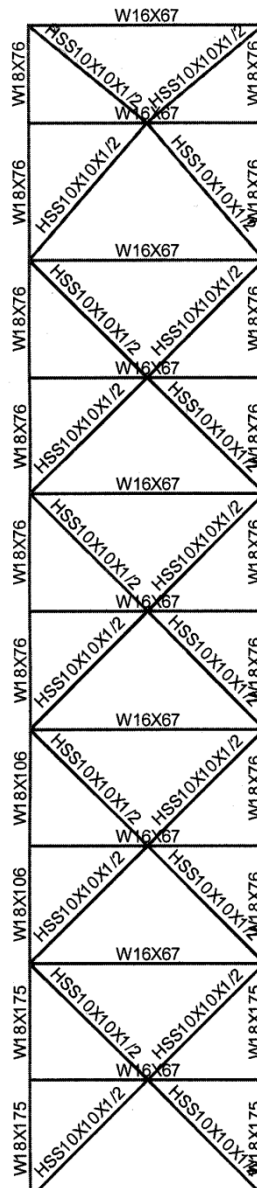
$$A_e = 15.88 \text{ in}^2$$

$$P_n = (58)(15.88) = 920.9 \text{ k}$$

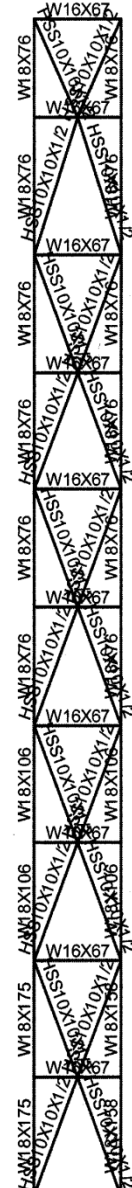
$$P_u < P_n \therefore \text{OK!}$$



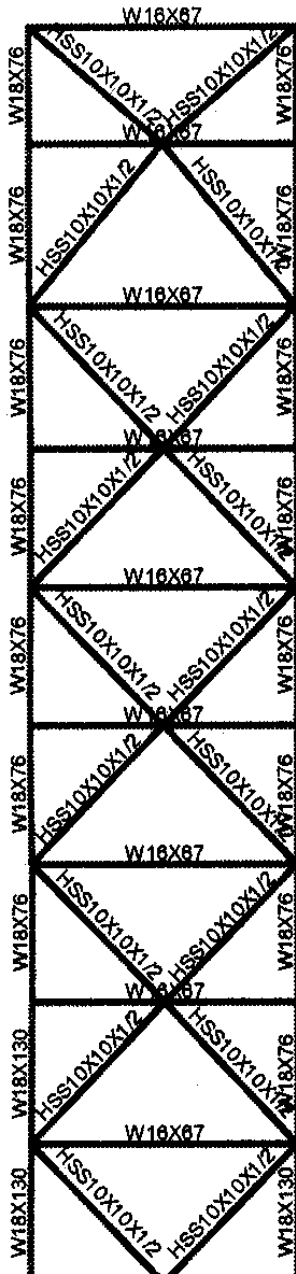
Frame Elevation 1



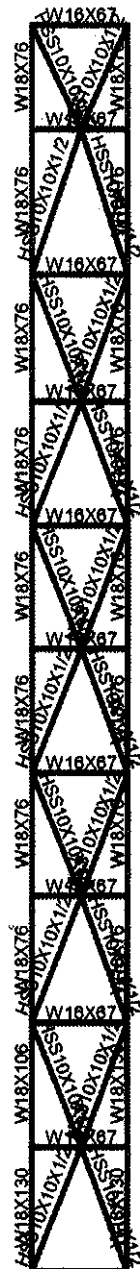
Frame Elevation 2



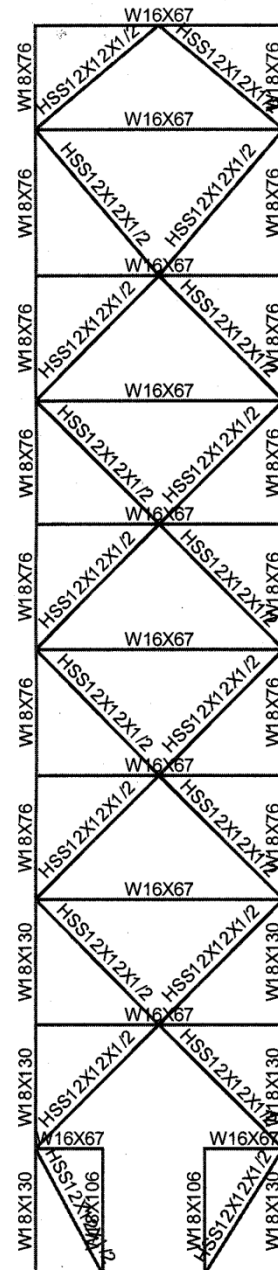
Frame Elevation 3



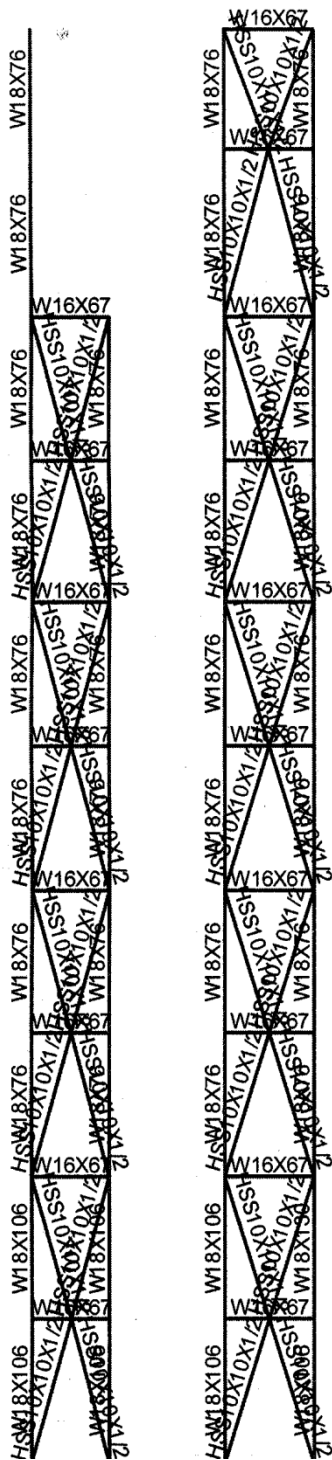
Frame Elevation 4



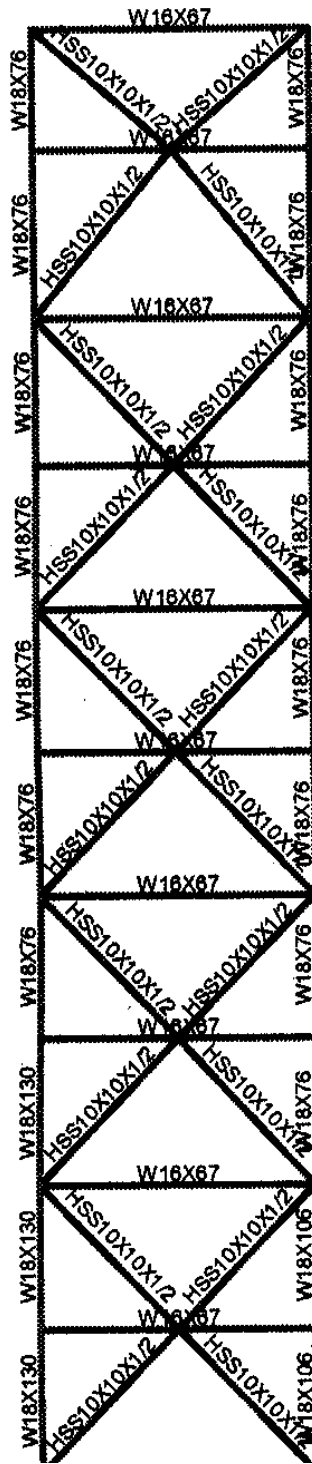
Frame Elevation 5



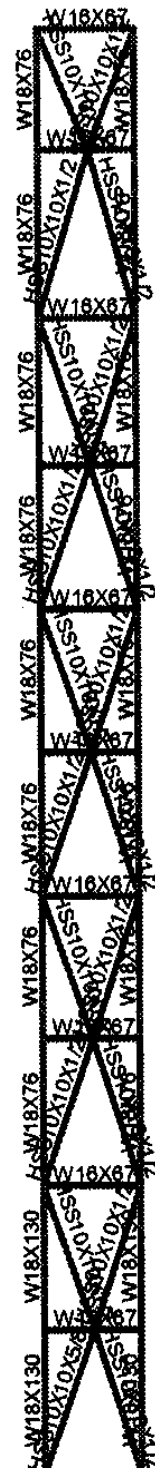
Frame Elevation 6



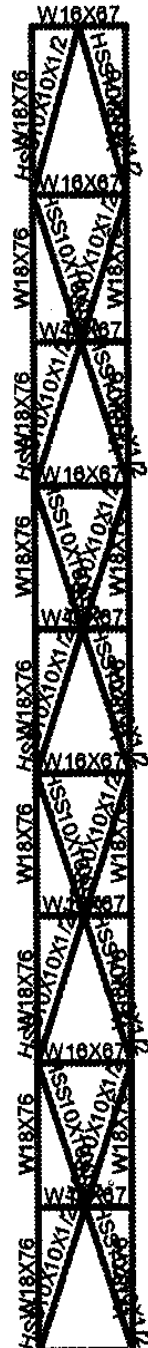
Frame Elevation 7 & 8



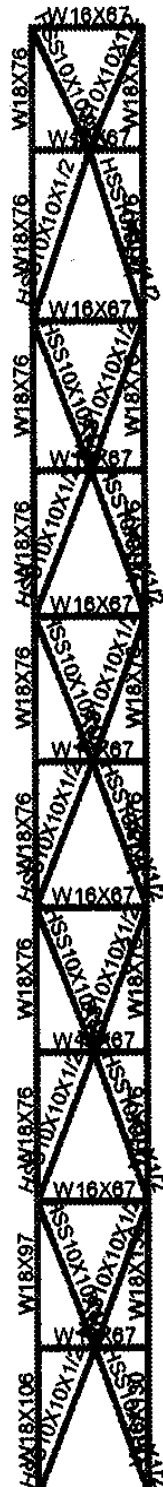
Frame Elevation 9



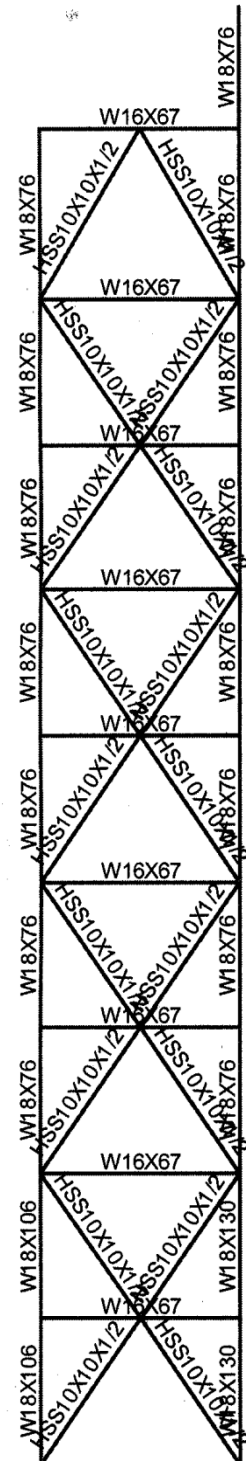
Frame Elevation 10



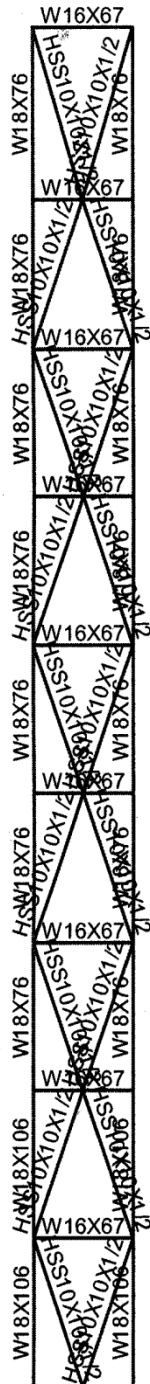
Frame Elevation 11



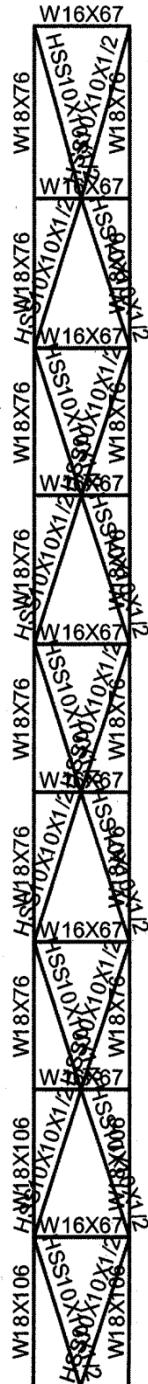
Frame Elevation 12



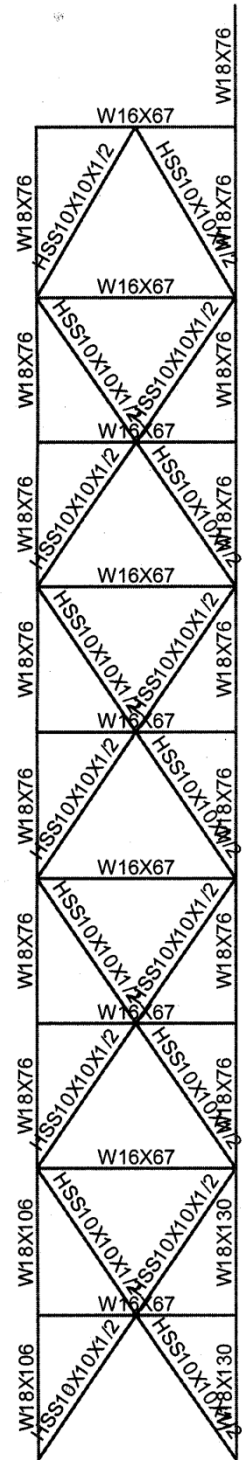
Frame Elevation 13



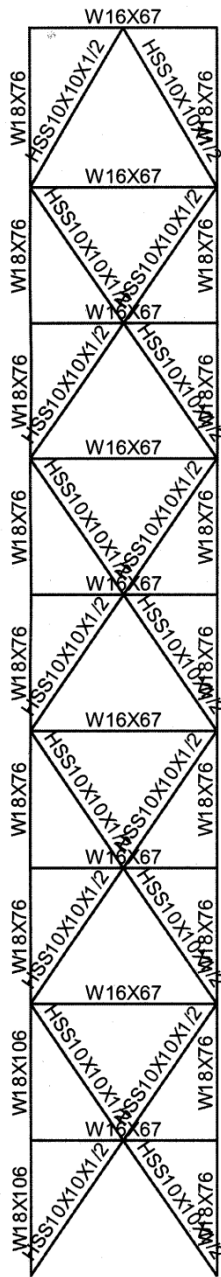
Frame Elevation 14



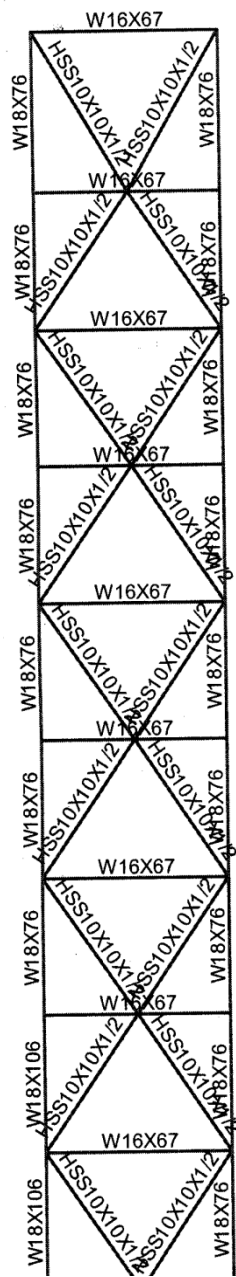
Frame Elevation 15



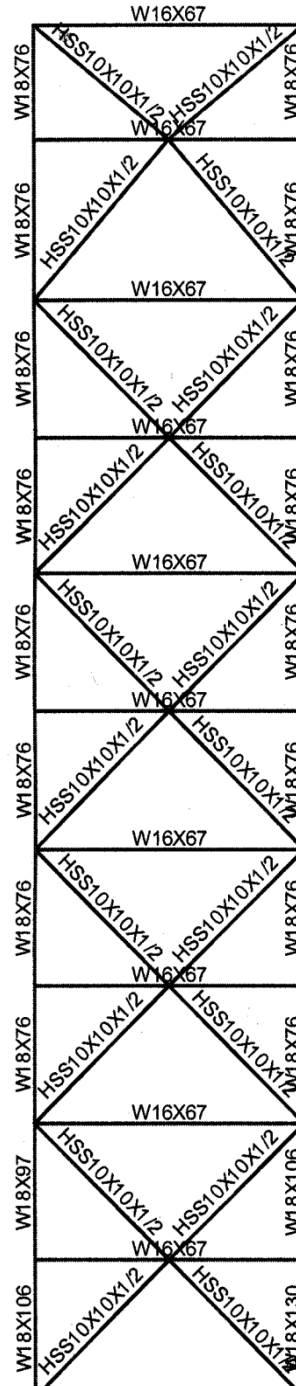
Frame Elevation 16



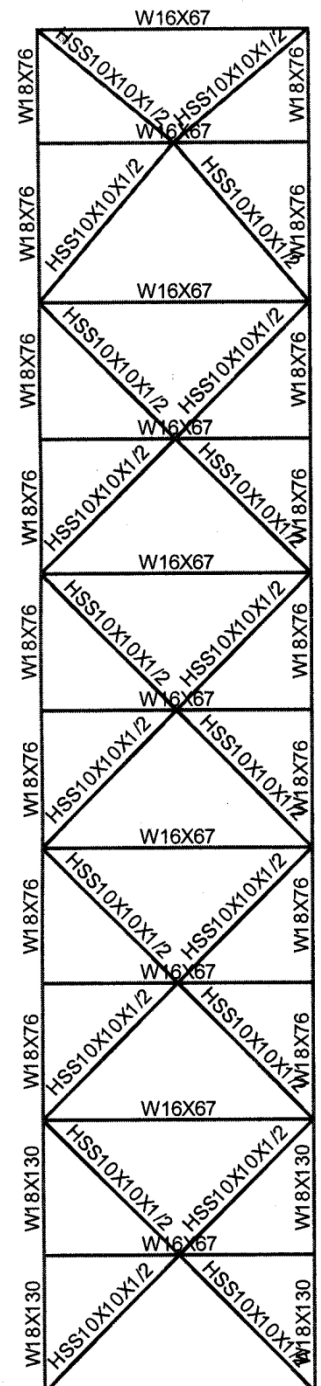
Frame Elevation 17



Frame Elevation 18



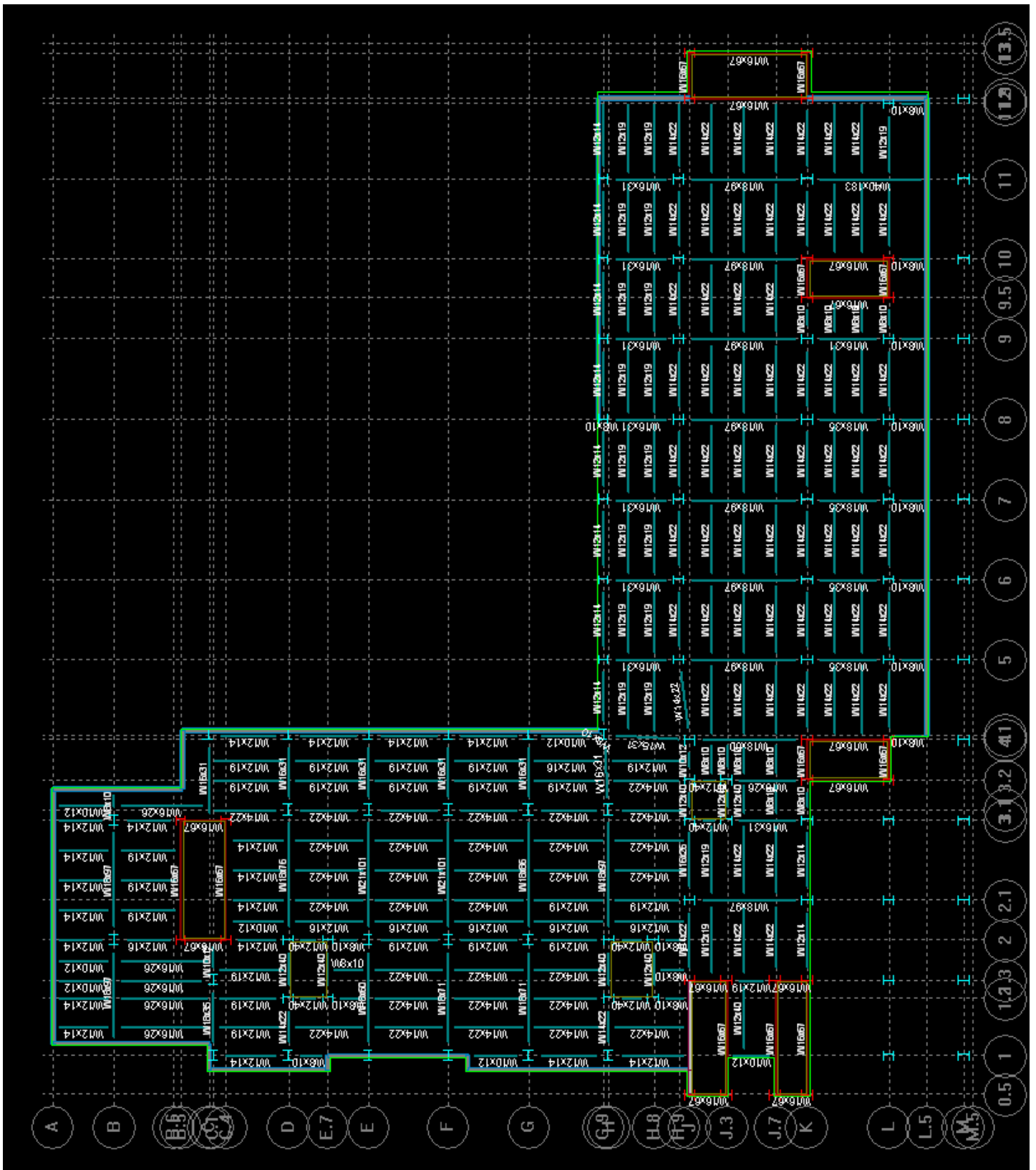
Frame Elevation 19



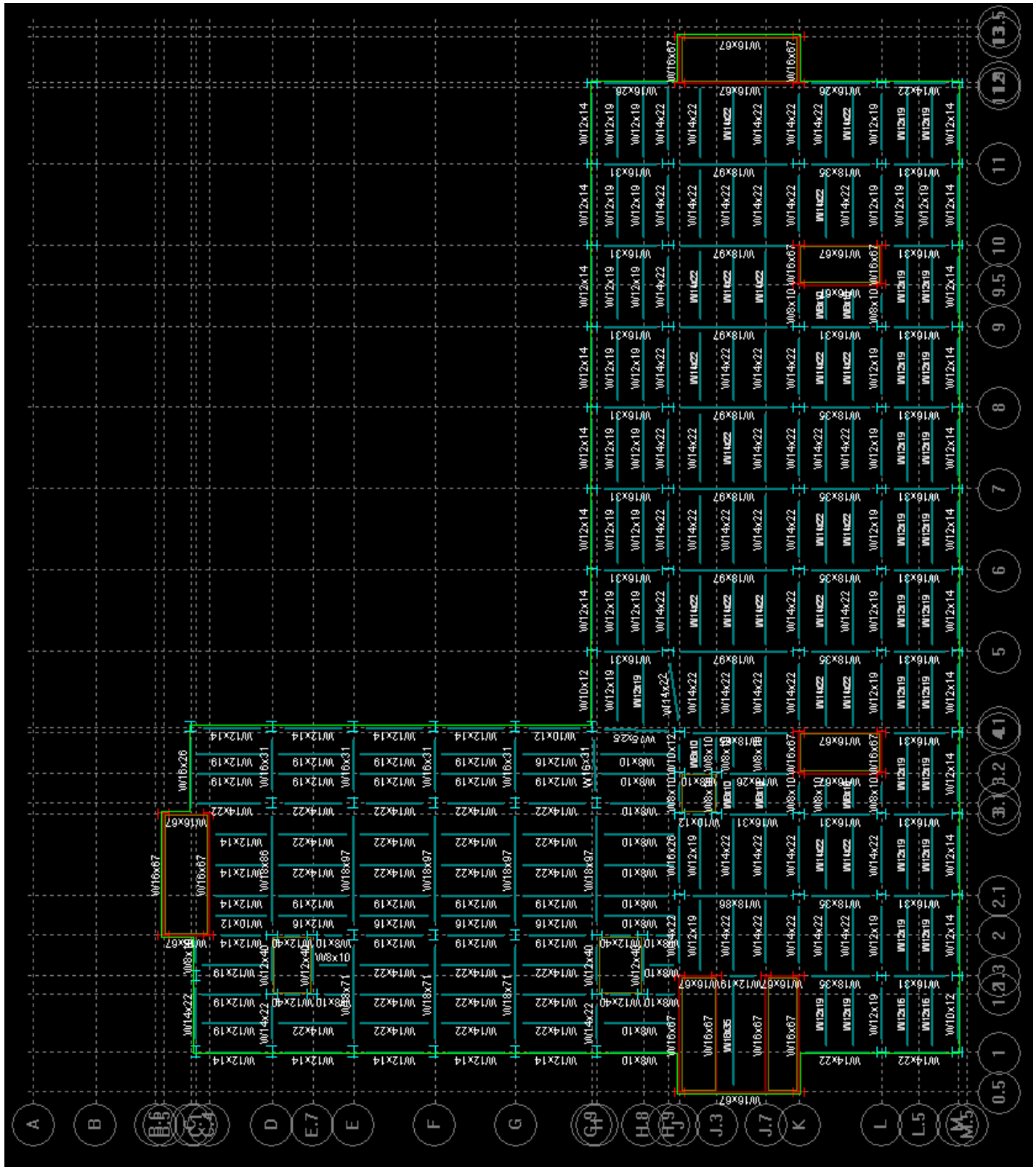
Frame Elevation 20

Appendix G: Steel Redesign Floor Plans

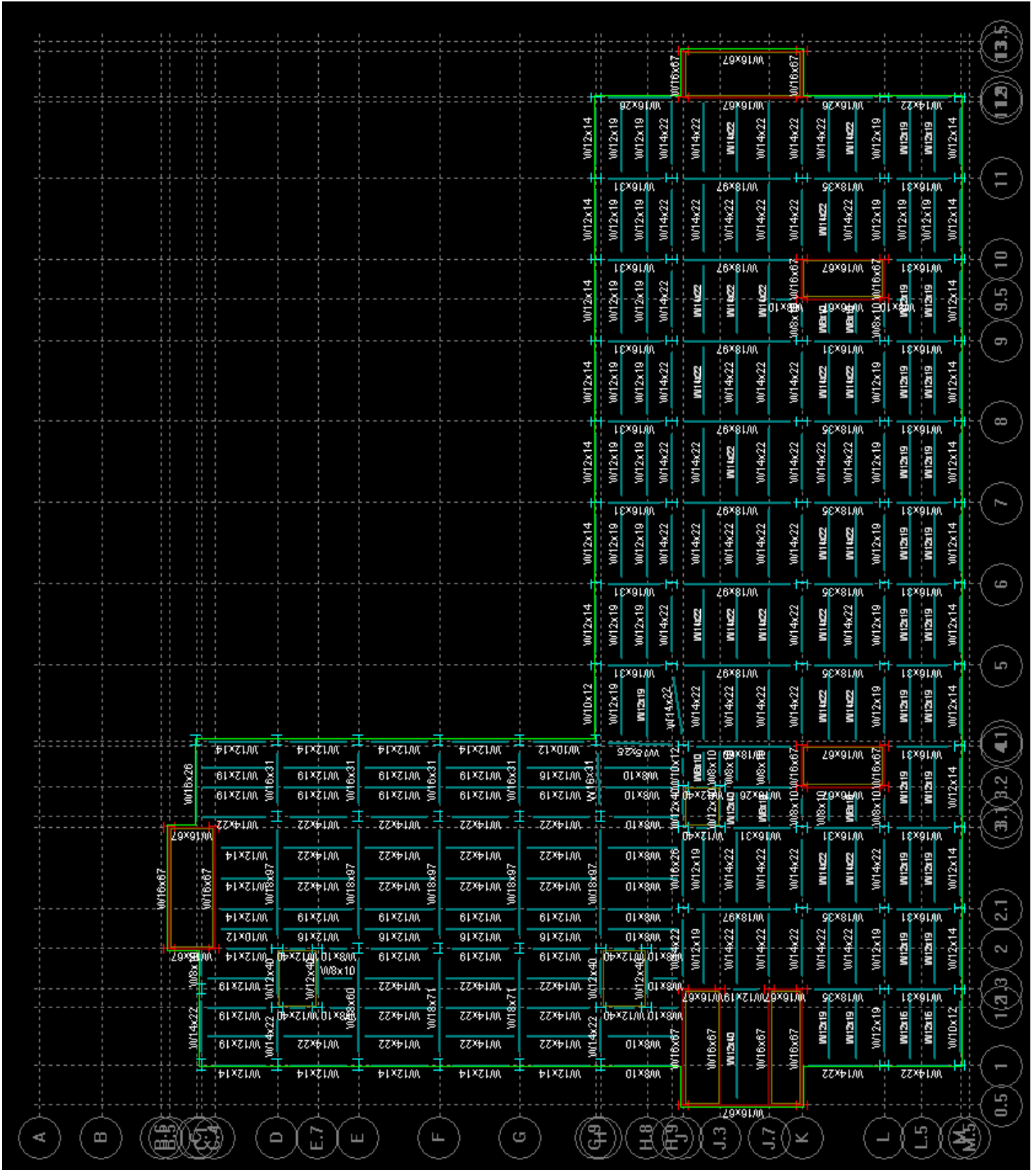
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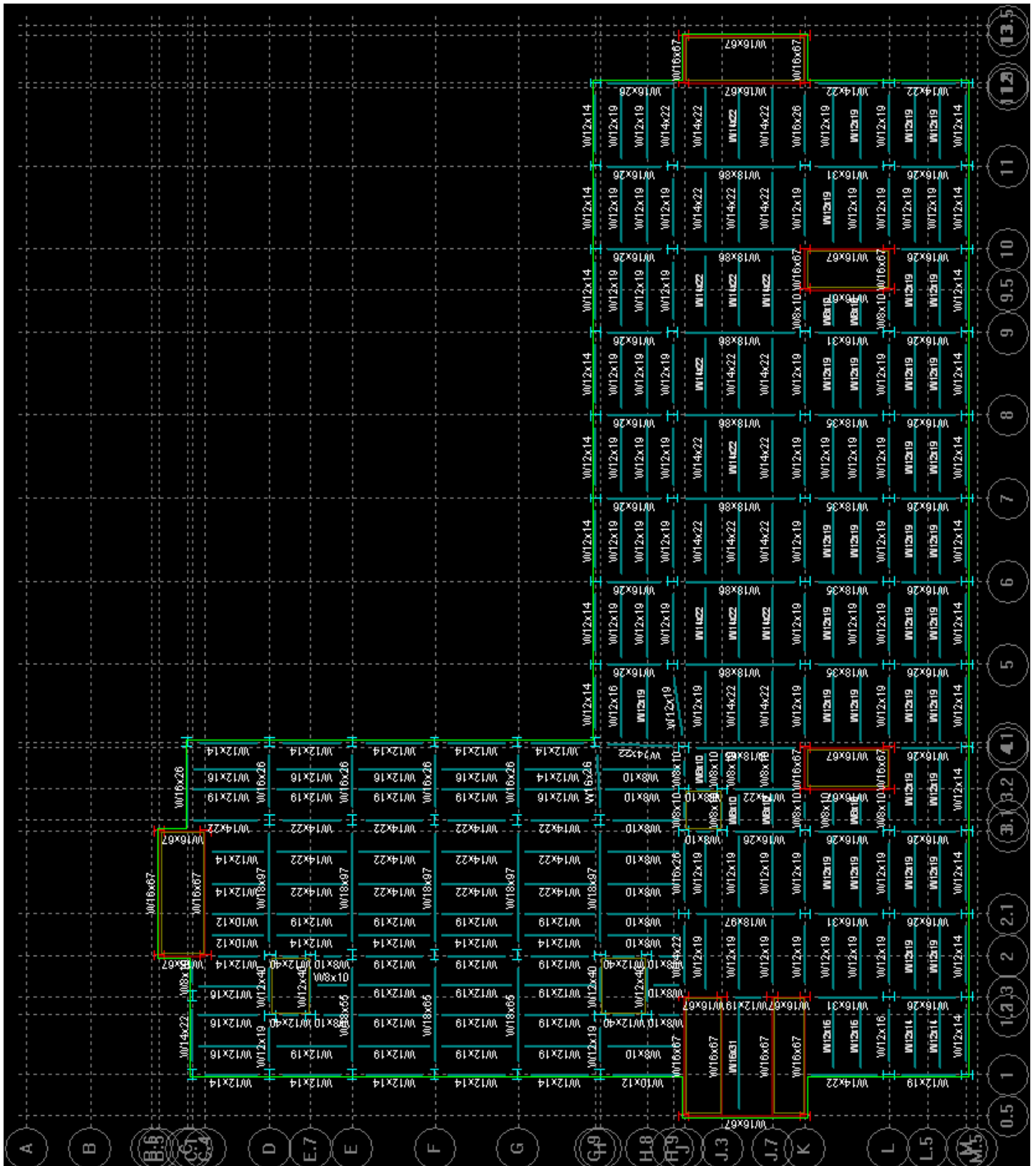
Floor 1



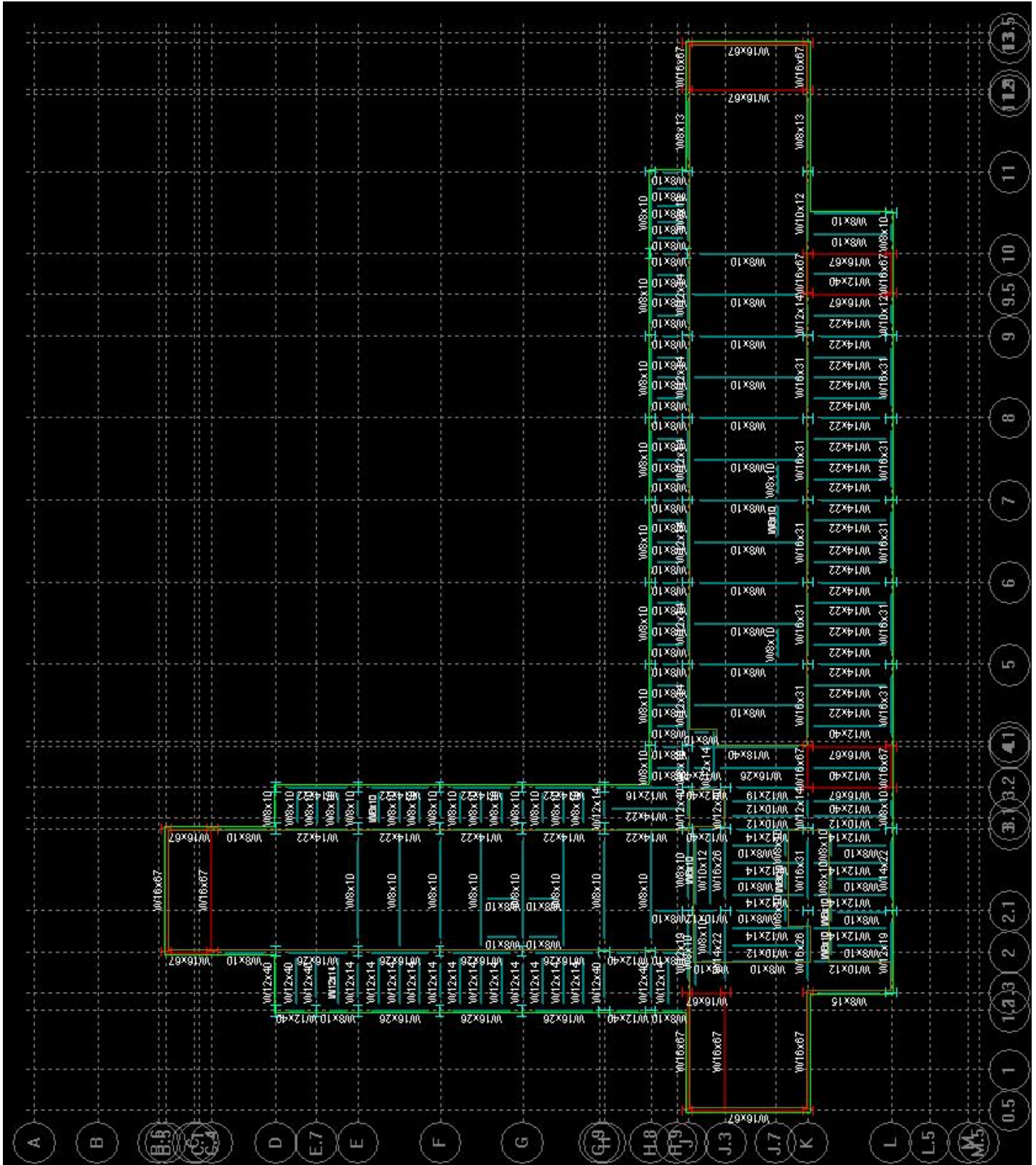
Floor 2



Floors 5-7



Roof/Penthouse



Lower Penthouse Roof

Appendix H: Construction Management Breadth

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RAM Frame v14.00.03.00
 DataBase: IRB Thesis
 Building Code: IBC

Frame Takeoff

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 04/04/10 15:27:15

Level: **LOADING DOCK**

Floor Area (ft**2): 0.0

TOTAL STRUCTURE FRAME TAKEOFF

Floor Area (ft**2): 359712.0

Columns:

Wide Flange:

Steel Grade: 50

Size	#	Length ft	Weight lbs	UnitWt psf
W18X76	164	2640.0	200325	
W18X97	1	16.0	1552	
W18X106	25	400.0	42330	
W18X130	16	256.0	33276	
W18X158	2	32.0	5041	
W18X175	6	96.0	16758	
	<u>214</u>		<u>299281</u>	0.83

Beams:

Wide Flange:

Steel Grade: 50

Size	#	Length ft	Weight lbs	UnitWt psf
W16X67	219	4510.7	302366	
	<u>219</u>		<u>302366</u>	0.84

Braces:

Tube:

Steel Grade: 36

Size	#	Length ft	Weight lbs	UnitWt psf
HSS10X10X5/8	1	16.9	1205	
HSS10X10X1/2	415	8059.9	471722	
HSS12X12X1/2	20	440.3	31314	
	<u>436</u>		<u>504242</u>	1.40

Note: Length and Weight based on Centerline dimensions.



Gravity Beam Design Takeoff

RAM Steel v14.00.03.00
 DataBase: IRB Thesis
 Building Code: IBC

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 04/04/10 15:20:03
 Steel Code: AISC360-05 LRFD

SIZE	#	LENGTH (ft)	WEIGHT (lbs)
W40X183	1	31.67	5743
	-----		-----
	273		163741

Total Number of Studs = 3617

TOTAL STRUCTURE GRAVITY BEAM TAKEOFF

Steel Grade: 50

SIZE	#	LENGTH (ft)	WEIGHT (lbs)
W8X10	379	5414.94	54540
W8X13	2	42.67	558
W8X15	1	21.67	327
W10X12	106	2573.21	30996
W12X14	294	5950.40	84231
W12X16	62	1288.46	20650
W12X19	596	12557.09	238001
W12X40	133	1855.61	73877
W14X22	737	15626.38	345093
W16X26	82	1780.83	46539
W16X31	188	3830.02	118989
W16X50	2	20.04	1002
W18X35	52	1133.84	39739
W18X40	1	31.33	1258
W18X55	1	30.67	1691
W18X60	11	341.33	20442
W18X76	2	66.00	5008
W18X65	4	124.00	8059
W18X86	10	341.00	29357
W18X71	15	460.00	32558
W18X97	93	3173.95	307807
W21X101	2	69.33	7031
W40X183	1	31.67	5743
	-----		-----
	2774		1473496

Total Number of Studs = 29125



Gravity Column Design TakeOff

RAM Steel v14.00.03.00
 DataBase: IRB Thesis
 Building Code: IBC

04/04/10 15:20:03
 Steel Code: AISC360-05 LRFD

Steel Grade: 50

I section

Size	#	Length (ft)	Weight (lbs)
W10X33	205	3344.0	110489
W10X39	35	560.0	21914
W12X40	88	1408.0	56056
W14X43	33	536.0	22981
W12X45	6	96.0	4279
W10X45	32	512.0	23172
W14X48	4	64.0	3071
W10X49	47	752.0	36848
W12X50	16	256.0	12718
W12X53	15	240.0	12740
W14X53	12	192.0	10192
W10X54	5	80.0	4301
W12X58	8	128.0	7404
W10X60	10	160.0	9582
W14X61	40	640.0	38982
W12X65	15	240.0	15598
W10X68	11	176.0	11978
W14X68	11	176.0	11978
W12X72	9	144.0	10339
W14X74	13	208.0	15430
W10X77	9	144.0	11074
W12X79	31	496.0	39156
W14X82	9	144.0	11760
W12X87	6	104.1	9070
W10X88	2	32.0	2820
W14X90	38	608.0	54826
W12X96	1	16.0	1535
W14X99	3	48.0	4753
W10X100	2	32.0	3201
W12X106	1	16.0	1699
W14X109	2	32.0	3484
W10X112	12	192.0	21495
W14X145	10	160.0	23248
W14X159	2	32.0	5085
W14X176	3	48.0	8461
W12X190	6	96.0	18228
W14X193	1	16.0	3092
	753		663040

Structural Steel Estimate										
Member Size	Unit	Quantity	Length (LF)	Unit Mat'l Cost	Mat'l Cost	Unit Labor Cost	Labor Cost	Unit Equipment Cost	Equipment Cost	Total Item Cost
Beams and Girders										
Wide Flange Shapes										
W8X10	LF	379	5414.94000	\$12.10	\$65,521	\$2.83	\$15,324	\$2.68	\$14,512	\$95,357
W8X13	LF	2	42.67000	\$18.15	\$774	\$2.83	\$121	\$2.68	\$114	\$1,010
W8X15	LF	1	21.67000	\$18.15	\$393	\$2.83	\$61	\$2.68	\$58	\$513
W10X12	LF	106	2573.21000	\$14.50	\$37,312	\$2.83	\$7,282	\$2.68	\$6,896	\$51,490
W12X14	LF	294	5950.40000	\$19.35	\$115,140	\$1.93	\$11,484	\$1.83	\$10,889	\$137,514
W12X16	LF	62	1288.46000	\$19.35	\$24,932	\$1.93	\$2,487	\$1.83	\$2,358	\$29,776
W12X19	LF	596	12557.09000	\$19.35	\$242,980	\$1.93	\$24,235	\$1.83	\$22,979	\$290,194
W12X40	LF	133	1855.61000	\$42.50	\$78,863	\$2.10	\$3,897	\$1.98	\$3,674	\$86,434
W14X22	LF	737	15626.38000	\$31.50	\$492,231	\$1.71	\$26,721	\$1.62	\$25,315	\$544,267
W16X26	LF	82	1780.83000	\$31.50	\$56,096	\$1.71	\$3,045	\$1.62	\$2,885	\$62,026
W16X31	LF	188	3830.02000	\$37.50	\$143,626	\$1.89	\$7,239	\$1.79	\$6,856	\$157,720
W16X50	LF	2	20.01000	\$60.50	\$1,211	\$2.12	\$42	\$2.01	\$40	\$1,293
W18X35	LF	52	1133.84000	\$42.50	\$48,188	\$2.65	\$3,005	\$1.83	\$2,075	\$53,268
W18X40	LF	1	31.33000	\$48.50	\$1,520	\$2.65	\$83	\$1.83	\$57	\$1,660
W18X55	LF	1	30.67000	\$66.50	\$2,040	\$2.79	\$86	\$1.92	\$59	\$2,184
W18X60	LF	11	341.33000	\$66.50	\$22,698	\$2.79	\$952	\$1.92	\$655	\$24,306
W18X65	LF	4	124.00000	\$78.50	\$9,734	\$2.82	\$350	\$1.95	\$242	\$10,325
W18X71	LF	15	460.00000	\$78.50	\$36,110	\$2.82	\$1,297	\$1.95	\$897	\$38,304
W18X76	LF	2	66.00000	\$92.00	\$6,072	\$2.82	\$186	\$1.95	\$129	\$6,387
W18X86	LF	10	341.00000	\$104.00	\$35,464	\$2.82	\$962	\$1.95	\$665	\$37,091
W18X97	LF	93	3173.95000	\$104.00	\$330,091	\$2.82	\$8,951	\$1.95	\$6,189	\$345,231
W21X101	LF	2	69.33000	\$122.00	\$8,458	\$2.54	\$176	\$1.75	\$121	\$8,756
W40X183	LF	1	31.67000	\$235.00	\$7,442	\$2.26	\$72	\$1.56	\$49	\$7,563
Columns										
Wide Flange Shapes										
W10X33	LF	205	3344.00000	\$54.50	\$182,248	\$1.64	\$5,484	\$1.56	\$5,217	\$192,949
W10X39	LF	35	560.00000	\$54.50	\$30,520	\$1.64	\$918	\$1.56	\$874	\$32,312
W10X45	LF	32	512.00000	\$54.50	\$27,904	\$1.64	\$840	\$1.56	\$799	\$29,542
W10X49	LF	47	752.00000	\$54.50	\$40,984	\$1.64	\$1,233	\$1.56	\$1,173	\$43,390
W10X54	LF	5	80.00000	\$54.50	\$4,360	\$1.64	\$131	\$1.56	\$125	\$4,616
W10X60	LF	10	160.00000	\$54.50	\$8,720	\$1.64	\$262	\$1.56	\$250	\$9,232
W10X68	LF	11	176.00000	\$82.50	\$14,520	\$1.72	\$303	\$1.63	\$287	\$15,110
W10X77	LF	9	144.00000	\$82.50	\$11,880	\$1.72	\$248	\$1.63	\$235	\$12,362
W10X88	LF	2	32.00000	\$82.50	\$2,640	\$1.72	\$55	\$1.63	\$52	\$2,747
W10X100	LF	2	32.00000	\$82.50	\$2,640	\$1.72	\$55	\$1.63	\$52	\$2,747
W10X112	LF	12	192.00000	\$136.00	\$26,112	\$1.77	\$340	\$1.67	\$321	\$26,772
W12X40	LF	88	1408.00000	\$60.50	\$85,184	\$1.64	\$2,309	\$1.56	\$2,196	\$89,690
W12X45	LF	6	96.00000	\$60.50	\$5,808	\$1.64	\$157	\$1.56	\$150	\$6,115
W12X50	LF	16	256.00000	\$60.50	\$15,488	\$1.64	\$420	\$1.56	\$399	\$16,307
W12X53	LF	15	240.00000	\$60.50	\$14,520	\$1.64	\$394	\$1.56	\$374	\$15,288
W12X58	LF	8	128.00000	\$60.50	\$7,744	\$1.64	\$210	\$1.56	\$200	\$8,154
W12X65	LF	15	240.00000	\$60.50	\$14,520	\$1.64	\$394	\$1.56	\$374	\$15,288
W12X72	LF	9	144.00000	\$60.50	\$8,712	\$1.64	\$236	\$1.56	\$225	\$9,173
W12X79	LF	31	496.00000	\$60.50	\$30,008	\$1.64	\$813	\$1.56	\$774	\$31,595
W12X87	LF	6	104.00000	\$105.00	\$10,920	\$1.72	\$179	\$1.63	\$170	\$11,268
W12X96	LF	1	16.00000	\$105.00	\$1,680	\$1.72	\$28	\$1.63	\$26	\$1,734
W12X106	LF	1	16.00000	\$105.00	\$1,680	\$1.72	\$28	\$1.63	\$26	\$1,734
W12X190	LF	6	96.00000	\$230.00	\$22,080	\$1.86	\$179	\$1.76	\$169	\$22,428
W14X43	LF	33	536.00000	\$89.50	\$47,972	\$1.72	\$922	\$1.63	\$874	\$49,768
W14X48	LF	4	64.00000	\$89.50	\$5,728	\$1.72	\$110	\$1.63	\$104	\$5,942
W14X53	LF	12	192.00000	\$89.50	\$17,184	\$1.72	\$330	\$1.63	\$313	\$17,827
W14X61	LF	40	640.00000	\$89.50	\$57,280	\$1.72	\$1,101	\$1.63	\$1,043	\$59,424
W14X68	LF	11	176.00000	\$89.50	\$15,752	\$1.72	\$303	\$1.63	\$287	\$16,342
W14X74	LF	13	208.00000	\$89.50	\$18,616	\$1.72	\$358	\$1.63	\$339	\$19,313
W14X82	LF	9	144.00000	\$89.50	\$12,888	\$1.72	\$248	\$1.63	\$235	\$13,370
W14X90	LF	38	608.00000	\$89.50	\$54,416	\$1.72	\$1,046	\$1.63	\$991	\$56,453
W14X99	LF	3	48.00000	\$89.50	\$4,296	\$1.72	\$83	\$1.63	\$78	\$4,457
W14X109	LF	2	32.00000	\$89.50	\$2,864	\$1.72	\$55	\$1.63	\$52	\$2,971
W14X145	LF	10	160.00000	\$145.00	\$23,200	\$1.77	\$283	\$1.67	\$267	\$23,750
W14X159	LF	2	32.00000	\$145.00	\$4,640	\$1.77	\$57	\$1.67	\$53	\$4,750
W14X176	LF	3	48.00000	\$213.00	\$10,224	\$1.86	\$89	\$1.76	\$84	\$10,398
W14X193	LF	1	16.00000	\$213.00	\$3,408	\$1.86	\$30	\$1.76	\$28	\$3,466

Final Report

Chapel Hill, NC

Braced Frames										
Wide Flange Shapes										
Columns										
W18X76	LF	164	2640.00000	\$92.00	\$242,880	\$2.82	\$7,445	\$1.95	\$5,148	\$255,473
W18X97	LF	1	16.00000	\$104.00	\$1,664	\$2.82	\$45	\$1.95	\$31	\$1,740
W18X106	LF	25	400.00000	\$128.00	\$51,200	\$2.82	\$1,128	\$1.95	\$780	\$53,108
W18X130	LF	16	256.00000	\$148.00	\$37,888	\$2.54	\$650	\$1.75	\$448	\$38,986
W18X158	LF	2	32.00000	\$148.00	\$4,736	\$2.54	\$81	\$1.75	\$56	\$4,873
W18X175	LF	6	96.00000	\$148.00	\$14,208	\$2.54	\$244	\$1.75	\$168	\$14,620
Beams										
W16X67	LF	219	4510.70000	\$77.50	\$349,579	\$2.36	\$10,645	\$1.69	\$7,623	\$367,848
Braces										
HSS10X10X5/8	LF	1	16.90000	\$1,200.00	\$75	\$29.50	\$31	\$27.50	\$29	\$135
HSS10X10X1/2	LF	415	8059.90000	\$1,200.00	\$31,125	\$29.50	\$14,860	\$27.50	\$13,853	\$59,838
HSS12X12X1/2	LF	20	440.30000	\$1,200.00	\$1,500	\$29.50	\$812	\$27.50	\$757	\$3,069
Subtotal Costs					\$3,351,091		\$174,228		\$155,825	\$3,681,143.53
Adjusted for Location (0.91)										\$3,349,840.61
Design Contingency (1.5%)										\$50,247.61
Escalation Contingency (3.5%)										\$117,244.42
Insurance (3%)										\$100,495.22
Bonds (2%)										\$66,996.81
Overhead & Profit (10%)										\$334,984.06
							Total Structural Steel Cost:		\$4,019,808.73	

Appendix I: Enclosure Breadth: Blast Design

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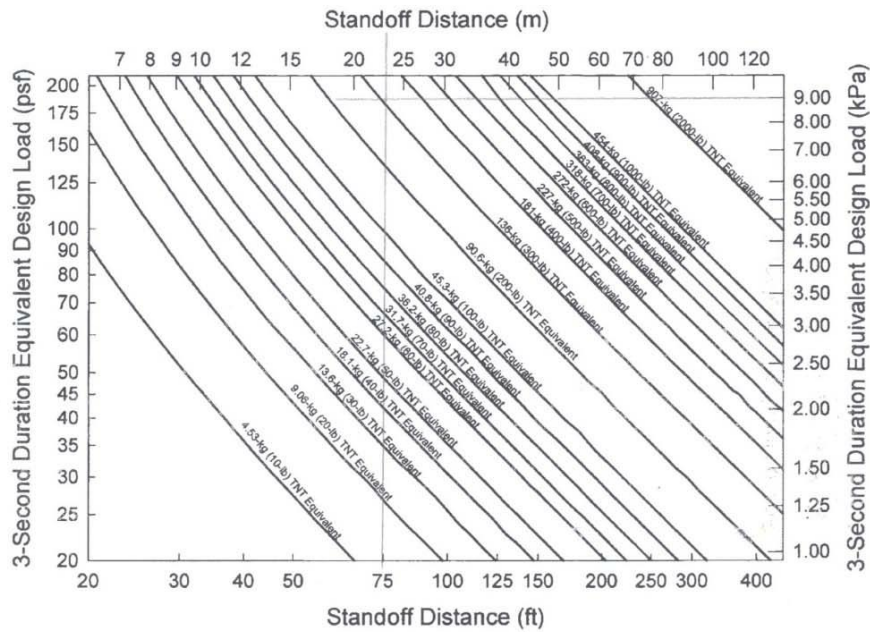


Fig. 3. Chart that relates standoff distance and charge size to equivalent 3-s duration equivalent design loading from ASTM F 2248-03. (Reprinted with permission from ASTM F 2248-03, copyright ASTM International, 100 Barr Harbor Dr., West Conshohocken, PA 19428.)

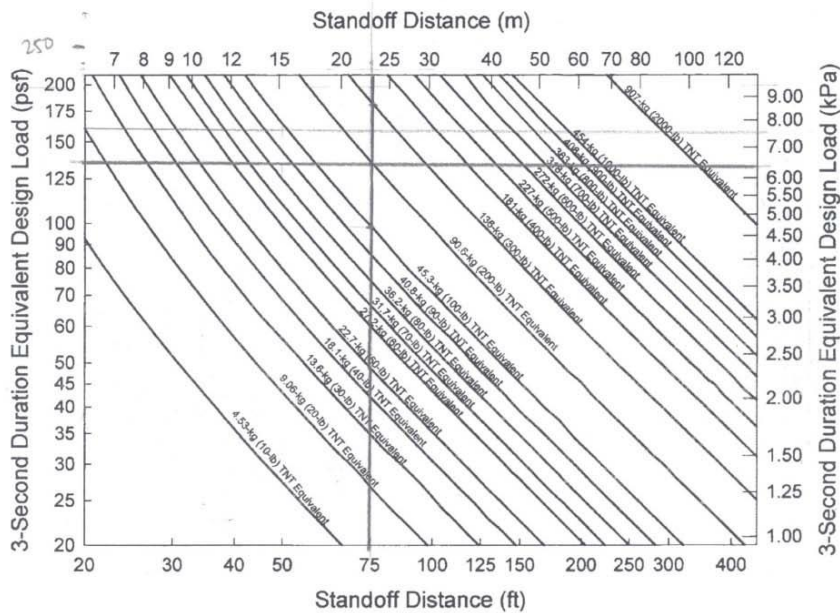


Fig. 3. Chart that relates standoff distance and charge size to equivalent 3-s duration equivalent design loading from ASTM F 2248-03. (Reprinted with permission from ASTM F 2248-03, copyright ASTM International, 100 Barr Harbor Dr., West Conshohocken, PA 19428.)

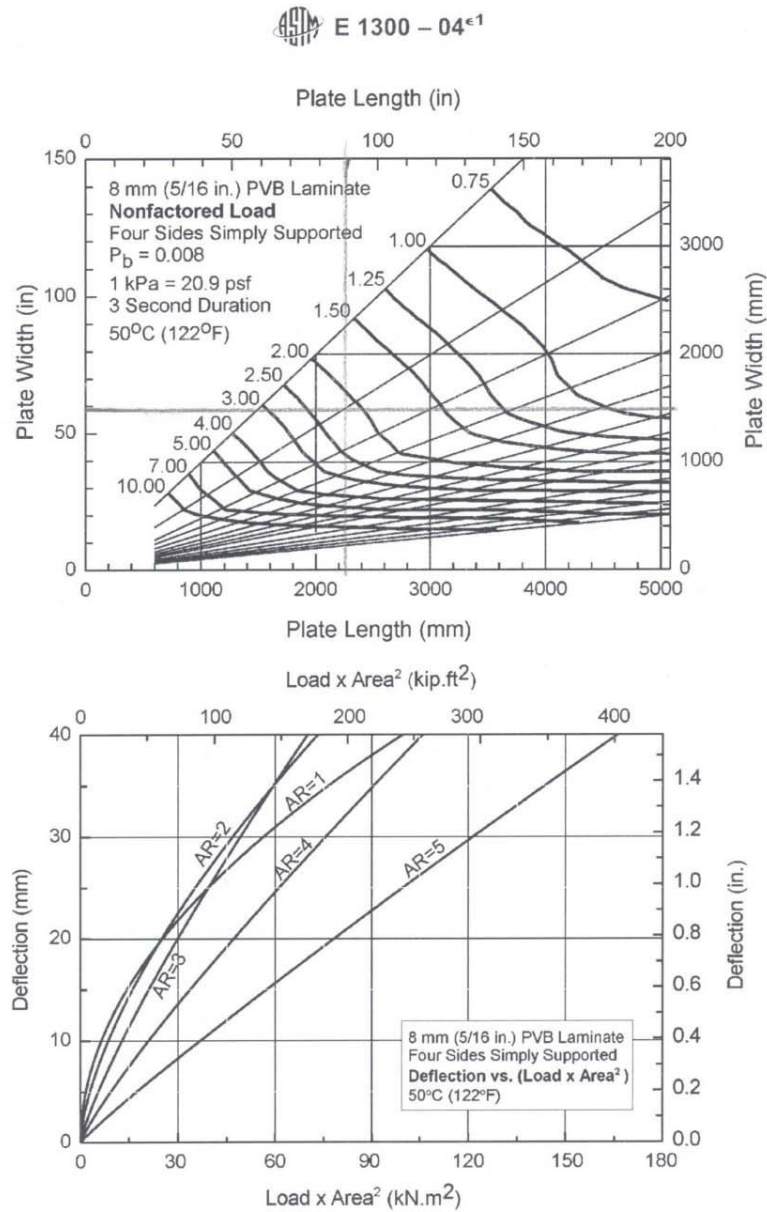


FIG. A1.29 (upper chart) Nonfactored Load Chart for 8.0 mm (5/16 in.) Laminated Glass with Four Sides Simply Supported
 (lower chart) Deflection Chart for 8.0 mm (5/16 in.) Laminated Glass with Four Sides Simply Supported