Appendices

Appendix A: Typical Plans

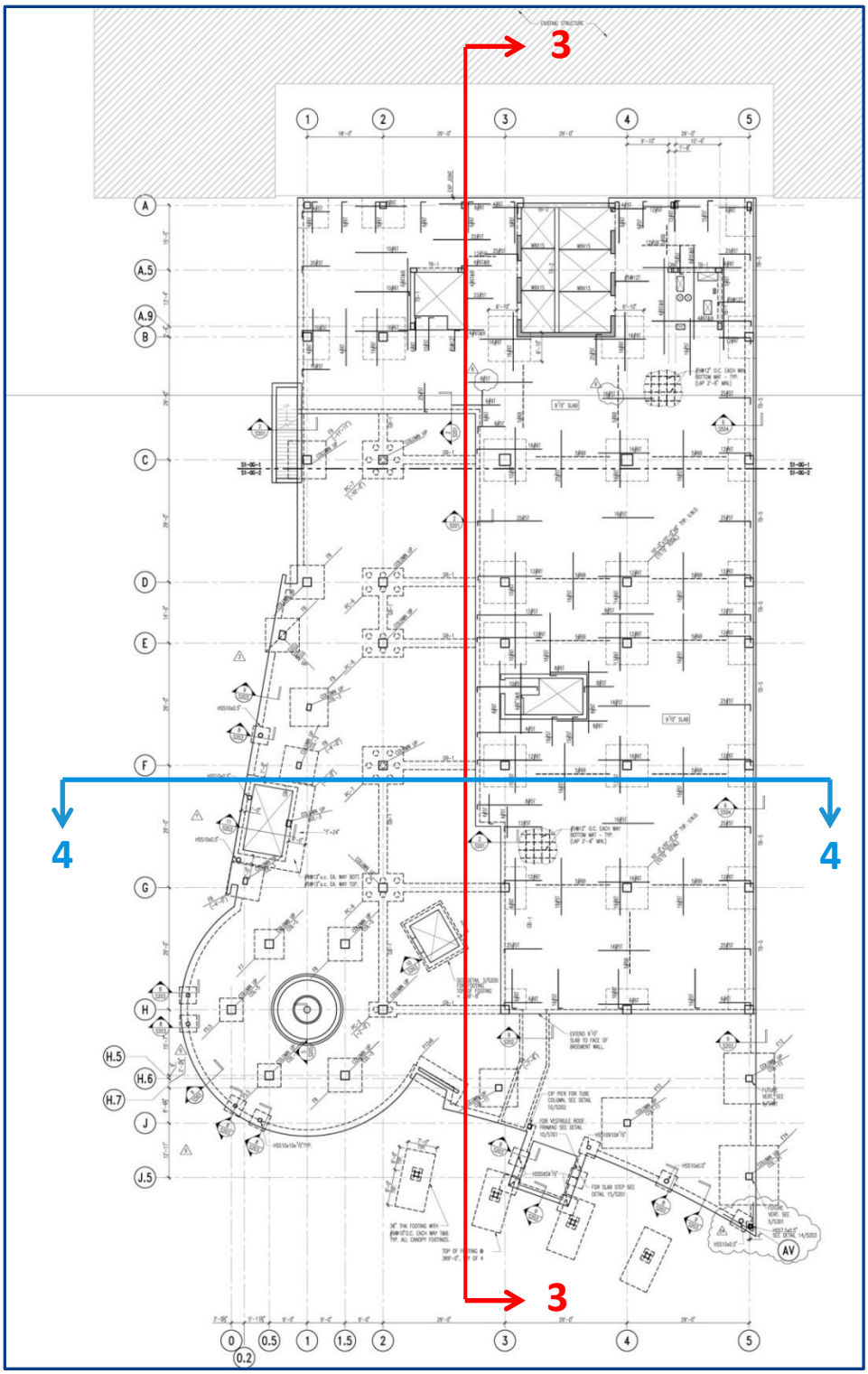

Figure 1:
Ground floor plan (See following figures for sections indicated on the plan)

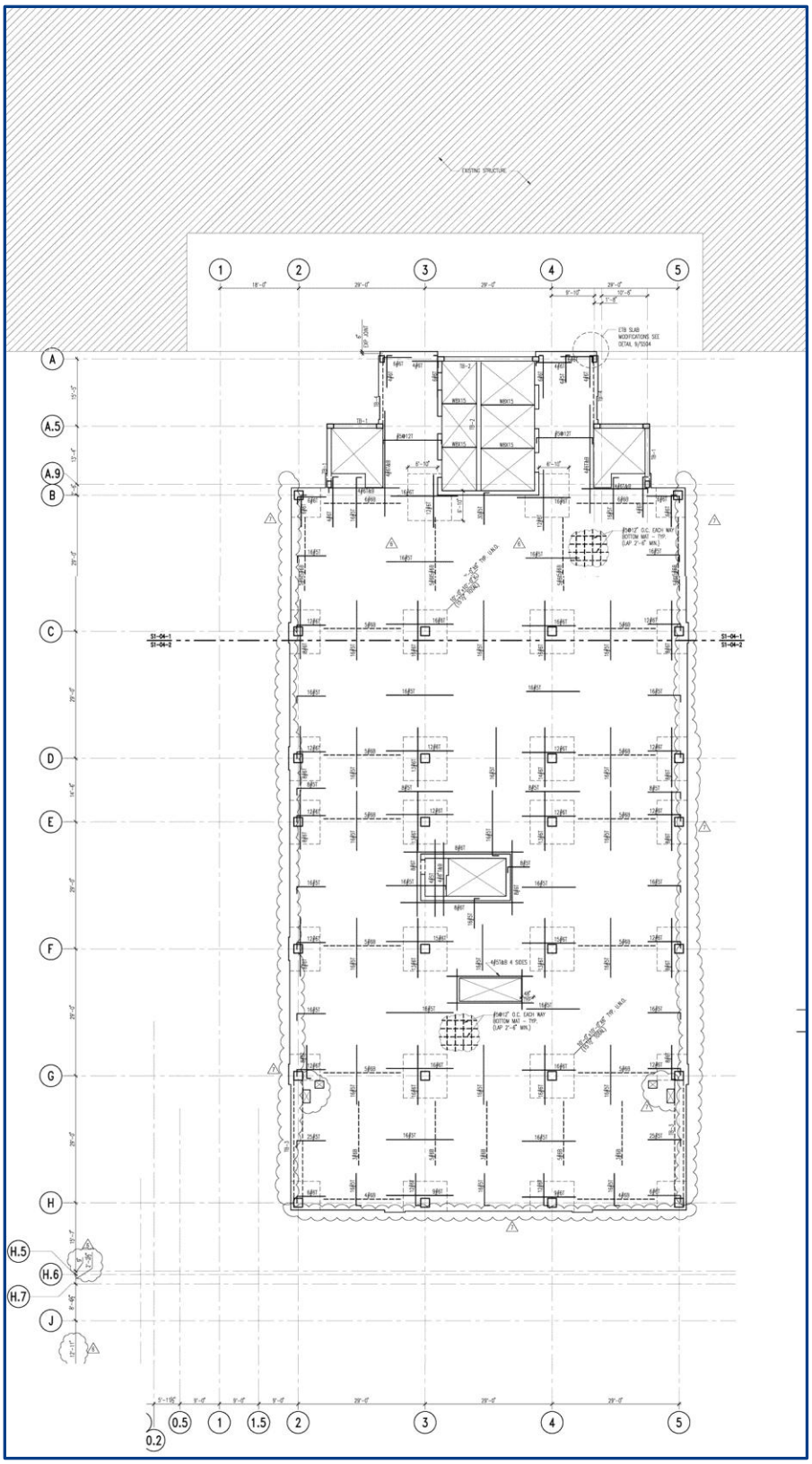

Figure 2:
Typical floor plan (6th – 11th)

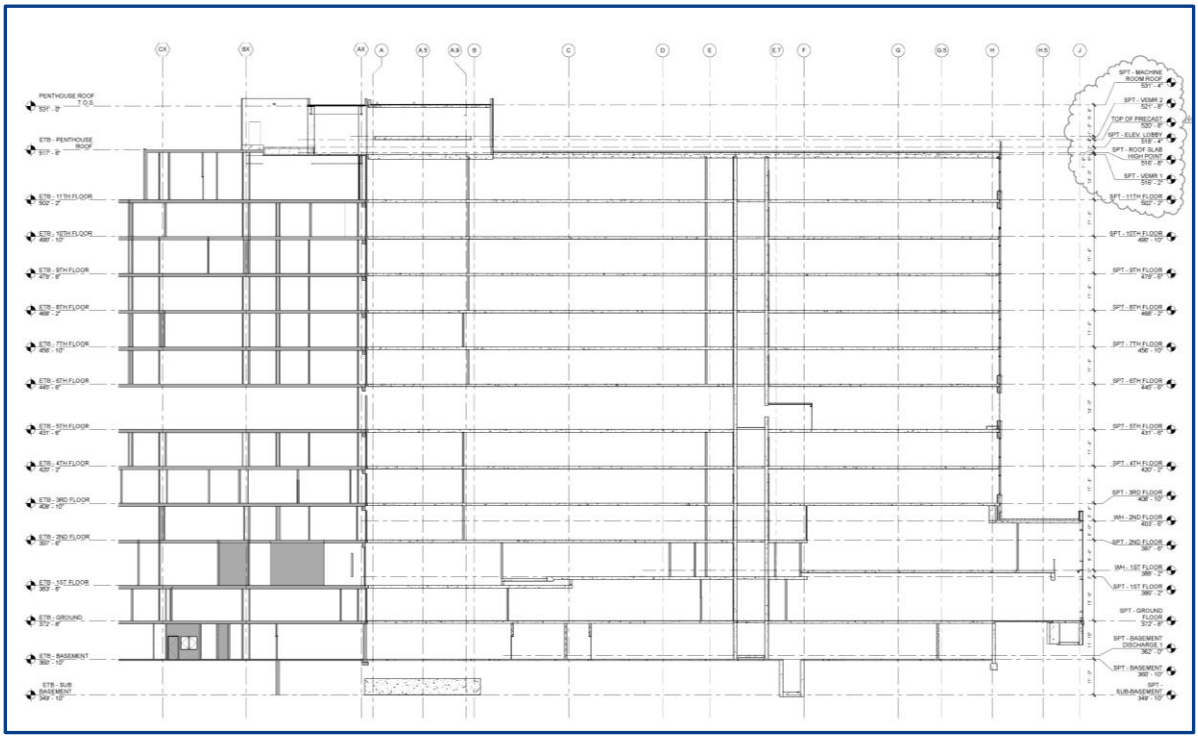

Figure 3:
North – South section cut

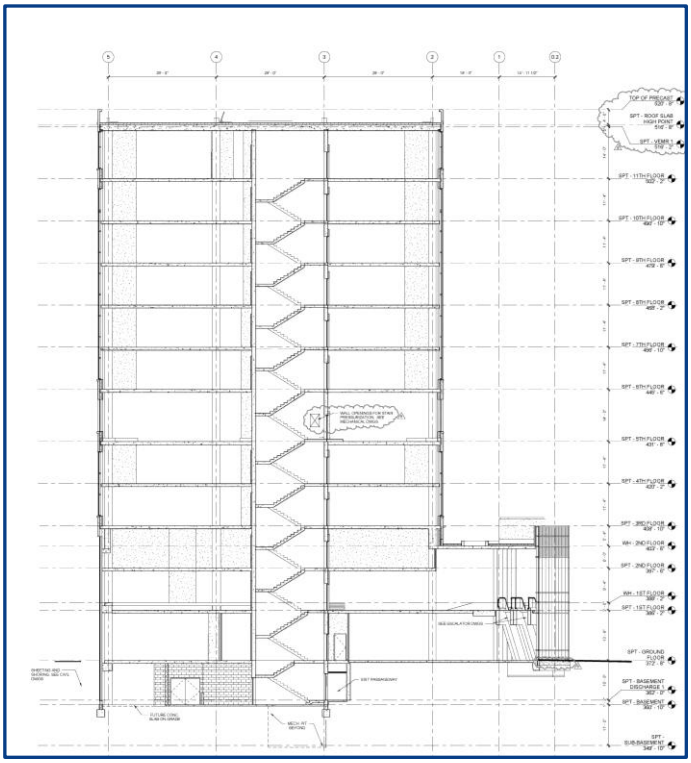

Figure 4:
East – West section cut

Appendix B: Wind Load Calculations

Existing Structure: Falls Church, VA

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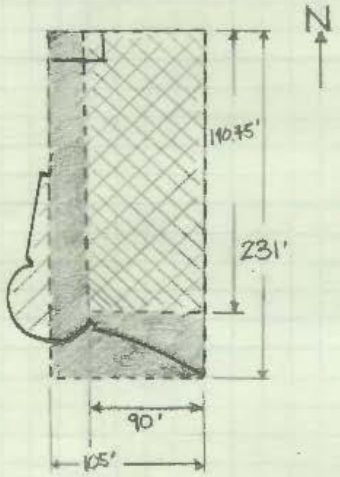
SIMPLIFYING ASSUMPTIONS:



N-S DIRECTION WIND:

0 → 36.17'
L = 231'
B = 105'
36.17' → 175'
L = 190.75'
B = 90'

E-W DIRECTION WIND:

0 → 36.17'
L = 105'
B = 231'
36.17' → 175'
L = 90'
B = 190.75'

USE METHOD 2 SINCE BUILDING WITH SIMPLIFYING ASSUMPTIONS MEETS CRITERIA OF 6.5.1 AND 6.5.2

BASIC WIND SPEED: V = 90 mph (FIGURE 6-1C)

WIND DIRECTIONALITY FACTOR: $K_d = 0.85$ (TABLE 6-4)

OCCUPANCY CATEGORY: TYPE IV (TABLE 6-1)

IMPORTANCE FACTOR: I = 1.15 (TABLE 6-1)

EXPOSURE CATEGORY: B - Urban/Suburban (§ 6.5.6.3)

TOPOGRAPHIC FACTOR: $K_{zt} = 1.0$ (§ 6.5.7)

VELOCITY PRESSURE COEFFICIENTS: Varies with height → See Excel Spreadsheet (TABLE 6-3)

VELOCITY PRESSURES: $q_z = 0.00256 K_z K_{zt} K_d V^2 I$ (§ 6.5.10)

GUST EFFECT FACTOR:

$$n_1 = \frac{385 (C_w)^{0.5}}{H}$$

$$C_w = \frac{100}{A_s} \sum \left(\frac{H}{h_i}\right)^2 \frac{A_i}{[1 + 0.83(h_i/D_i)^2]}$$

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$A_B = (105') \times (231') = 24255\ ft^2$
$H = 174'-4"$

EAST - WEST DIRECTION:

Shear Wall 3:

$h_i = 174'-4"$
$D_i = 25'$
$A_i = (174'-4")(25') = 4358.25$

$$\left(\frac{174.33'}{174.33'}\right)^2 \frac{4358.25}{1+0.83\left(\frac{174.33}{25'}\right)^2} = 105.38$$

Shear Wall 5 & 6:

$h_i = 145'$
$D_i = 20'$
$A_i = (145')(20') = 2900$

$$\left(\frac{174.33'}{145}\right)^2 \frac{2900}{1+0.83\left(\frac{145}{20}\right)^2} = 93.93$$

$$C_w = \left(\frac{100}{24255}\right)\left(105.38 + 2(93.93)\right) = 1.20$$

$$n_i = \frac{385(1.2)^{0.5}}{174'-4"} = 2.43 > 1.0 \rightarrow \text{RIGID STRUCTURE}$$

NORTH - SOUTH DIRECTION

Shear Wall 1 and 2:

$h_i = 174'-4"$
$D_i = 30.75'$
$A_i = (174'-4")(30.75') = 5360.75$

$$\left(\frac{174.33'}{174.33'}\right)^2 \frac{5360.75}{1+0.83\left(\frac{174.33}{30.75}\right)^2} = 193.69$$

Shear Wall 4 and 7:

$h_i = 145'$
$D_i = 10'$
$A_i = (145')(10') = 1450$

$$\left(\frac{174.33}{145}\right)^2 \frac{1450}{1+0.83\left(\frac{145}{10'}\right)^2} = 11.94$$

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$C_W = \left(\frac{100}{24255}\right)(2\times193.69 + 2\times11.94) = 1.69$

$n_1 = \frac{385(1.69)^{0.5}}{174'-4''} = 2.88 > 1.0 \rightarrow$ RIGID STRUCTURE

∴ GUST EFFECT FACTOR MAY BE TAKEN AS 0.85 (§6.5.8.1)

ENCLOSURE CLASSIFICATION: Enclosed Building → $GC_{pi} = \pm 0.18$ (FIGURE 6-5)

DESIGN WIND PRESSURES: $p = qGC_p - q_i(GC_{pi})$

EXTERNAL PRESSURE COEFFICIENTS:

WALLS:

WINDWARD → $C_p = 0.8$

LEEWARD:

N-S:

$0 \rightarrow 36.17'$: $L/B = 231/105 = 2.2 \rightarrow C_p = -0.29$

$36.17' \rightarrow 175'$: $L/B = 190.75/90 = 2.1 \rightarrow C_p = -0.295$

E-W:

$0 \rightarrow 36.17'$: $L/B = 105/231 = 0.45 \rightarrow C_p = -0.5$

$36.17' \rightarrow 175'$: $L/B = 90/190.75 = 0.47 \rightarrow C_p = -0.5$

SIDE → $C_p = -0.7$

ROOF: $\theta = 0°$ (Only considered wind for taller tower)

N-S: $h/L = \frac{175'}{190.75'} = 0.917$

E-W: $h/L = \frac{175'}{90'} = 1.9 > 1.0 \rightarrow$

	C_p
$0 \rightarrow h/2$	-1.3**, -0.18
$> h/2$	-0.7, -0.18

** Value may be reduced:
Roof Area = (190.75')(90') = 17167.5 ft² → Reduction factor = 0.8

DESIGN WIND PRESSURES:

Windward Walls: $p_z = q_z GC_p - q_h(GC_{pi})$

Leeward Walls: $p_h = q_h(GC_p - GC_{pi})$

Side Walls

Roof

SAMPLE CALC:

$p_z = (11.55)(0.85)(0.8) - (23.51)(\pm 0.18) = 7.86 \text{ PSF} \pm 4.23 \text{ PSF}$

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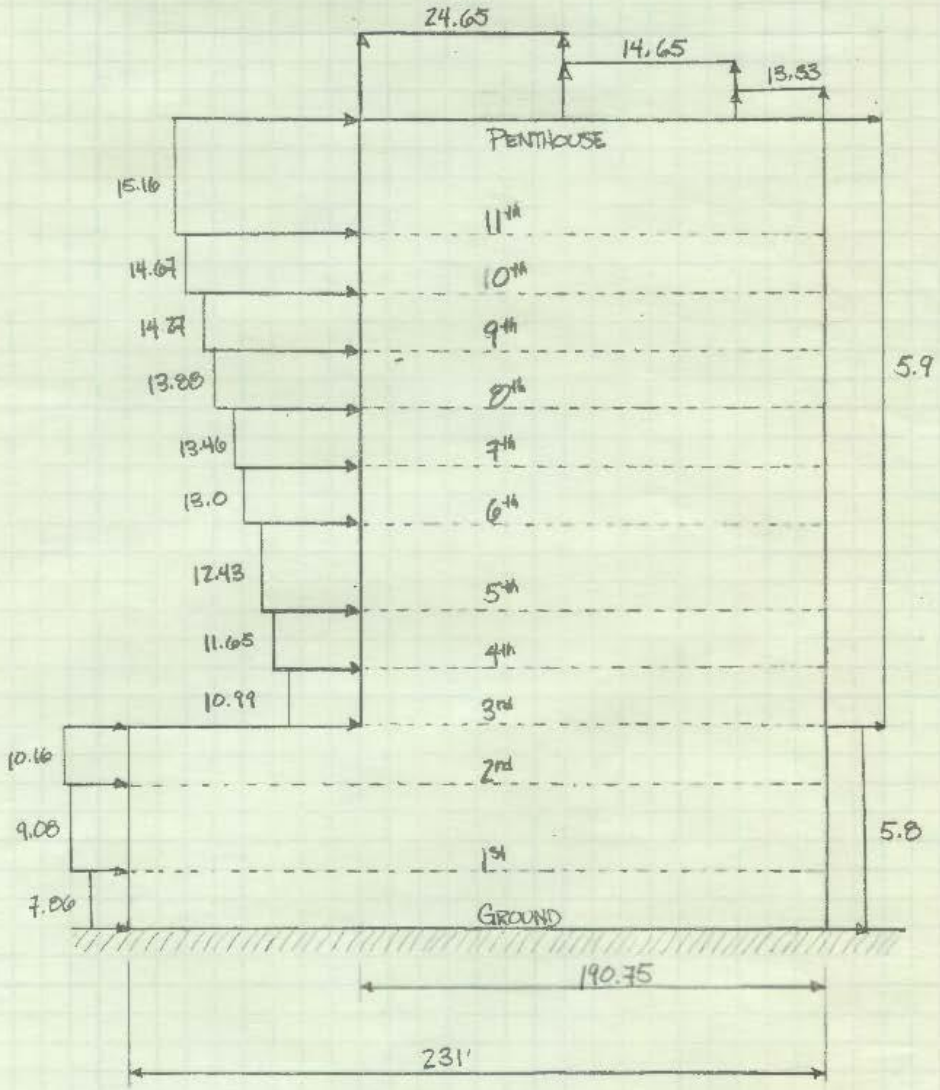
DIAGRAM OF N-S WIND PRESSURES:



*ALL WIND VALUES ARE IN PSF

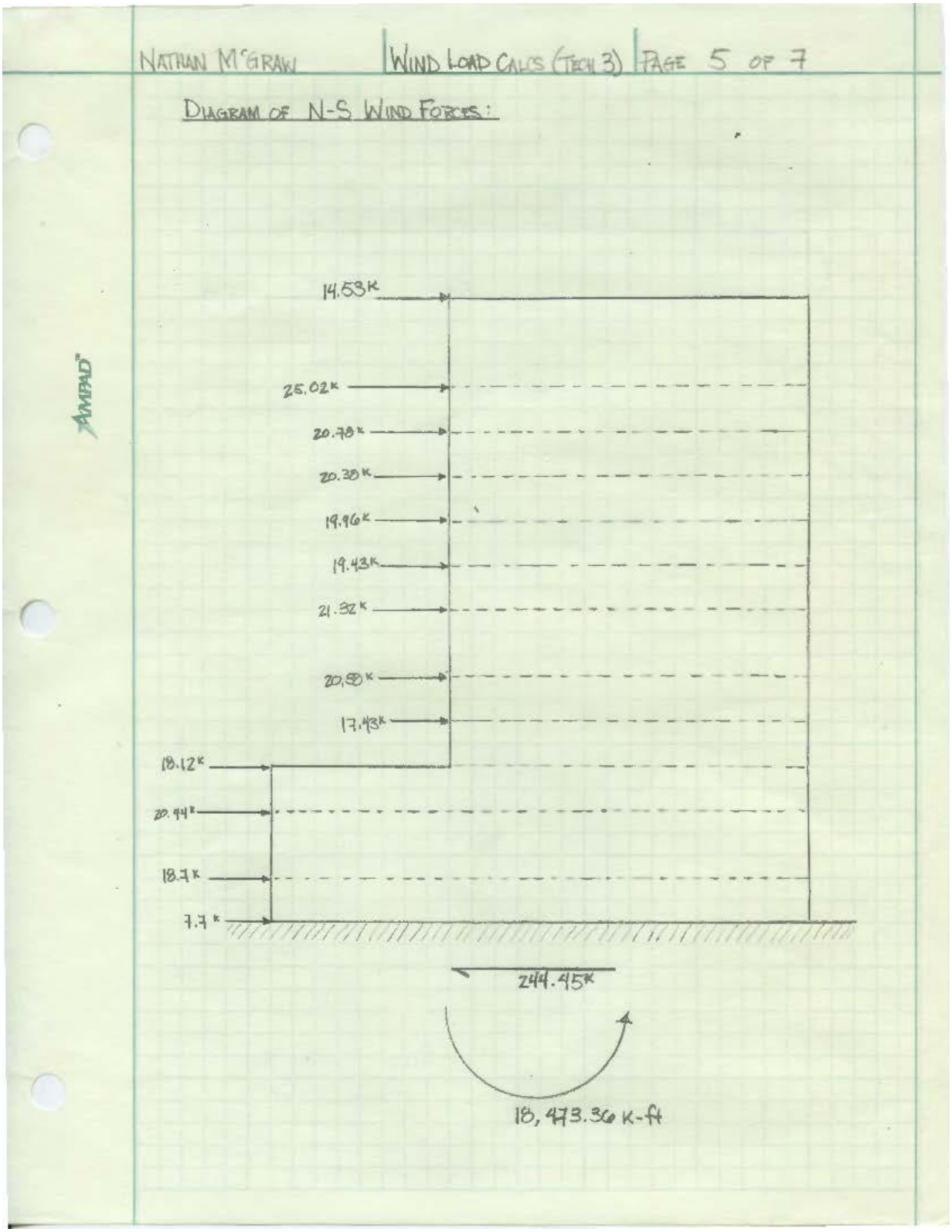

NATHAN M°GRAW
WIND LOAD CALCS (TECH 3)
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DIAGRAM OF N-S WIND FORCES:
14.53K
25.02K
20.78K
20.30K
19.96K
19.43K
21.32K
20.80K
17.43K
18.12K
20.44K
18.7K
7.7K
244.45K
18,473.36 K-ft

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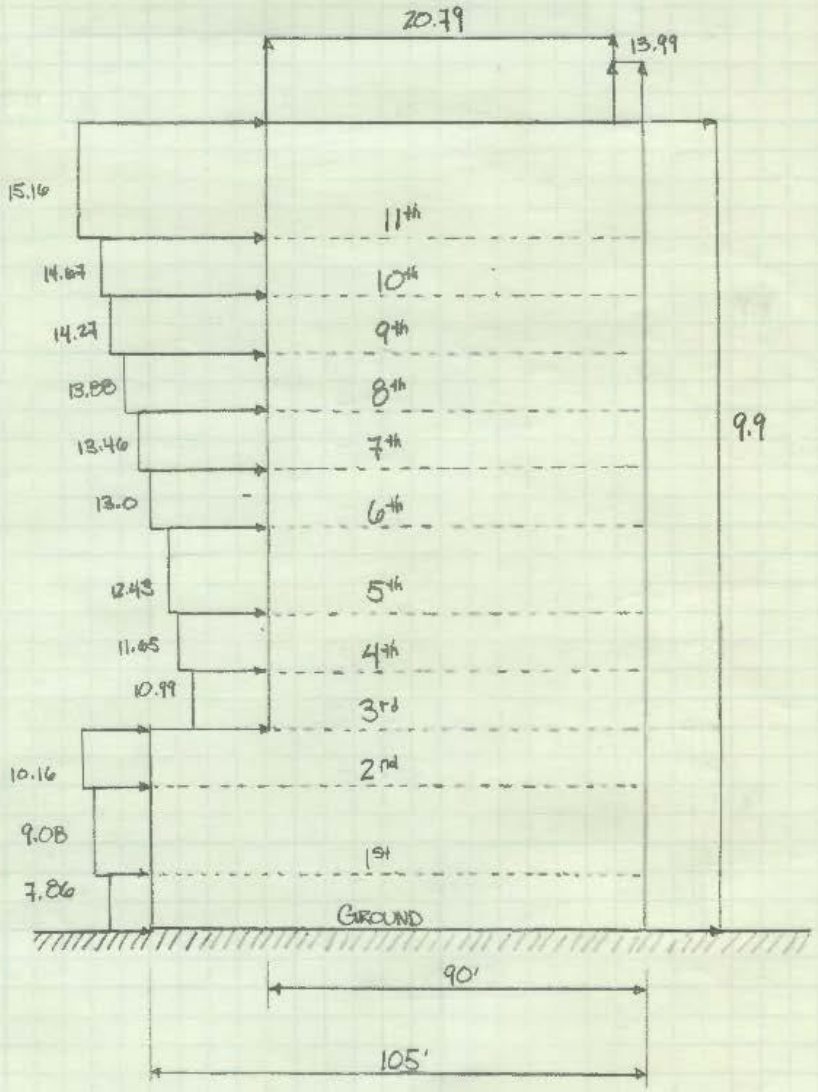
DIAGRAM OF E-W WIND PRESSURES:



* ALL WIND VALUES ARE IN PSF

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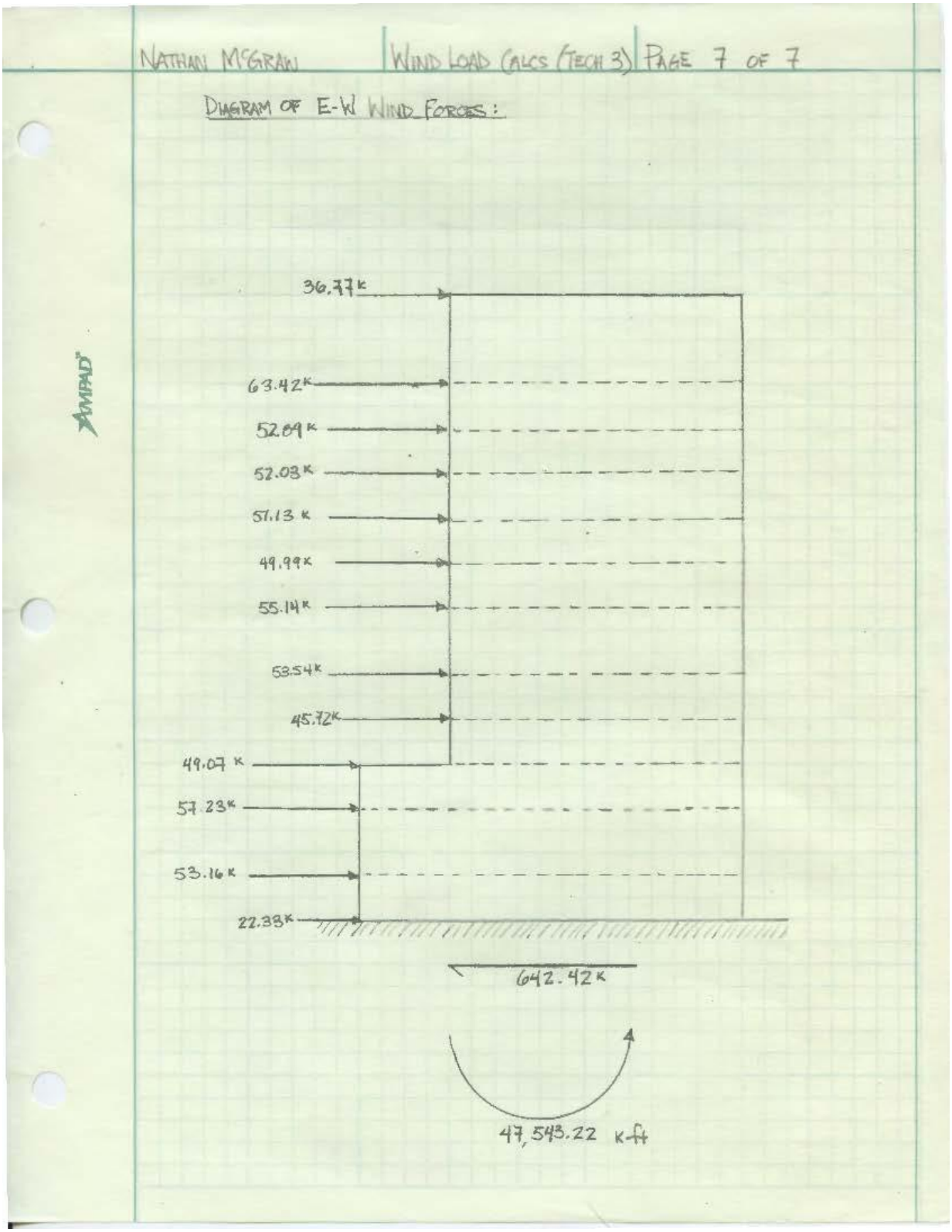
DIAGRAM OF E-W WIND FORCES:



Building Dimensions			
Height Level		N-S Wind	E-W Wind
0' - 36.17'			
	B (ft)	105	231
	L (ft)	231	105
	h (ft)	Not Used	Not Used
36.17' - 175'			
	B (ft)	90	190.75
	L (ft)	190.75	90
	h (ft)	175	175

General Wind Load Design Criteria		
Design Wind Speed	90 mph	ASCE 7-05 (Fig. 6-1C)
Directionality Factor (K_d)	0.85	ASCE 7-05 (Table 6-4)
Importance Factor (I_w)	1.15	ASCE 7-05 (Table 6-1)
Exposure Category	B	ASCE 7-05 (§ 6.5.6.3)
Topographic Factor (K_{zt})	1	ASCE 7-05 (§ 6.5.7)
Internal Pressure Coefficient (GC_{pi})	± 0.18	ASCE 7-05 (Fig. 6-5)

Velocity Pressure Coefficients (K_z) and Velocity Pressures (q_z)			
Level	Elevation (ft)	K_z	q_z (psf)
Ground	0.0	0.57	11.55
1st	10.83	0.57	11.55
2nd	24.83	0.659	13.36
3rd	36.17	0.737	14.94
4th	47.50	0.7975	16.16
5th	58.67	0.845	17.13
6th	72.93	0.902	18.28
7th	84.17	0.943	19.11
8th	95.50	0.9765	19.79
9th	106.83	1.007	20.41
10th	118.17	1.035	20.98
11th	129.5	1.064	21.57
Penthouse	144.83	1.10	22.30
Roof	175.00	1.16	23.51

External Pressure Coefficients (C_p)			
Description		**N-S Wind**	**E-W Wind**
0' - 36.17'			
	L/B	2.2	0.45
	Windward Walls	0.8	
	Leeward Walls	-0.29	-0.5
	Side Walls	-0.7	
	h/L	Not Used	Not Used
	Roof - 0 to h/2		
	Roof - h/2 to h		
	Roof - h to 2h		
	Roof - > 2h		
36.17' - 175'			
	L/B	2.12	0.472
	Windward Walls	0.8	
	Leeward Walls	-0.295	-0.5
	Side Walls	-0.7	
	h/L	0.917	1.9
	Roof - 0 to 87.5'	-1.2336	-1.04
	Roof - 87.5' to 175'	-0.7332	-0.7
	Roof - 175' to 350'	-0.6668	-0.7
	Roof - > 350'	-0.6336	-0.7

Wind Forces N-S Direction									
Floor Level	Elevation (ft)	Tributary Below		Tributary Above		Story Force (k)	Story Shear (k)	Overturning Moment (k-ft)	Factored Forces (k)
		Height (ft)	Area (ft^2)	Height (ft)	Area (ft^2)				
Ground	0.00	N/A	0.00	5.42	568.58	7.77	244.45	0.00	12.43
1st	10.83	5.42	568.58	7.00	735.00	18.70	236.68	202.56	29.93
2nd	24.83	7.00	735.00	5.67	595.35	20.44	217.98	507.49	32.70
3rd	36.17	5.67	595.35	5.67	510.00	18.12	197.54	655.24	28.99
4th	47.50	5.67	510.00	5.58	502.50	17.43	179.42	828.11	27.89
5th	58.67	5.58	502.50	7.13	641.70	20.58	161.99	1207.50	32.93
6th	72.93	7.13	641.70	5.62	505.80	21.32	141.41	1555.01	34.12
7th	84.17	5.62	505.80	5.67	509.85	19.43	120.09	1635.45	31.09
8th	95.50	5.67	509.85	5.67	509.85	19.96	100.66	1905.75	31.93
9th	106.83	5.67	509.85	5.67	510.30	20.38	80.70	2176.94	32.60
10th	118.17	5.67	510.30	5.67	509.85	20.78	60.32	2455.62	33.25
11th	129.50	5.67	509.85	7.67	689.85	25.02	39.54	3239.55	40.03
Roof	144.83	7.67	689.85	N/A	0.00	14.53	14.53	2104.13	23.25
					Total Base Shear =	**244.45**			**391.2 k**
							Total Overturning Moment =	**18,473.36 k-ft**	**29,557.38 k-ft**

Wind Forces E-W Direction									
Floor Level	Elevation (ft)	Tributary Below		Tributary Above		Story Force (k)	Story Shear (k)	Overturning Moment (k-ft)	Factored Forces (k)
		Height (ft)	Area (ft^2)	Height (ft)	Area (ft^2)				
Ground	0.00	N/A	0.00	5.42	1250.87	22.33	642.42	0.00	35.72
1st	10.83	5.42	1250.87	7.00	1617.00	53.16	620.09	575.77	85.06
2nd	24.83	7.00	1617.00	5.67	1309.77	57.23	566.93	1420.97	91.56
3rd	36.17	5.67	1309.77	5.67	1080.92	49.07	509.70	1774.84	78.51
4th	47.50	5.67	1080.92	5.58	1065.02	45.72	460.63	2172.07	73.16
5th	58.67	5.58	1065.02	7.13	1360.05	53.54	414.91	3141.15	85.66
6th	72.93	7.13	1360.05	5.62	1072.02	55.14	361.37	4021.21	88.22
7th	84.17	5.62	1072.02	5.67	1080.60	49.99	306.23	4207.29	79.98
8th	95.50	5.67	1080.60	5.67	1080.60	51.13	256.24	4883.29	81.81
9th	106.83	5.67	1080.60	5.67	1081.55	52.03	205.11	5558.62	83.25
10th	118.17	5.67	1081.55	5.67	1080.60	52.89	153.08	6249.54	84.62
11th	129.50	5.67	1080.60	7.67	1462.10	63.42	100.19	8212.81	101.47
Roof	144.83	7.67	1462.10	N/A	0.00	36.77	36.77	5325.66	58.83
					Total Base Shear =	**642.42**			**1027.87 k**
							Total Overturning Moment =	**47,543.22 k-ft**	**76,069.15 k-ft**

Proposed Structure: University of California – Davis (Sacramento) CA – Base Model

Building Dimensions:

		N-S Wind	E-W Wind
1.) 0' - 36'			
	B:	105	231
	L:	231	105
	h:	N/A	N/A
1.) 36' - 145'			
	B:	90	190.75
	L:	190.75	90
	h:	145	145

General Wind Load Design Criteria:

Desing Wind Speed:	85	(Figure 6-1C)
Directionality Factor (K_d):	0.85	(Table 6-4)
Importance Factor (I_w):	1.15	(Table 6-1)
Exposure Category:	B	(§ 6.5.6.3)
Topographic Factor (K_{zt})	1.0	(§ 6.5.7)
Intern Pressure Coefficient (GC_{pi}):	± 0.18	(Figure 6-5)

Velocity Pressure Coefficients (K_z) and Velocity Pressures (q_z):

Level	Elevation (ft)	K_z	q_z (psf)
Penthouse	145	1.10	19.9
11th	129.5	1.06	19.2
10th	118.17	1.04	18.7
9th	106.83	1.01	18.2
8th	95.5	0.98	17.7
7th	84.17	0.94	17.0
6th	72.93	0.90	16.3
5th	58.67	0.84	15.3
4th	47.5	0.80	14.4
3rd	36.17	0.74	13.3
2nd	24.83	0.66	11.9
1st	10.83	0.57	10.3
Ground	0	0.57	10.3

Gust Effect Factor: Due to Flexible Diaphragm (frequency < 1 Hz) § 6.5.8.2

g_Q:	3.4
g_v:	3.4
α:	7
z_g (ft):	1200
$\hat{a}$	0.143
$\hat{b}$	0.84
$\bar{a}$	0.25
$\bar{b}$	0.45
c	0.3
l (ft):	320
ϵ	0.333
z_{min} (ft)*:	30
max	87

n_1:	100/H =	0.690	(Average Value from C6-17)	*Used for Calculations
n_1:	75/H =	0.517	(Lower Bound from C6-18)	

g_R:	4.10	(Eqn. 6-9)
I_z:	0.255	(Eqn. 6-5)
L_z:	442.1	(Eqn. 6-7)
V_z:	71.48	(Eqn. 6-14)
N_1:	4.26	(Eqn. 6-12)
R_n:	0.0561	(Eqn. 6-11)
β:	0.01	(Assumed, Convservative for Concrete Shear Walls)

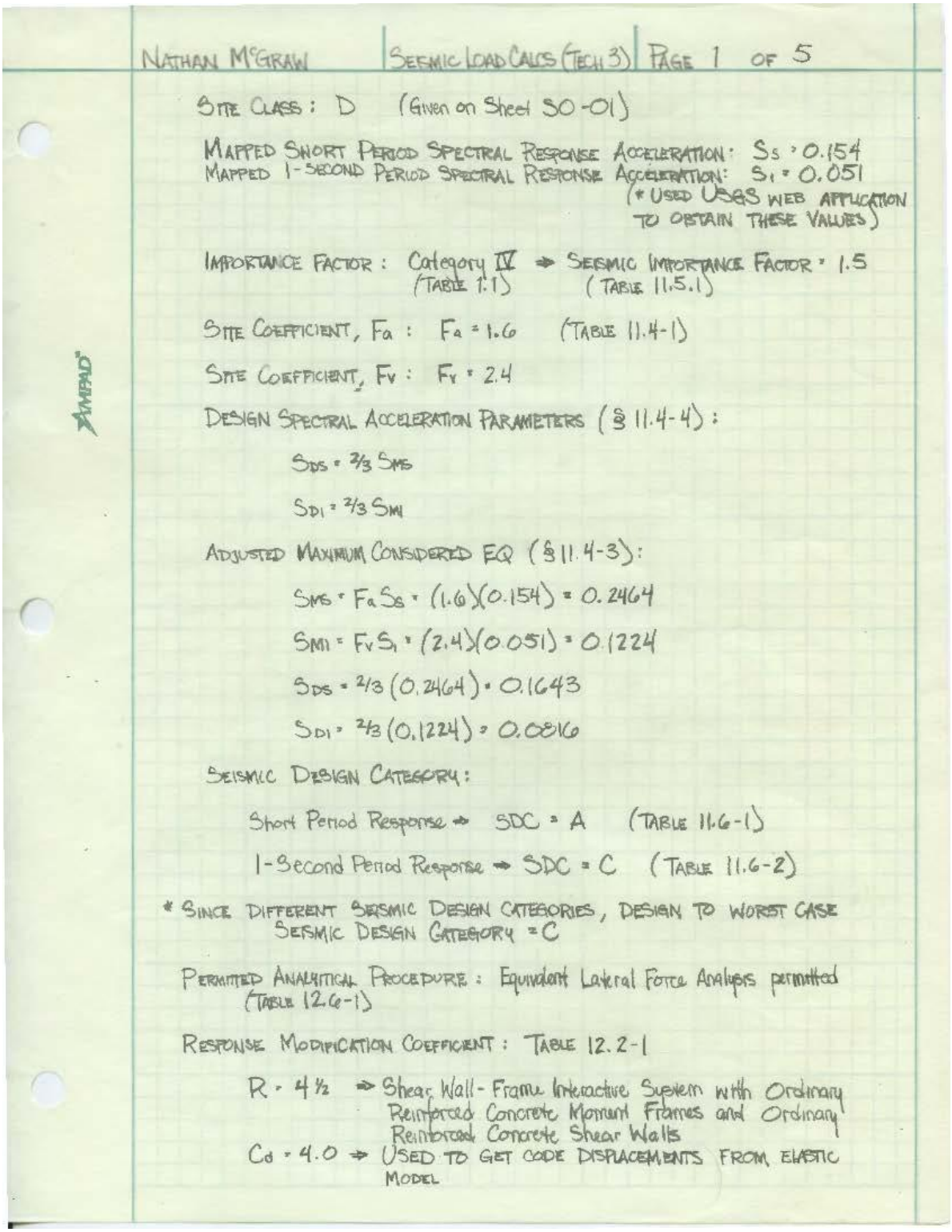
North-South		East-West	
B:	90	B:	190.75
L:	190.75	L:	90
h:	145	h:	145
η_n:	6.43	η_n:	6.43
R_h:	0.143	R_h:	0.143
η_B:	3.99	η_B:	8.47
R_B:	0.219	R_B:	0.111
η_L:	28.34	η_L:	13.37
R_L:	0.035	R_L:	0.072
R:	0.310	R:	0.224
Q:	0.838	Q:	0.809
G_f:	0.880	G_f:	0.844

External Pressure Coefficients (C_p):

		N-S Wind		E-W Wind
0' - 36'				
	L/B:	2.20		0.45
	Windward Wall:		0.8	
	Leeward Wall:	-0.29		-0.5
	Side Wall:		-0.7	
36' - 145'				
	L/B:	2.12		0.47
	Windward Wall:		0.8	
	Leeward Wall:	-0.294		-0.5
	Side Wall:		-0.7	
	h/L:	0.760		1.611
	Roof: 0 - 72.5'	-1.108		-1.04
	Roof: 72.5 to 145	-0.796		-1.04
	Roof: 145 to 290	-0.604		-0.7
	Roof: > 290'	-0.508		-0.7

Appendix C: Seismic Load Calculations

Existing Structure: Falls Church, VA



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SITE CLASS: D (Given on Sheet SO-01)

MAPPED SHORT PERIOD SPECTRAL RESPONSE ACCELERATION: $S_S = 0.154$
MAPPED 1-SECOND PERIOD SPECTRAL RESPONSE ACCELERATION: $S_1 = 0.051$
(* USED USGS WEB APPLICATION TO OBTAIN THESE VALUES)

IMPORTANCE FACTOR: Category IV (TABLE 1.1) → SEISMIC IMPORTANCE FACTOR = 1.5 (TABLE 11.5.1)

SITE COEFFICIENT, F_a: $F_a = 1.6$ (TABLE 11.4-1)

SITE COEFFICIENT, F_v: $F_v = 2.4$

DESIGN SPECTRAL ACCELERATION PARAMETERS (§ 11.4-4):

$S_{DS} = \frac{2}{3} S_{MS}$

$S_{D1} = \frac{2}{3} S_{M1}$

ADJUSTED MAXIMUM CONSIDERED EQ (§ 11.4-3):

$S_{MS} = F_a S_S = (1.6)(0.154) = 0.2464$

$S_{M1} = F_v S_1 = (2.4)(0.051) = 0.1224$

$S_{DS} = \frac{2}{3}(0.2464) = 0.1643$

$S_{D1} = \frac{2}{3}(0.1224) = 0.0816$

SEISMIC DESIGN CATEGORY:

Short Period Response → SDC = A (TABLE 11.6-1)

1-Second Period Response → SDC = C (TABLE 11.6-2)

* SINCE DIFFERENT SEISMIC DESIGN CATEGORIES, DESIGN TO WORST CASE SEISMIC DESIGN CATEGORY = C

PERMITTED ANALYTICAL PROCEDURE: Equivalent Lateral Force Analysis permitted (TABLE 12.6-1)

RESPONSE MODIFICATION COEFFICIENT: TABLE 12.2-1

R = 4½ → Shear Wall-Frame Interactive System with Ordinary Reinforced Concrete Moment Frames and Ordinary Reinforced Concrete Shear Walls

$C_d = 4.0$ → USED TO GET CODE DISPLACEMENTS FROM ELASTIC MODEL

NATHAN MCGRAW | SEISMIC LOAD CALCS (TECH 3) | PAGE 2 OF 5

APPROXIMATE FUNDAMENTAL PERIODS: §12.8.2.1 AND TABLE 12.8-2

$T_a = C_t h_n^x$ $\quad C_t = 0.02$, $x = 0.75$ "ALL OTHER STRUCTURAL SYSTEMS"

$T_a = (0.02)(145')^{0.75}$

$T_a = 0.8857$ sec. $\quad C_u = 1.7$ (TABLE 12.8-1)

SEISMIC RESPONSE COEFFICIENT: §12.8.1.1

$$C_s = \begin{cases} \dfrac{S_{DS}}{(R/I)} \\ \dfrac{S_{D1}}{T(R/I)} \quad \geq 0.01 \\ \min \dfrac{S_{D1} T_L}{T^2 (R/I)} \end{cases}$$

$T_L = 8$ sec. (FIGURE 22-15)

$T = C_u \cdot T_a$

$T = 1.7(0.8857) = 1.4207$

$$C_s = \begin{cases} \dfrac{(0.1643)}{(4.5/1.5)} = 0.0548 \\ \dfrac{(0.0816)}{(1.4207)(4.5/1.5)} = 0.019145 \\ \min \dfrac{(0.0816)(8)}{(1.4207)^2(4.5/1.5)} = 0.1078 \end{cases}$$

$\Rightarrow C_s\ 0.019145 > 0.01$ ∴OK ✓

ETABS PERIOD:

RIGID DIAPHRAGM MODEL:

$T_x = 2.943$ SEC
$T_y = 2.112$ SEC
$T_z = 1.729$ SEC

TWO-WAY SLAB SYSTEM MODELED AS SHELL ELEMENT:

$T_x = 2.0813$ SEC
$T_y = 1.5947$ SEC
$T_z = 1.4134$ SEC

* BECAUSE T_x AND T_y ARE BOTH GREATER THAN THE UPPER LIMIT ($C_u \cdot T_a$), T OF 1.4207 SEC WAS USED TO CALCULATE THE FORCES IN BOTH THE X AND Y DIRECTIONS.

NATHAN MCGRAW | SEISMIC LOAD CALCS (TECH 3) | PAGE 3 OF 5

WEIGHT CALCULATIONS:

FACADE:

5½" Concrete + ½" Thin Brick Face = (6"/12")(150 lb/ft³) = 75 psf

2" Air space ⇒ 0 psf

4" Glass Fiber Insulation with Vapor Barrier = 1½ psf x 4" = 6 psf

3⅝" Metal Studs = 1 psf

FACADE TOTAL WEIGHT = 75 + 6 + 1 = 82 psf

MAIN ROOF:

12" Concrete = (12"/12")(150 lb/ft³) = 150 psf

ROOF Membrane = 2 psf

5/8" Roof Board = 1½ psf x 5/8" = 0.9375 psf

MAIN ROOF TOTAL WEIGHT = 150 + 2 + 0.9375 = 152.9375 psf

Typical ROOF:

9½" Concrete = (9½"/12")(150 lb/ft³) = 118.75 psf

6" Rigid Insulation = 1½ psf x 6" = 9 psf

ROOF Membrane = 2 psf

TYPICAL ROOF TOTAL WEIGHT = 118.75 + 9 + 2 = 129.75 psf

VEGETATED ROOF SYSTEM:

EXTRUDED - Polystyrene Board Insulation = (1.8 lb/ft³)(6"/12") = 0.9 psf

ROOF Pavers = 25 psf

VEGATED SYSTEM = 30 psf

VEGETATED ROOF TOTAL WEIGHT = 0.9 + 25 + 30 = 55.9 psf

* EXCEL CONTAINS TOTAL BUILDING WEIGHT WITH FLOOR BY FLOOR BREAKDOWN

NATHAN MCGRAW | SEISMIC LOAD CALCS (TECH 3) | PAGE 4 OF 5

BASE SHEAR:

$V = C_s W$

W = weight of building (Calculated in spreadsheet)

$C_{s\,N\text{-}S} = C_{s\,E\text{-}W} = 0.01795$

$V = (0.019145)(39{,}026.339^{K})$

$\boxed{V = 747.16^{K}}$

(STRUCTURAL DRAWINGS = 700K → 6.74% DIFFERENCE ✓
* DIFFENCE DUE TO DIFFERENT WEIGHT CALCS AND DIFFENT S_S AND S_1 VALUES

STORY FORCES:

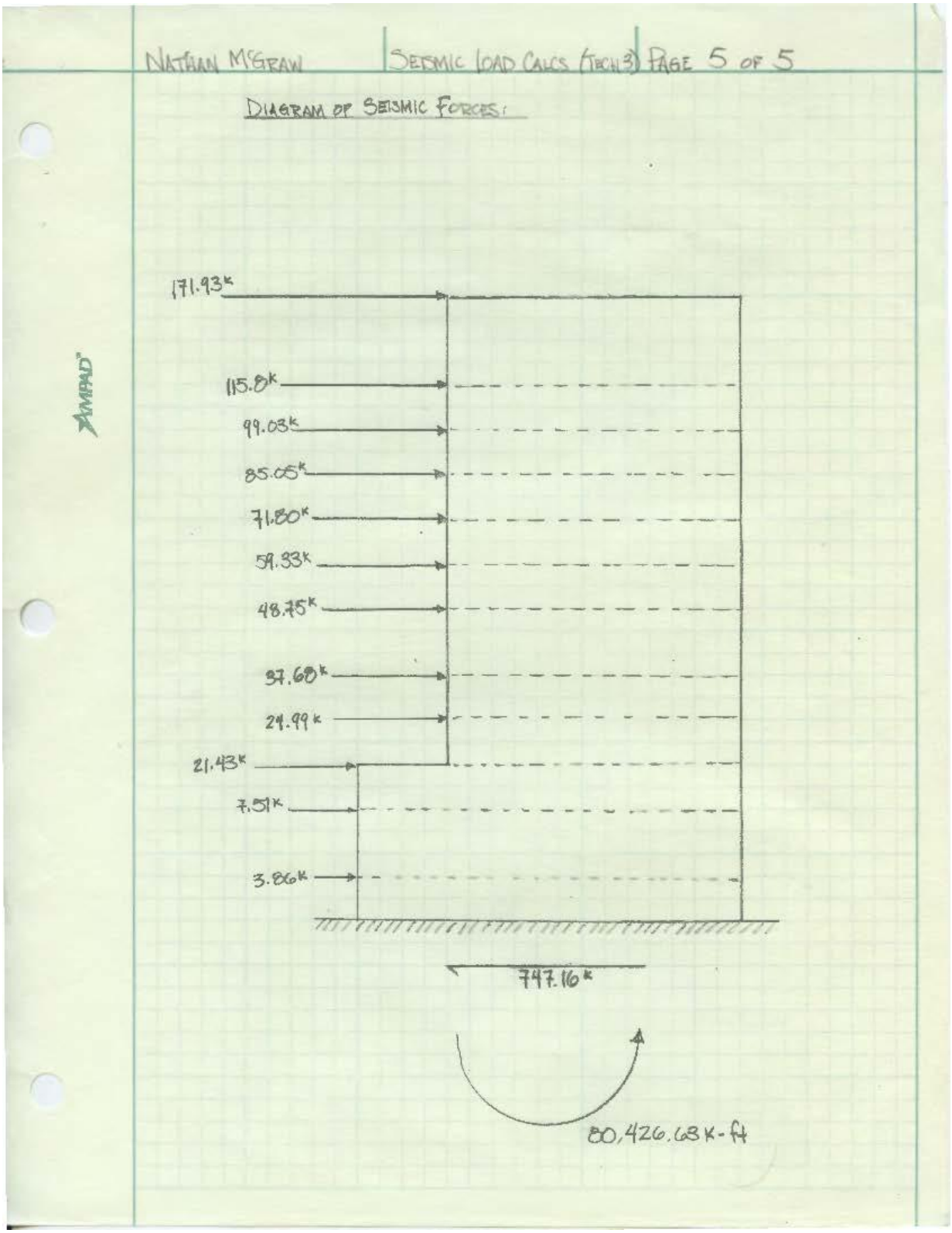
$F_x = C_{vx} V$

$C_{vx} = \frac{w_x h_x^{K}}{\sum w_i h_i^{K}}$

w = weight of each story
h = height of story above grade
$K = 1 + \frac{T - 0.5}{2}$ $(1 \leq K \leq 2)$

$K = 1 + \frac{1.4207 - 0.5}{2} = 1.5076$

* CALCULATED THE STORY FORCES AND OVERTURNING MOMENTS IN AN EXCEL SPREADSHEET


NATHAN MCGRAW
SEISMIC LOAD CALCS (TECH 3) PAGE 5 OF 5
DIAGRAM OF SEISMIC FORCES:
171.93k
115.8k
99.03k
85.05k
71.80k
59.33k
48.75k
37.60k
24.99k
21.43k
7.51k
3.86k
747.16k
80,426.68 k-ft

Proposed Structure: University of California – Davis (Sacramento) CA – Base Model

Superimposed Dead Loads	
Description	**Load**
Floors	20 psf
Standard Roof	20 psf
Main Roof	20 psf

Weight Per Level		
Level	**Area (ft^2)**	**Weight (kips)**
Ground	25513	N/A
1st	25513	3855
2nd	11649	2732
3rd	17958	3186
4th	16571	2911
5th	16571	3013
6th	16571	3013
7th	16571	2911
8th	16571	2911
9th	16571	2911
10th	16571	2911
11th	16571	2999
Penthouse/Roof	16571	3831
		37184

Slab Weights			
Level	**Slab Area (ft^2)**	**Beam Area (ft^2)**	**Weight (kips)**
Ground	10268	4904	N/A
1st	10268	4904	2276
2nd	4450	4904	1403
3rd	6501	4904	1711
4th	6501	4904	1711
5th	6501	4904	1711
6th	6501	4904	1711
7th	6501	4904	1711
8th	6501	4904	1711
9th	6501	4904	1711
10th	6501	4904	1711
11th	6501	4904	1711
Penthouse/Roof	6501	4904	1711
			20787

Superimposed Dead Load			
Level	Slab Area (ft^2)	Roof Area (ft^2)	Weight (kips)
Ground	25611	0	N/A
1st	25611	0	512
2nd	11649	0	233
3rd	16571	9040	512
4th	16571	0	331
5th	16571	0	331
6th	16571	0	331
7th	16571	0	331
8th	16571	0	331
9th	16571	0	331
10th	16571	0	331
11th	16571	0	331
Penthouse/Roof	0	16571	331
			4240

Shear Wall Weights		
Level	Volume (ft^3)	Weight (kips)
1st	2022.9	303.4
2nd	2077.6	311.6
3rd	1858.8	278.8
4th	1858.8	278.8
5th	2077.6	311.6
6th	2077.6	311.6
7th	1858.8	278.8
8th	1858.8	278.8
9th	1858.8	278.8
10th	1858.8	278.8
11th	2186.9	328.0
Penthouse/Roof	1257.5	188.6
		3427.9

Curtain Wall Weights						
Level	Tributary Height (ft)	Length (ft)	With (ft)	Total Perimeter (ft)	Area (ft^2)	Weight (kips)
1st	12.333	231	105	672	8288.0	485.3
2nd	12.667	231	105	672	8512.2	498.4
3rd	11.333	231	105	672	7615.8	445.9
4th	11.333	190.75	90	561.5	6363.5	372.6
5th	12.667	190.75	90	561.5	7112.5	416.4
6th	12.667	190.75	90	561.5	7112.5	416.4
7th	11.333	190.75	90	561.5	6363.5	372.6
8th	11.333	190.75	90	561.5	6363.5	372.6
9th	11.333	190.75	90	561.5	6363.5	372.6
10th	11.333	190.75	90	561.5	6363.5	372.6
11th	11.333	190.75	90	561.5	6363.5	372.6
Penthouse/Roof	7.667	190.75	90	561.5	4305.0	252.1
						4750.0

Column Weights									
Level	24"x24"	26"x26"	12"x18"	12"x24"	28"x28"	18"x18"	18"x24"	Volume (ft^2)	Weight (kips)
1st - Below	28	0	8	1	4	1	1	1854	278
1st - Top	28	1	8	1	3	1	1		
2nd - Below	28	1	8	1	3	1	1	1906	286
2nd - Top	28	1	8	1	3	1	1		
3rd - Below	28	1	8	1	3	1	1	1587	238
3rd - Top	27	0	6	0	2	0	0		
4th - Below	27	0	6	0	2	0	0	1449	217
4th - Top	27	0	6	0	2	0	0		
5th - Below	27	0	6	0	2	0	0	1620	243
5th - Top	27	0	6	0	2	0	0		
6th - Below	27	0	6	0	2	0	0	1620	243
6th - Top	27	0	6	0	2	0	0		
7th - Below	27	0	6	0	2	0	0	1449	217
7th - Top	27	0	6	0	2	0	0		
8th - Below	27	0	6	0	2	0	0	1449	217
8th - Top	27	0	6	0	2	0	0		
9th - Below	27	0	6	0	2	0	0	1449	217
9th - Top	27	0	6	0	2	0	0		
10th - Below	27	0	6	0	2	0	0	1449	217
10th - Top	27	0	6	0	2	0	0		
11th - Below	27	0	6	0	2	0	0	1705	256
11th - Top	27	0	6	0	2	0	0		
Penthouse/Roof Below	27	0	6	0	2	0	0	980	147
									2778

Sacramento CA
Latitude: 38.55
Longitude: -121.74

Site Class:	D	
S_S =	0.900	*USGS Web Application (Confirmed with Figure 22-1 of ASCE 7-05)
S_1 =	0.325	*USGS Web Application (Confirmed with Figure 22-2 of ASCE 7-05)
T_L =	8	sec. (Confirmed with Figure 22-15 of ASCE 7-05)

Occupancy Category =	IV	(Table 1.1)
Importance Factor =	1.5	(Table 11.5.1)

Site Coefficient, F_a =	1.0	(Table 11.4-1)
Site Coefficient, F_v =	1.5	(Table 11.4-2)

S_{MS} =	0.90	$F_a.S_s$	(11.4-1)
S_{M1} =	0.49	$F_v.S_1$	(11.4-2)
S_{DS} =	0.600	$(2/3)S_{MS}$	(11.4-3)
S_{D1} =	0.325	$(2/3)S_{M1}$	(11.4-4)

Short Period SDC =	D	(Table 11.6-1)
1.0-s Period SDC =	D	(Table 11.6-2)

Permitted Analytical Procedure: Modal Response Spectrum Analysis (Table 12.6-1)
Seismic Response History Procedure (Table 12.6-1)

Response Modification Coefficient =	6.5	(Table 12.2-1)
Amplification Factor =	5.0	(Table 12.2-1)

Approximate Fundamental Period:

$T_a = C_t h_n^{\ x}$

C_t =	0.02	(Table 12.8-2)
x =	0.75	(Table 12.8-2)
h_n =	145	ft.
T_a =	0.8357	sec.
C_u =	1.4	(Table 12.8-1)
$C_u T_a$ =	1.17	sec. (Upper Limit on Calculated Period)

Seismic Response Coefficient:

$$C_s = \begin{cases} \dfrac{S_{DS}}{(R/I)} = \dfrac{0.6}{(4.5/1.5)} = 0.138 & \text{(Eqn. 12.8-2)} \\ \dfrac{S_{D1}}{T(R/I)} = \dfrac{0.325}{(1.17)(4.5/1.5)} = 0.064 \quad \geq 0.01 & \text{(Eqn. 12.8-3)} \\ \dfrac{S_{D1}T_L}{T^2(R/I)} = \dfrac{(0.325)(8)}{(1.17)^2(4.5/1.5)} = 0.438 & \text{(Eqn. 12.8-4)} \end{cases}_{min}$$

For $S_1 \geq 0.6g$:

Apply: No

$$C_s \geq \frac{0.5S_{DS}}{(R/I)} = \frac{1.333}{(4.5/1.5)} = 0.069 \quad \text{(Eqn. 12.8-6)}$$

$C_s =$ 0.064

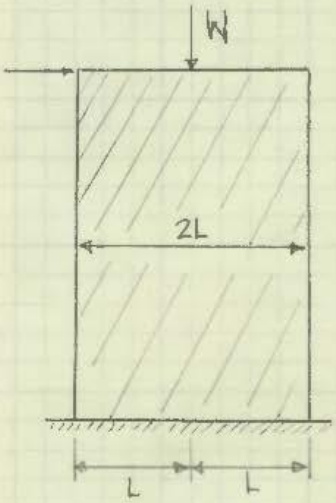
Base Shear: $V = C_sW$

$W =$ 37,184 kips

$V = C_sW =$ 2,384 kips

NATHAN M'GRAW | OVERTURNING MOMENT | FINAL REPORT

CONTROLLING BASE OVERTURNING MOMENT:



$M_{RESISTING} = \frac{1}{2}\left|\begin{matrix}B\\L\end{matrix}\right|_{MIN} \times W = \frac{1}{2}\left|\begin{matrix}90'\\190.75'\end{matrix}\right|_{MIN} = 45' \times W$

CONTROLLING LOAD COMBINATION: $(0.9 - 0.2S_{DS})D + \rho Q_E + 1.6H$

§12.4.2.3 (ASCE 7-05)

$M_{RESISTING} = (0.9 - 0.2S_{DS})D$

$M_{OVERTURNING} = \rho Q_E$

$M_{RESISTING} = (0.9 - 0.2(0.6))(37{,}184 \text{ KIPS})(45') = (45)(0.78)(37184)$

$M_{RESISTING} = 1305158'^K = 1{,}305{,}158'^K$

$M_{OVERTURNING} = (1.3)(214{,}867'^K) = 279{,}327'^K$

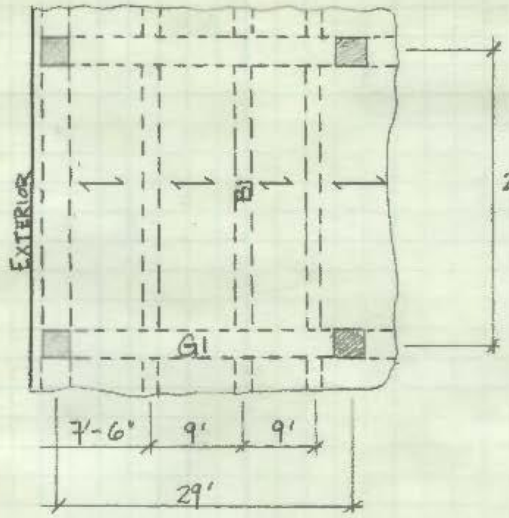
$\frac{2}{3}M_R > M_O$

$\frac{2}{3}(1305158) > 279{,}327$

$870{,}105'^K > 279{,}327'^K \quad \therefore OK\checkmark$

Appendix D: Gravity Redesign Calculations

NATHAN M^CGRAW — GRAVITY REDESIGN - FINAL



COLUMN SIZES = 24" x 24"

f'_c = 5000 psi

F_y = 60 ksi

* IGNORED SLIGHT OVERHANG

MINIMUM SLAB THICKNESS: PER TABLE 9.5(a) ACI318-08

EXTERIOR BAY = $\frac{l}{24} = \frac{7.5'(12")}{24} = 3.75"$

INTERIOR BAY = $\frac{l}{28} = \frac{9'(12")}{28} = 3.86"$

∴ USE A SLAB THICKNESS t = 5.0" (FOR TWO-HOUR FIRE RATING)

W_D = (5"/12")(150 lb/ft³) = 62.5 PSF + 20 PSF SUPERIMPOSED = 82.5 PSF
W_L = 60 PSF + 20 PSF PARTITION = 80 PSF

$W_U = 1.2(82.5) + 1.6(80) = 227$ PSF

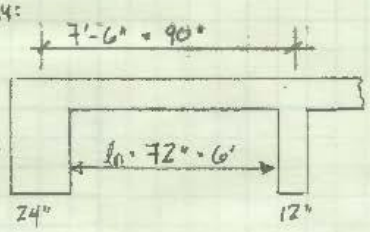
SLAB DESIGN:

ASSUME TENSION-CONTROLLED SECTION → $\phi = 0.9$

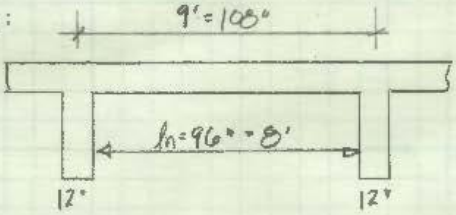
W_L = 80 PSF ≤ 3(82.5) = 247.5 PSF ∴ CAN USE ACI MOMENT COEFFICIENTS

BEAM WIDTH = 12"

EXTERIOR BAY:



INTERIOR BAY:



$l_{n\,AVG} = \frac{72"+96"}{(2)(12")} = 7'-0"$

FIRST INTERIOR SUPPORT:

$$M_u = \frac{-w_u l_n^2}{10} = -\frac{(227)(7')^2}{10}(1'\text{ WIDTH}) = 1112.3\ \text{lb-ft/width} = 1.1123\ \text{K-ft/ft}$$

SECOND INTERIOR SUPPORT:

$$M_u = \frac{-w_u l_n^2}{11} = -\frac{(227)(8')^2}{11}(1') = 1320.7\ \text{lb-ft/width} = 1.321\ \text{K-ft/ft}$$

MAXIMUM NEGATIVE MOMENT (DESIGN) = $M_u = 1.321$ K-ft/ft

REINFORCEMENT (& ASSUME $jd = 0.95d$) $d = h - c_{cover} - d_b/2 = 5 - 3/4 - \#5/2 = 4"$

$$A_s \geq \frac{M_u}{\phi f_y (d - a/2)} \cong \frac{M_u}{\phi f_y (jd)} = \frac{(1.321)(12")}{0.9(60)(0.95 \times 4)} = 0.07725\ \text{IN}^2/\text{FT}$$

$$a = \frac{A_s f_y}{0.85 f'_c b} = \frac{(0.07725)(60)}{0.85(5)(12")} = 0.0909" \rightarrow \phi = 0.9$$

$$A_s \geq \frac{(1.321)(12")}{(0.9)(60)(4 - 0.0909/2)} = 0.0742\ \text{IN}^2/\text{FT}$$

$$\rho = \frac{A_s/f_t}{bd} = \frac{0.0742}{12" \times 4"} = 0.00155$$

SHEAR CHECK:

SHEAR AT EXTERIOR SUPPORT FACE OF THE FIRST INTERIOR SUPPORT

$$V_u = \frac{1.15 w_u l_n}{2} = \frac{1.15(227)(6')}{2} = 783.15 \text{ lb/ft WIDTH OF SLAB}$$

$$\phi V_c = 0.75(2\lambda\sqrt{f'_c}\, b w d) = 0.75(2)(1.0)\sqrt{5000}(12")(4") = 5091 \text{ lb/ft WIDTH}$$

$\phi V_c > V_u \rightarrow \therefore$ OK ✓

DESIGN OF REINFORCEMENT:

	EXT. SUPPORT	EXT. MIDSPAN	1ST INT. SUPPORT	INT. MIDSPAN	2ND INT. SUPPORT
1. l_n (ft)	6	6	7	8	8
2. $w_u l_n^2$ (K-ft)	8.172	8.172	11.123	14.528	14.528
3. M COEFFICIENT	-1/24	1/14	-1/10	1/16	-1/11
4. M_u (K-ft/ft)	0.3405	0.5837	1.1123	0.908	1.3207
5. $A_{S\,REQ}$ (in^2/ft)	0.0227	0.0389	0.0742	0.0606	0.0881
6. $A_{S\,MIN}$ (in^2/ft)	0.108	0.108	0.108	0.108	0.108
7. BARS	No. 4 @ 12" →				
8. FINAL A_S (in^2/ft)	0.2 →				

STEP 5 FACTOR = $\frac{0.0742}{1.1123} = 0.0667$

$A_{S\,MIN} = 0.0018(12")(5") = 0.108$

TRANSVERSE DIRECTION:

$A_{MIN\,S.T} = 0.0018(12")(5") = 0.108 \rightarrow$ USE #4's

MAXIMUM SPACING $\leq 5h = 5(5) = 25"$
$\leq 18"$ $\therefore$ OK ✓

SPACING:

$$S = 15\left(\frac{40000}{f_s}\right) - 2.5C_c \leq 12\left(\frac{40000}{f_s}\right) \qquad f_s = 2/3 f_y = 40000$$

$$S = 15\left(\frac{40000}{40000}\right) - 2.5(0.75) \leq 12\left(\frac{40000}{40000}\right)$$

$S = 13.125 \leq 12$ $\therefore$ USE 12" SPACING

SLAB DETAILS:

5" SLAB
No. 4 BARS AT 12" FOR TOP/BOTTOM
No. 4 BARS AT 18" FOR TRANSVERSE DIRECTION

BEAM:

$b = 12"$

$h = 24"$ (FOR CONSTRUCTION PURPOSES)

$h \approx l/12 - l/18$

$h \approx \frac{(29')(12")}{12} = 29" - \frac{(29')(12")}{18} = 19.3"$ $\therefore$ 24" OK✓

$W_{BEAM} = \frac{(24" - 5")(12")(150\ lb/ft^3)}{144} = 237.5\ lb/ft = 0.2375\ k/ft$

$W_{SLAB+SI} = (62.5 + 20)(9') = 742.5\ lb/ft = 0.742\ k/ft$

$LL_r = 0.25 + \frac{15}{\sqrt{(29')(9')(2)}} = 0.907$

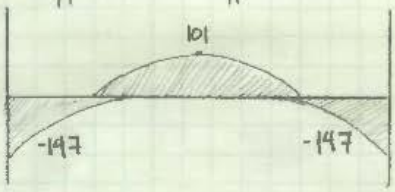
$= 522 > 400$ $\therefore$ OK✓

$W_L = (0.907)(80\ psf)(9') = 653.04\ lb/ft = 0.653\ k/ft$

$W_u = 1.2(0.2375 + 0.742) + 1.6(0.653) = 2.22\ k/ft$

$M_u^+ = \frac{wl^2}{16} = \frac{(2.22)(29' - 2')^2}{16} = 101'k$

$M_u^- = \frac{-wl^2}{11} = -\frac{(2.22)(29' - 2')^2}{11} = -147'k$



AT MIDSPAN: $M_u = 101'k$

$A_s = \frac{M_u}{4d} = \frac{101}{4(21")} = 1.20\ in^2$

TRY (3) # 6's : $A_s = (3)(0.44) = 1.32\ in^2$

$\rho = 0.125\% \rightarrow \rho = \frac{1.32}{(12)(21)} = 0.00524$ $\therefore$ OK✓

$f'_c = 4000\ psi$ $\therefore$ OK✓

$d = 24" - 1.5" - \frac{1}{2}" - 0.75/2 = 21.625"$

4 STIRRUP ← 1.5" ; 0.75/2 → ½ db

b_{eff} = | 1/4 SPAN LENGTH = 1/4 (29')(12") = 87" ← CONTROLS
MIN | $b_w + 16h_f$ = 12" + 16(5") = 92"
MIN | $b_w + 2(\frac{1}{2}$ CLR DISTANCE$)$ = 12' + 2(½(9' - 1'))(12") = 108"

$M_{u\text{-}TBM} = \phi\, 0.85 f'_c\, b_{eff}\, h_f\, (d - h_f/2) = \frac{(0.9)(0.85)(5)(87)(5)(21.6 - 5/2)}{12}$

$M_{u\text{-}TBM}$ = 2651.8 'K > M_u ⇒ TREAT AS RECTANGULAR BEAM

$a = \frac{A_s f_y}{0.85 f'_c b} = \frac{(1.32)(60)}{0.85(5)(12)} = 1.55"$

$c = \frac{a}{\beta_1} = \frac{1.55}{0.8} = 1.9375$

$\varepsilon_s = \frac{(d-c)\varepsilon}{c} = \frac{(21.6 - 1.9375)(0.003)}{1.9375} = 0.0305 > 0.005 \therefore \phi = 0.9$

$\phi M_n = \frac{(0.9)(1.32)(60)(21.6 - 1.55/2)}{12} = 124\text{'K} > 101\text{'K} \therefore$ OK✓

$A_{s\,MIN} = \frac{3\sqrt{f'_c}}{f_y} b d = \frac{3\sqrt{5000}}{60000}(12)(21.6) = 0.916\ in^2 < A_s$ PROVIDED $\therefore$ OK✓

MAX | $\frac{200}{f_y} b d = \frac{200(12)(21.6)}{60000} = 0.86\ in^2$

SPACING : MEETS ACI 318-08 REQUIREMENTS

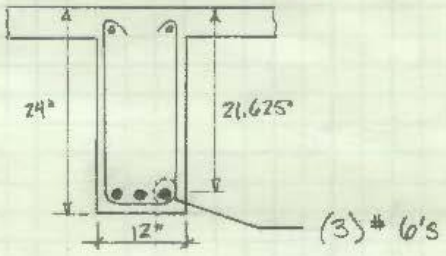
VERTICAL SHEAR : #4 STIRRUPS @ 12" o.c.

$V_u = \frac{w_u l_n}{2} = \frac{2.22(29' - 2')}{2} = 29.97^K$

$\phi V_n = \phi(V_c + V_s) = 0.75\left[2\sqrt{5000}(12")(21.6) + (2)(0.2)(60000)(21.6/12)\right]$

$\phi V_n = 59.9^K > 29.97^K \therefore$ OK✓

BEAM DESIGN AT MIDSPAN:



AT SUPPORTS: $M_u = -147'^K$

$A_s = \frac{M_u}{4d} = \frac{147}{4(21.5)} = 1.71\ in^2$

TRY (4)#6's → $A_s = (4)(0.44) = 1.76$

$\rho = \frac{1.76}{(12)(21)} = 0.00698 > 0.0025$ ∴ OK✓

* TREAT AS RECTANGULAR BEAM

$a = \frac{(1.76)(60)}{0.85(5)(12)} = 2.07"$

$c = \frac{2.07}{0.8} = 2.5875$

$d = 24" - 1.5" - \frac{1}{2}" - 0.75/2 = 21.625"$

$\varepsilon_s = \frac{(21.6 - 2.5875)}{2.5875}(0.003) = 0.022 > 0.005$ ∴ $\phi = 0.9$

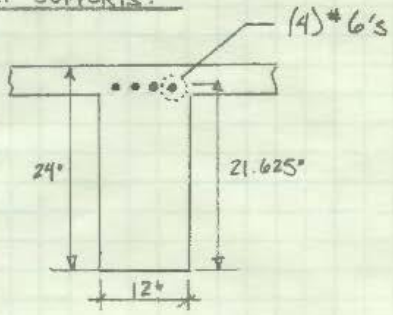
$\phi M_n = \frac{0.9(1.71)(60)(21.625 - 2.07/2)}{12} = 158'^K > 147'^K$ ∴ OK✓

$A_{s\,MIN} = 0.916\ in^2 < A_{s\,PROV.}$ ∴ OK✓

SHEAR → OK✓ BY INSPECTION

SPACING MEETS ACI 318-08 REQUIREMENTS

BEAM DESIGN AT SUPPORTS:



Beam Deflection Check:

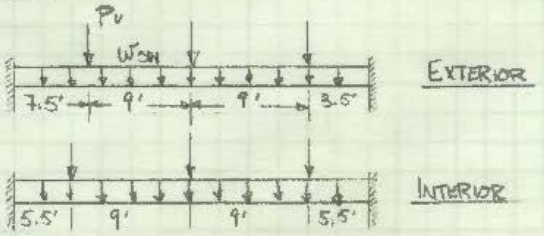
$$\Delta_{LL} = \frac{5(653.04\ plf)(29')^4(1728)}{384(57000\sqrt{5000})(1/12(12)(24)^3)} = 0.187"$$

$\Delta_{LL\ Allowable} = \frac{29' \times 12"}{480} = 0.725" > 0.187"$ ∴ OK✓

$$\Delta_{TL} = \frac{5(0.2375+0.742+0.653)(1000)(29')^4(1728)}{384(57000\sqrt{5000})(1/12(12)(24)^3)} = 0.466"$$

$\Delta_{TL\ Allowable} = \frac{29' \times 12"}{240} = 1.45" > 0.466"$ ∴ OK✓

Girder Design:



$$LL_r = 0.25 + \frac{15}{\sqrt{(29' \times 29')(2)}} = 0.616$$

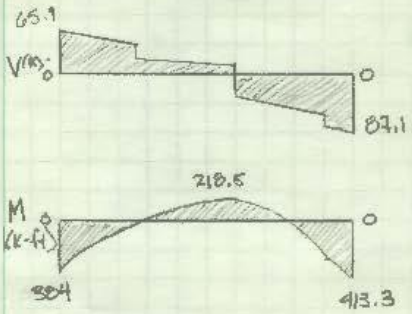
> 400 ft² ∴ OK✓

$W_u = 1.2(82.5) + 1.6(0.616)(80) = 177.8\ plf = 0.1778\ klf$

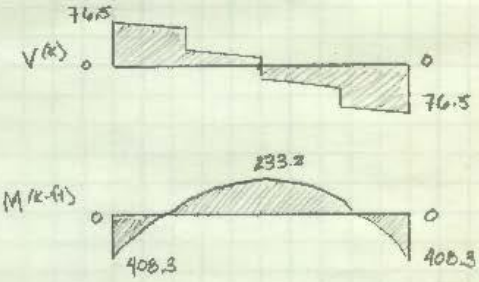
$P_u = 0.1778(9')(29') = 46.4^k$ (Conservative)

$W_{self\text{-}weight} = \frac{(24" - 5")(24")(150\ lb/ft^3)}{144} = 475\ lb/ft = 0.475\ klf$

Exterior (Risa Output)



Interior (Risa)



$V_{MAX} = 87.1^K$

$M^+_{MAX} = 238.2'^K$ (AT MIDSPAN)

$M^-_{MAX} = 413.3'^K$

AT MIDSPAN: $M_u = 238.2'^K$

$A_s = \frac{M_u}{4d} = \frac{238.2}{4(21")} = 2.78\ in^2$

TRY $(4)\#8's \Rightarrow A_s = (4)(0.79) = 3.16\ in^2$

$d = 24" - 1.5" - \frac{1}{2}" - 1\frac{1}{2}" = 21.5"$

$\rho = \frac{3.16}{(24)(21.5)} = 0.00612 > 0.00125 \therefore$ OK✓

b_{eff} - MIN:
- $\frac{1}{4}(29')(12") = 87" \Rightarrow$ CONTROLS
- $24 + 16(5") = 104"$
- $24 + 2(\frac{1}{2}(29' - 2'))(12") = 348"$

$M_{u\text{-}TBM} = \frac{0.9[0.85(5)(87")(5")(21.5 - 5\frac{1}{2})]}{12} = 2634'^K > M_u$

$a = \frac{(3.16)(60)}{0.85(5)(24)} = 1.86"$

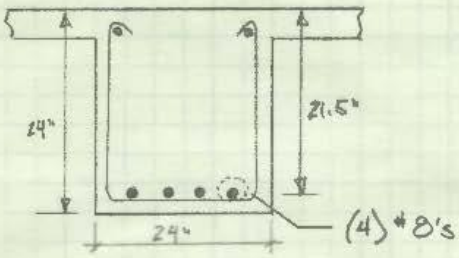
$c = \frac{1.86}{0.8} = 2.325$

$\varepsilon_s = \frac{(21.5 - 2.325)(0.003)}{2.325} = 0.0247 > 0.005 \quad \therefore \phi = 0.9$

$\phi M_n = \frac{0.9(2.78)(60)(21.5 - 1.86/2)}{12} = 257.3'^K > 233.2'^K \therefore$ OK✓

$A_{s\ MIN}$:
- MIN: $\frac{3\sqrt{5000}(24)(21.5)}{60000} = 1.82\ in^2 \Rightarrow$ CONTROLS
- MAX: $\frac{200(24)(21.5)}{60000} = 1.72\ in^2$

GIRDER DESIGN AT MIDSPAN:



AT SUPPORTS:

$M_u = 413.3'^K$

$A_s = \frac{M_u}{4d} = \frac{413.3}{4(21)} = 4.9\ in^2$

TRY (5) #9's $\Rightarrow A_s = (5)(1.0) = 5\ in^2$

$d = 24 - 1.5 - \frac{1}{2} - 1.128/2 = 21.436"$

$\rho = \frac{5}{24(21.436)} = 0.0097 < 0.025 \therefore$ OK✓

*TREAT AS RECTANGULAR BEAM

$a = \frac{5(60)}{0.85(5)(24)} = 2.94$

$c = \frac{2.94}{0.8} = 3.675$

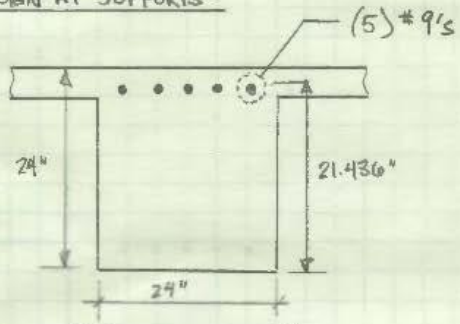
$\varepsilon_s = \frac{(21.436 - 3.675)(0.003)}{3.675} = 0.145 > 0.005 \quad \therefore \phi = 0.9$

$\phi M_n = \frac{0.9(5\ in^2)(60)(21.436 - 2.94/2)}{12} = 449.2'^K > 413.3'^K \therefore$ OK✓

$A_{s\,MIN} = 1.82\ in^2 < 5\ in^2 \therefore$ OK✓

SPACING MEETS ACI 318-08

GIRDER DESIGN AT SUPPORTS:



VERTICAL SHEAR: (#4 STIRRUPS @ 12")

$V_u = 87.1^k$

$\phi V_n = 0.75\left[2\sqrt{5000}(24")(21.436) + 2(0.2)(60000)\left(\frac{21.436}{12}\right)\right]$

$\phi V_n = 86.7^k < V_u \therefore$ NG!

TRY #4's @ 10" $\Rightarrow A_s = 0.24\ in^2$

$\phi V_n = 0.75\left[2\sqrt{5000}(24)(21.436) + 2(0.24)(60000)\left(\frac{21.436}{12}\right)\right]$

$\phi V_n = 93.2^k > 87.1^k \therefore$ OK✓

DEFLECTION: ASSUME SIMPLY SUPPORTED

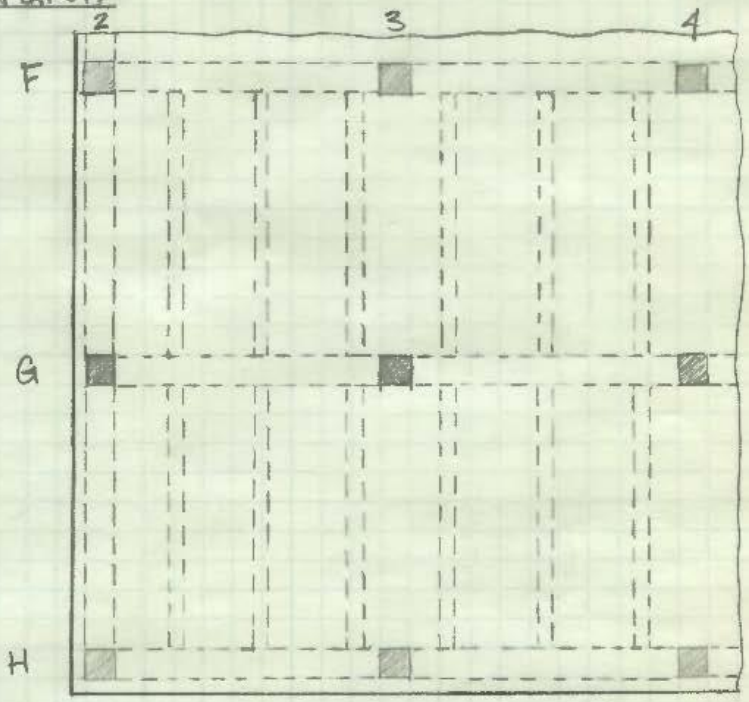
Δ_{LL} ALLOWABLE = 0.725"
Δ_{TL} ALLOWABLE = 1.45"

$\Delta_{LL} = 0.2869"$ (OBTAINED FROM RAM CONCEPT) $\therefore$ OK✓

$\Delta_{TL} = 0.702"$ (OBTAINED FROM RAM CONCEPT) $\therefore$ OK✓

NATHAN MCGRAW — COLUMN LOAD CALCULATIONS

FLOOR PLAN LAYOUT:



BAY SIZES = 29' x 29'
COLUMN SIZES = 24" x 24"
GIRDERS = 24" x 24"
BEAMS = 12" x 24"
LIVE LOAD = 80 PSF
ROOF LIVE LOAD = 100 PSF (UNREDUCIBLE)

SUPERIMPOSED DL = 20 PSF
LIVE LOAD MECH. FLOOR = 150 PSF (U)

TRIBUTARY AREA = (29')(29') = 841 FT²
INFLUENCE AREA = (4)(29')(29') = 3364 FT² > 400 FT² ∴ CAN REDUCE LOADS

DL SLAB = (5"/12")(150 PCF) = 62.5 PSF
DL BEAMS = $\frac{(24-5")}{144}$(12")(150 PCF) = 237.5 PLF
DL GIRDER = $\frac{(24-5)}{144}$(24)(150 PCF) = 475 PLF

COLUMN LOADS: (G3)

ROOF:

$$P_D = \frac{(841)(62.5+20)}{1000} + \frac{3(27')(237.5)}{1000} + \frac{(27')(475)}{1000} = 101.4^K$$

$$P_L = \frac{(841)(100)}{1000} = 84.1^K$$

11th FLOOR:

$$P_D = 101.4^K + \left[\frac{(24")(24")(150)(15.333')}{144}\right]/1000 = 110.6^K$$

$$LL_r = 0.25 + \frac{15}{\sqrt{3364}} = 0.509 \Rightarrow P_L = \frac{(841)(80)(0.509)}{1000} = 34.2^K$$

10th FLOOR:

$$P_D = 101.4^K + \left[\frac{(24)(24)(150)(11.333)}{144}\right]/1000 = 108.2^K$$

$$LL_r = 0.25 + \frac{15}{\sqrt{2 \times 3364}} = 0.433 \Rightarrow P_L = \frac{(841)(80)(0.453)}{1000} = 29.1^K$$

9th FLOOR:

$$P_D = 108.2^K$$

$$LL_r = 0.25 + \frac{15}{\sqrt{3 \times 3364}} = 0.399 < 0.4 \Rightarrow P_L = \frac{(841)(80)(0.4)}{1000} = 26.9^K$$

8th FLOOR:

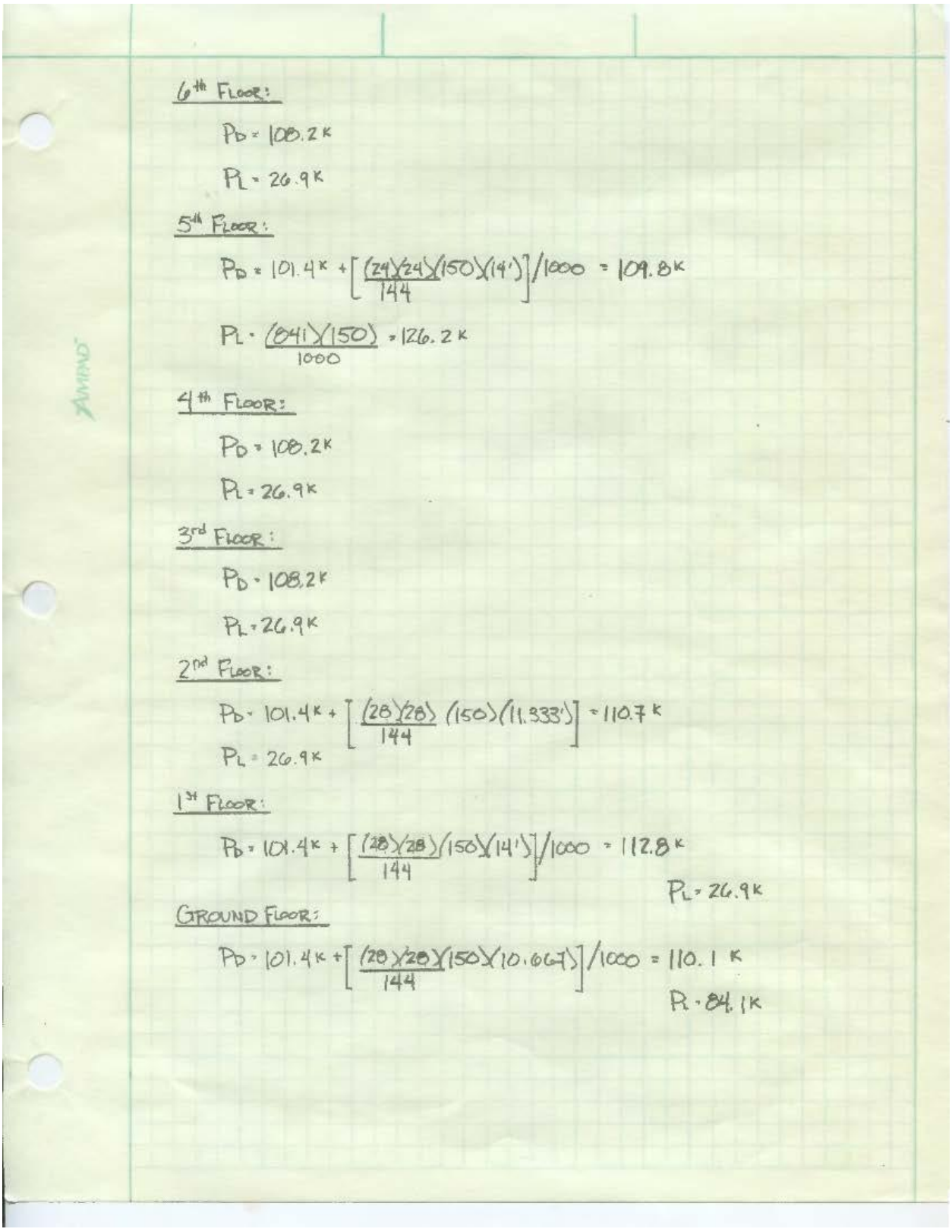
$$P_D = 108.2^K$$

$$P_L = 26.9^K$$

7th FLOOR:

$$P_D = 108.2^K$$

$$P_L = 26.9^K$$



6th Floor:

$P_D = 108.2^K$

$P_L = 26.9^K$

5th Floor:

$P_D = 101.4^K + \left[\frac{(24)(24)(150)(14')}{144}\right]/1000 = 109.8^K$

$P_L = \frac{(641)(150)}{1000} = 126.2^K$

4th Floor:

$P_D = 108.2^K$

$P_L = 26.9^K$

3rd Floor:

$P_D = 108.2^K$

$P_L = 26.9^K$

2nd Floor:

$P_D = 101.4^K + \left[\frac{(28)(28)}{144}(150)(11.333')\right] = 110.7^K$

$P_L = 26.9^K$

1st Floor:

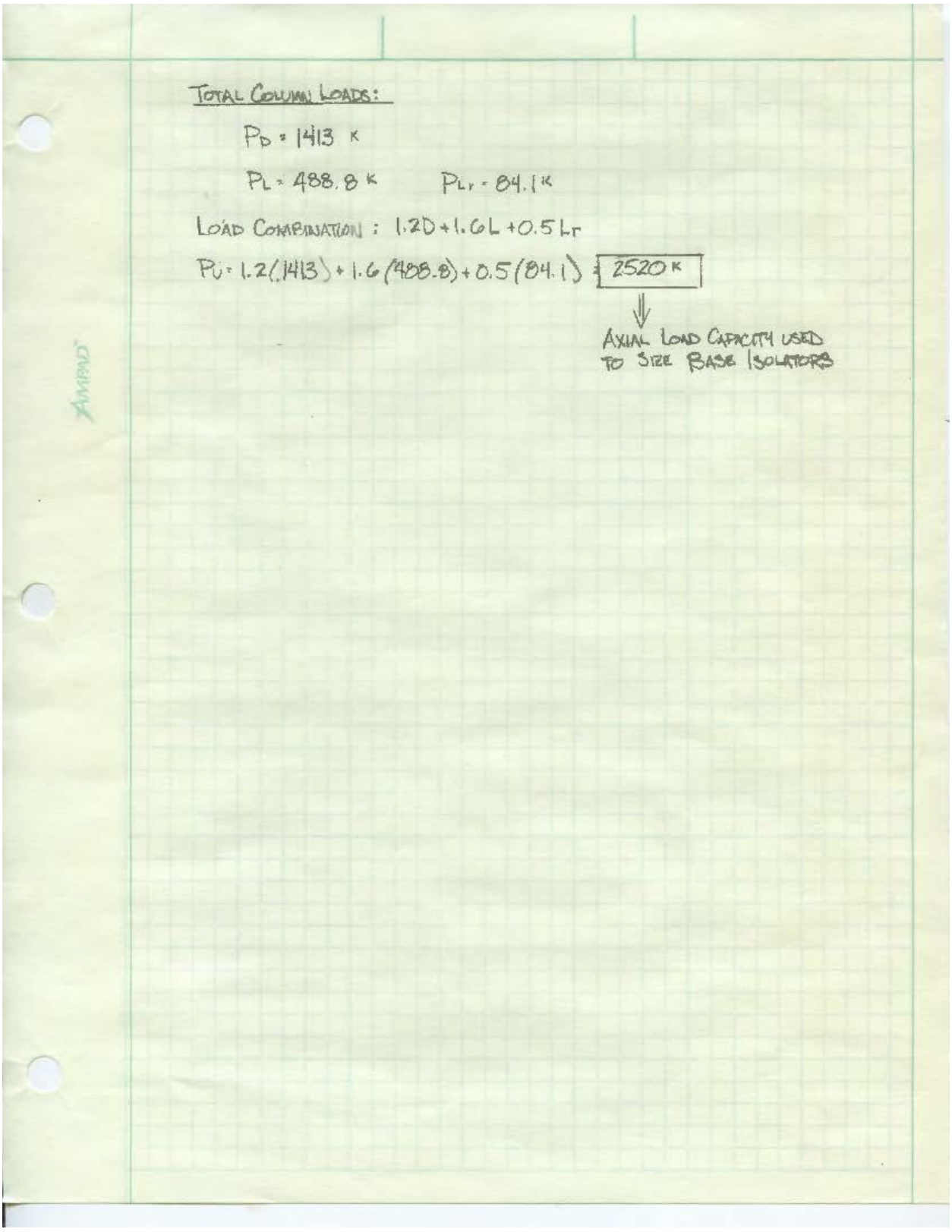
$P_D = 101.4^K + \left[\frac{(28)(28)(150)(14')}{144}\right]/1000 = 112.8^K$

$P_L = 26.9^K$

Ground Floor:

$P_D = 101.4^K + \left[\frac{(28)(28)(150)(10.667')}{144}\right]/1000 = 110.1^K$

$P = 84.1^K$



TOTAL COLUMN LOADS:

$P_D = 1413$ K

$P_L = 488.8$ K $\quad P_{Lr} = 84.1$ K

LOAD COMBINATION: $1.2D + 1.6L + 0.5L_r$

$P_U = 1.2(1413) + 1.6(488.8) + 0.5(84.1) = \boxed{2520\text{ K}}$

⇓

AXIAL LOAD CAPACITY USED TO SIZE BASE ISOLATORS

Appendix E: Fixed Base Iterations

	Model With Moment Frames						Deflection Criteria Met?			
12" Shear Walls	Frame Size	Period	Maximum Drift X (in.)	Maximum Drift Y (in.)	S-3 Δ_a (1.0%)	S-1 Δ_a (0.5%)	S-3 $_X$	S-3 $_Y$	S-1 $_X$	S-1 $_Y$
	24x24	1.944	1.650	1.316	1.84	0.92	Yes	Yes	No	No
	24x28	1.786	1.292	1.199	1.84	0.92	Yes	Yes	No	No
	24x32	1.651	1.038	1.093	1.84	0.92	Yes	Yes	No	No
	24x36	1.537	0.859	1.001	1.84	0.92	Yes	Yes	Yes	No
	Model With Moment Frames						Deflection Criteria Met?			
16" Shear Walls	Frame Size	Period	Maximum Drift X (in.)	Maximum Drift Y (in.)	S-3 Δ_a (1.0%)	S-1 Δ_a (0.5%)	S-3 $_X$	S-3 $_Y$	S-1 $_X$	S-1 $_Y$
	24x24	1.787	1.480	1.063	1.84	0.92	Yes	Yes	No	No
	24x28	1.660	1.201	0.986	1.84	0.92	Yes	Yes	No	No
	24x32	1.548	0.992	0.915	1.84	0.92	Yes	Yes	No	Yes
	24x36	1.450	0.836	0.851	1.84	0.92	Yes	Yes	Yes	Yes
	Model With Moment Frames						Deflection Criteria Met?			
18" Shear Walls	Frame Size	Period	Maximum Drift X (in.)	Maximum Drift Y (in.)	S-3 Δ_a (1.0%)	S-1 Δ_a (0.5%)	S-3 $_X$	S-3 $_Y$	S-1 $_X$	S-1 $_Y$
	24x24	1.722	1.404	0.969	1.84	0.92	Yes	Yes	No	No
	24x28	1.607	1.155	0.905	1.84	0.92	Yes	Yes	No	Yes
	24x32	1.504	0.964	0.845	1.84	0.92	Yes	Yes	No	Yes
	24x36	1.413	0.820	0.791	1.84	0.92	Yes	Yes	Yes	Yes
	Model With Moment Frames						Deflection Criteria Met?			
20" Shear Walls	Frame Size	Period	Maximum Drift X (in.)	Maximum Drift Y (in.)	S-3 Δ_a (1.0%)	S-1 Δ_a (0.5%)	S-3 $_X$	S-3 $_Y$	S-1 $_X$	S-1 $_Y$
	24x24	1.664	1.334	0.891	1.84	0.92	Yes	Yes	No	Yes
	24x28	1.559	1.111	0.837	1.84	0.92	Yes	Yes	No	Yes
	24x32	1.464	0.937	0.785	1.84	0.92	Yes	Yes	No	Yes
	24x36	1.379	0.803	0.738	1.84	0.92	Yes	Yes	Yes	Yes
	Model With Moment Frames						Deflection Criteria Met?			
22" Shear Walls	Frame Size	Period	Maximum Drift X (in.)	Maximum Drift Y (in.)	S-3 Δ_a (1.0%)	S-1 Δ_a (0.5%)	S-3 $_X$	S-3 $_Y$	S-1 $_X$	S-1 $_Y$
	24x24	1.611	1.269	0.824	1.84	0.92	Yes	Yes	No	Yes
	24x28	1.515	1.068	0.778	1.84	0.92	Yes	Yes	No	Yes
	24x32	1.427	0.909	0.733	1.84	0.92	Yes	Yes	Yes	Yes
	24x36	1.348	0.784	0.692	1.84	0.92	Yes	Yes	Yes	Yes
	Model With Moment Frames						Deflection Criteria Met?			
24" Shear Walls	Frame Size	Period	Maximum Drift X (in.)	Maximum Drift Y (in.)	S-3 Δ_a (1.0%)	S-1 Δ_a (0.5%)	S-3 $_X$	S-3 $_Y$	S-1 $_X$	S-1 $_Y$
	24x24	1.564	1.210	0.767	1.84	0.92	Yes	Yes	No	Yes
	24x28	1.475	1.028	0.727	1.84	0.92	Yes	Yes	No	Yes
	24x32	1.393	0.882	0.688	1.84	0.92	Yes	Yes	Yes	Yes
	24x36	1.319	0.766	0.652	1.84	0.92	Yes	Yes	Yes	Yes

Appendix F: Base Isolator Design Calculations

NATHAN McGRAW | SENIOR THESIS - FINAL | SEISMIC ISOLATION

ANALYSIS PROCEDURE SELECTION: CHAPTER 17: SEISMICALLY ISOLATED STRUCTURES

1. EQUIVALENT LATERAL FORCE PROCEDURE
   a. $S_1 < 0.6g \rightarrow S_1 = 0.325$ ∴ OK ✓
   b. SITE CLASS A, B, C OR D → SITE CLASS D ∴ OK ✓
   c. STRUCTURE ABOVE ISOLATION SURFACE ≤ 4 STORIES OR 65' → 145' ∴ NG X

∴ MUST USE DYNAMIC PROCEDURES

HOWEVER, NEED EQUIVALENT FORCE PROCEDURE VALUES:

EQUIVALENT LATERAL FORCE PROCEDURE:

DESIGN DISPLACEMENT:

$$D_D = \frac{g S_{D1} T_D}{4\pi^2 B_D}$$

EFFECTIVE PERIOD OF DESIGN DISPLACEMENT:

$$T_D = 2\pi \sqrt{\frac{W}{K_{D,MIN} g}}$$

MAXIMUM DISPLACEMENT:

$$D_M = \frac{g S_{M1} T_M}{4\pi^2 B_M}$$

EFFECTIVE PERIOD AT MAXIMUM DISPLACEMENT:

$$T_M = 2\pi \sqrt{\frac{W}{K_{M,MIN} g}}$$

TOTAL DISPLACEMENT:

$$D_{TD} = D_D \left[1 + y \frac{12e}{b^2 + d^2}\right]$$

$$D_{TM} = D_M \left[1 + y \frac{12e}{b^2 + d^2}\right]$$

MINIMUM LATERAL FORCES:

$$V_D = K_{D_{MAX}} D_D$$

STRUCTURE ELEMENTS ABOVE THE ISOLATION SYSTEM:

$$V_S = \frac{K_{D_{MAX}} D_D}{R_I}$$

$$R_I = \tfrac{3}{8} R \qquad 1.0 \leq R_I \leq 2.0$$

V_S SHALL NOT BE LESS THAN:

1. FIXED-BASE STRUCTURE USING T_D
2. WIND BASE SHEAR
3. FORCE REQUIRED TO ACTIVATE THE ISOLATION SYSTEM

VERTICAL DISTRIBUTION OF FORCE:

$$F_x = \frac{V_S w_x h_x}{\sum_{i=1} w_i h_i}$$

DRIFT LIMITS:

$$\Delta_{MAXIMUM} = 0.015 h_{sx} \quad (S\text{-}1 \text{ PERFORMANCE}: 0.005 h_{sx})$$

DYNAMIC PROCEDURE:

RESPONSE HISTORY PROCEDURE: §17.6.3.4 AND §17.3.2

§17.6.3.4
- NOT FEWER THAN 3 APPROPIATE GROUND MOTIONS
- MAXIMUM DISPLACEMENT = VECTORIAL SUM OF TWO ORTHOGONAL DISPLACEMENTS
- IF FEWER THAN 7 GROUND MOTIONS USED, THE MAXIMUM VALUE OF THE RESPONSE PARAMETER OF INTEREST SHALL BE USED FOR DESIGN

§17.3.2
- APPROPIATE MAGNITUDES, FAULT DISTANCE AND SOURCE MECHANISM THAT ARE CONSISTENT WITH THOSE THAT CONTROL THE MAXIMUM CONSIDERED EARTHQUAKE
- MOTIONS SHALL BE SCALED SUCH THAT FOR EACH PERIOD BETWEEN $0.5T_D$ AND $1.25T_M$, THE AVERAGE SRSS SPECTRA DOES NOT FALL BELOW 1.3 TIMES THE DESIGN RESPONSE SPECTRUM

MINIMUM LATERAL DISPLACEMENTS AND FORCES: § 17.6.4

- ISOLATION SYSTEM AND STRUCTURAL ELEMENTS BELOW ISOLATION SYSTEM:

  DESIGN LATERAL FORCE ≥ 0.9 V_D

  DESIGN DISPLACEMENT ≥ 0.9 D_{TD}

  MAXIMUM DISPLACEMENT ≥ 0.8 D_{TM}

$$D'_D = \frac{D_D}{\sqrt{1 + \left(\frac{T}{T_D}\right)^2}}$$

$$D'_M = \frac{D_M}{\sqrt{1 + \left(\frac{T}{T_M}\right)^2}}$$

- STRUCTURAL ELEMENTS ABOVE THE ISOLATION SYSTEM

  DESIGN LATERAL FORCE ≥ 0.8 V_S IF REGULAR IN CONFIGURATION
  ≥ 0.6 V_S IF RESPONSE HISTORY PROCEDURE USED

  DESIGN LATERAL FORCE ≥ V_S IF IRREGULAR IN CONFIGURATION
  ≥ 0.8 V_S IF RESPONSE HISTORY PROCEDURE USED

DRIFT LIMITS: § 17.6.4.4

1. IF RESPONSE SPECTRUM USED ⇒ 0.015 h_{sx}
2. IF RESPONSE HISTORY ANALYSIS ⇒ 0.020 h_{sx}
3. DRIFTS SHALL BE CALCULATED WITH THE C_D FACTOR OF THE ISOLATED STRUCTURE EQUAL TO R_I ($\geq 3/8 R$)

S_S =	0.900	
S_1 =	0.325	
S_{M1} =	0.49	
S_{D1} =	0.325	
R =	6.5	
W =	37,184	kips
b =	87	ft
d =	190.75	ft
e =	23.6	ft (with 5% accidental torsion)
g =	386.4	in./sec^2
$T_{str.}$ =	1.78	
T_D =	8.9	sec.
T_M =	10.2	sec.
Damping =	15%	
Variation =	10%	(Variation in stiffness from the mean stiffness values of the isolators is considered acceptable)

Effective Period of Design Displacement:

$$T_D = 2\pi\sqrt{\frac{W}{k_{D,MIN}\,g}}$$

$k_{D,MIN}$ = 48.0 k/in.

Effective Period at Maximum Displacement:

$$T_M = 2\pi\sqrt{\frac{W}{k_{M,MIN}\,g}}$$

$k_{M,MIN}$ = 36.3 k/in.

Design Effective Damping in the System:

$$\beta_D = \frac{1}{2\pi}\left[\frac{total\ area\ of\ hysteresis\ loop}{K_{D,MAX}\ D^2}\right]$$

$k_{D,MAX}$ = 58.6 k/in.

Maximum Effective Damping in the System:

$$\beta_M = \frac{1}{2\pi}\left[\frac{total\ area\ of\ hysteresis\ loop}{K_{M,MAX}\ D^2}\right]$$

$k_{D,MAX}$ = 44.3 k/in.

B_D =	1.35	(Table 17.5-1 Damping Coefficient)
B_M =	1.35	*Assumed same level of damping assigned to both directions

Design Displacement:

$$D_D = \frac{gS_{D1}T_D}{4\pi^2 B_D}$$ 20.97 in.

Maximum Displacement:

$$D_M = \frac{gS_{M1}T_M}{4\pi^2 B_M}$$ 36.36 in.

Total Displacement:

$$D_{TD} = D_D\left[1 + y\frac{12e}{b^2 + d^2}\right]$$ 33.9 in.

$$D_{TM} = D_M\left[1 + y\frac{12e}{b^2 + d^2}\right]$$ 58.7 in.

Minimum Lateral Forces: (Isolation System and Structural Elements below the Isolation System)

$$V_b = k_{D,MAX}D_D$$ 1229 kips

Structure Elements Above the Isolation System:

$$V_S = \frac{k_{D,MAX}D_D}{R_I}$$ 614.7 kips

$R_I = (3/8)R =$ 2.438 $1.0 \le R_I \le 2.0$ ∴ 2.0

Limits on V_S:

1.) V_S > The lateral system force required from Section 12.8 for a fixed base structure of the same effective seismic weight and a period equal to the isolated period (T_D)

2.) The base shear corresponding to the factored design wind load

3.) The lateral sesimic force required to fully activate the isolation system multiplied by 1.5

1.)

Sacramento CA
Latitude: 38.55
Longitude -121.74

Site Class: D

S_S =	0.900	*USGS Web Application (Confirmed with Figure 22-1 of ASCE 7-05)
S_1 =	0.325	*USGS Web Application (Confirmed with Figure 22-2 of ASCE 7-05)
T_L =	8	sec. (Confirmed with Figure 22-15 of ASCE 7-05)

Occupancy Category IV (Table 1.1)
Importance Factor = 1.5 (Table 11.5.1)

Site Coefficient, F_a = 1.0 (Table 11.4-1)
Site Coefficient, F_v = 1.5 (Table 11.4-2)

S_{MS} =	0.90	$F_a.S_s$	(11.4-1)
S_{M1} =	0.49	$F_v.S_1$	(11.4-2)
S_{DS} =	0.600	$(2/3)S_{MS}$	(11.4-3)
S_{D1} =	0.325	$(2/3)S_{M1}$	(11.4-4)

Short Period SDC = D (Table 11.6-1)
1.0-s Period SDC = D (Table 11.6-2)

Permitted Analytical Procedure: Modal Response Spectrum Analysis (Table 12.6-1)
Seismic Response History Procedure (Table 12.6-1)

Response Modification Coeffic 6.5 (Table 12.2-1)
Amplification Factor 5.0 (Table 12.2-1)

Approximate Fundamental Period:

$T_a = C_t h_n^x$

C_t =	0.02	(Table 12.8-2)
x =	0.75	(Table 12.8-2)
h_n =	145	ft.

T_a = 0.8357 sec.

C_u = 1.4 (Table 12.8-1)

$C_u T_a$ = 1.17 sec. (Upper Limit on Calculated Period)

T_D = 8.90 sec.

Seismic Response Coefficient:

$$C_s = \begin{cases} \dfrac{S_{DS}}{(R/I)} = \dfrac{0.6}{(4.5/1.5)} = 0.138 & \text{(Eqn. 12.8-2)} \\ \dfrac{S_{D1}}{T(R/I)} = \dfrac{0.325}{.17)(4.5/1.} = 0.008 \geq 0.01 & \text{(Eqn. 12.8-3)} \\ \dfrac{S_{D1}T_L}{T^2(R/I)} = \dfrac{(0.325)(8)}{.17)^2(4.5/1} = 0.008 & \text{(Eqn. 12.8-4)} \end{cases}_{min}$$

For $S_1 \geq 0.6g$:

Apply: No

$$C_s \geq \frac{0.5S_{DS}}{(R/I)} = \frac{1.333}{(4.5/1.5)} = 0.069 \quad \text{(Eqn. 12.8-6)}$$

$C_s =$ 0.008

Base Shea $V = C_sW$

W = 37,184 kips

$V = C_sW =$ 282 kips < $V_S =$ 615 kips OK

2.)

$V_{wind} =$ 416 kips < $V_S =$ 615 kips OK

3.)

Assume the lateral sesimic force required to fully activate the isolation system is met OK

Proposed Structure: University of California – Davis (Sacramento) CA – Base Isolation Model (only worst EQ iteration for preliminary size is shown for convenience)

El Centro Array #6 - Maximum Displacements/Drifts							
	Level	δ_{XE}	Δ_X	S-3 Δ_a (1.0%)	S-1 Δ_a (0.5%)	S-3 Met	S-1 Met
T = 2.6 sec., K_{vert} = 16000 k/in., K_{linear} - 37 k/in., $K_{nonlinear}$ = 370 k/in., Yield Strength = 75 k, Post Yield Stiffness Ratio = 0.2	Penthouse/Roof	15.4	1.0	1.88	0.94	Yes	No
	11th	14.5	0.7	1.36	0.68	Yes	No
	10th	13.7	0.8	1.36	0.68	Yes	No
	9th	13.0	0.8	1.36	0.68	Yes	No
	8th	12.1	0.9	1.36	0.68	Yes	No
	7th	11.2	0.9	1.36	0.68	Yes	No
	6th	10.3	1.2	1.68	0.84	Yes	No
	5th	9.1	1.0	1.36	0.68	Yes	No
	4th	8.1	1.0	1.36	0.68	Yes	No
	3rd	7.1	0.6	1.36	0.68	Yes	Yes
	2nd	6.5	1.5	1.68	0.84	Yes	No
	1st	5.0	2.4	1.28	0.64	No	No
	Ground	2.6	N/A	N/A	N/A	N/A	N/A

El Centro Array #6 - Maximum Displacements/Drifts							
	Level	δ_{XE}	Δ_X	S-3 Δ_a (1.0%)	S-1 Δ_a (0.5%)	S-3 Met	S-1 Met
T = 3.1 sec., K_{vert} = 16000 k/in., K_{linear} = 15.5 k/in., $K_{nonlinear}$ = 155 k/in., Yield Strength = 75 k, Post Yield Stiffness Ratio = 0.2	Penthouse/Roof	13.1	0.7	1.88	0.94	Yes	Yes
	11th	12.5	0.5	1.36	0.68	Yes	Yes
	10th	12.0	0.5	1.36	0.68	Yes	Yes
	9th	11.4	0.6	1.36	0.68	Yes	Yes
	8th	10.9	0.6	1.36	0.68	Yes	Yes
	7th	10.3	0.6	1.36	0.68	Yes	Yes
	6th	9.6	0.8	1.68	0.84	Yes	Yes
	5th	8.8	0.7	1.36	0.68	Yes	No
	4th	8.1	0.7	1.36	0.68	Yes	Yes
	3rd	7.4	0.4	1.36	0.68	Yes	Yes
	2nd	7.0	1.1	1.68	0.84	Yes	No
	1st	6.0	1.8	1.28	0.64	No	No
	Ground	4.2	N/A	N/A	N/A	N/A	N/A

El Centro Array #6 - Maximum Displacements/Drifts							
	Level	δ_{XE}	Δ_X	S-3 Δ_a (1.0%)	S-1 Δ_a (0.5%)	S-3 Met	S-1 Met
T = 4.51 sec., K_{vert} = 16000 k/in., K_{linear} = 6 k/in., $K_{nonlinear}$ = 60 k/in., Yield Strength = 75 k, Post Yield Stiffness Ratio = 0.2	Penthouse/Roof	13.6	0.4	1.88	0.94	Yes	Yes
	11th	13.1	0.3	1.36	0.68	Yes	Yes
	10th	12.8	0.4	1.36	0.68	Yes	Yes
	9th	12.4	0.4	1.36	0.68	Yes	Yes
	8th	12.1	0.4	1.36	0.68	Yes	Yes
	7th	11.7	0.4	1.36	0.68	Yes	Yes
	6th	11.2	0.6	1.68	0.84	Yes	Yes
	5th	10.7	0.5	1.36	0.68	Yes	Yes
	4th	10.2	0.4	1.36	0.68	Yes	Yes
	3rd	9.8	0.2	1.36	0.68	Yes	Yes
	2nd	9.6	0.8	1.68	0.84	Yes	Yes
	1st	8.8	1.4	1.28	0.64	No	No
	Ground	7.4	N/A	N/A	N/A	N/A	N/A

El Centro Array #6 - Maximum Displacements/Drifts							
	Level	δ_{XE}	Δ_X	S-3 Δ_a (1.0%)	S-1 Δ_a (0.5%)	S-3 Met	S-1 Met
T = 2.6 sec., K_{vert} = 16000 k/in., K_{linear} - 37 k/in., $K_{nonlinear}$ = 370 k/in., Yield Strength = 150 k, Post Yield Stiffness Ratio = 0.2	Penthouse/Roof	11.0	0.7	1.88	0.94	Yes	Yes
	11th	10.4	0.5	1.36	0.68	Yes	Yes
	10th	9.8	0.6	1.36	0.68	Yes	Yes
	9th	9.3	0.6	1.36	0.68	Yes	Yes
	8th	8.7	0.6	1.36	0.68	Yes	Yes
	7th	8.0	0.7	1.36	0.68	Yes	Yes
	6th	7.4	0.9	1.68	0.84	Yes	No
	5th	6.5	0.7	1.36	0.68	Yes	No
	4th	5.8	0.7	1.36	0.68	Yes	No
	3rd	5.1	0.5	1.36	0.68	Yes	Yes
	2nd	4.6	1.0	1.68	0.84	Yes	No
	1st	3.5	1.7	1.28	0.64	No	No
	Ground	1.9	N/A	N/A	N/A	N/A	N/A

El Centro Array #6 - Maximum Displacements/Drifts							
	Level	δ_{XE}	Δ_X	S-3 Δ_a (1.0%)	S-1 Δ_a (0.5%)	S-3 Met	S-1 Met
T = 3.1 sec., K_{vert} = 16000 k/in., K_{linear} = 15.5 k/in., $K_{nonlinear}$ = 155 k/in., Yield Strength = 150 k, Post Yield Stiffness Ratio = 0.2	Penthouse/Roof	8.1	0.4	1.88	0.94	Yes	Yes
	11th	7.7	0.3	1.36	0.68	Yes	Yes
	10th	7.4	0.3	1.36	0.68	Yes	Yes
	9th	7.1	0.4	1.36	0.68	Yes	Yes
	8th	6.7	0.4	1.36	0.68	Yes	Yes
	7th	6.3	0.4	1.36	0.68	Yes	Yes
	6th	5.9	0.5	1.68	0.84	Yes	Yes
	5th	5.4	0.4	1.36	0.68	Yes	Yes
	4th	4.9	0.4	1.36	0.68	Yes	Yes
	3rd	4.5	0.3	1.36	0.68	Yes	Yes
	2nd	4.2	0.7	1.68	0.84	Yes	Yes
	1st	3.6	1.1	1.28	0.64	Yes	No
	Ground	2.5	N/A	N/A	N/A	N/A	N/A

El Centro Array #6 - Maximum Displacements/Drifts							
	Level	δ_{XE}	Δ_X	S-3 Δ_a (1.0%)	S-1 Δ_a (0.5%)	S-3 Met	S-1 Met
T = 4.51 sec., K_{vert} = 16000 k/in., K_{linear} = 6 k/in., $K_{nonlinear}$ = 60 k/in., Yield Strength = 150 k, Post Yield Stiffness Ratio = 0.2	Penthouse/Roof	8.7	0.3	1.88	0.94	Yes	Yes
	11th	8.4	0.2	1.36	0.68	Yes	Yes
	10th	8.2	0.2	1.36	0.68	Yes	Yes
	9th	7.9	0.3	1.36	0.68	Yes	Yes
	8th	7.7	0.3	1.36	0.68	Yes	Yes
	7th	7.4	0.3	1.36	0.68	Yes	Yes
	6th	7.1	0.4	1.68	0.84	Yes	Yes
	5th	6.7	0.3	1.36	0.68	Yes	Yes
	4th	6.4	0.3	1.36	0.68	Yes	Yes
	3rd	6.1	0.1	1.36	0.68	Yes	Yes
	2nd	6.0	0.5	1.68	0.84	Yes	Yes
	1st	5.5	0.9	1.28	0.64	Yes	No
	Ground	4.6	N/A	N/A	N/A	N/A	N/A

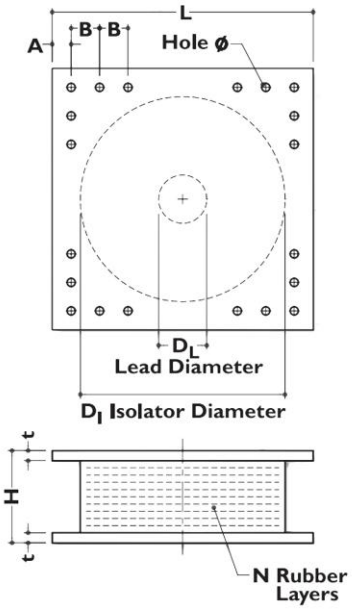
El Centro Array #6 - Maximum Displacements/Drifts							
T = 2.6 sec., K_{vert} = 16000 k/in., K_{linear} - 37 k/in., $K_{nonlinear}$ = 370 k/in., Yield Strength = 37.5 k, Post Yield Stiffness Ratio = 0.2	Level	δ_{XE}	Δ_X	S-3 Δ_a (1.0%)	S-1 Δ_a (0.5%)	S-3 Met	S-1 Met
	Penthouse/Roof	18.6	1.1	1.88	0.94	Yes	No
	11th	17.4	0.9	1.36	0.68	Yes	No
	10th	16.5	0.9	1.36	0.68	Yes	No
	9th	15.6	1.0	1.36	0.68	Yes	No
	8th	14.6	1.1	1.36	0.68	Yes	No
	7th	13.5	1.1	1.36	0.68	Yes	No
	6th	12.4	1.5	1.68	0.84	Yes	No
	5th	11.0	1.2	1.36	0.68	Yes	No
	4th	9.8	1.2	1.36	0.68	Yes	No
	3rd	8.6	0.8	1.36	0.68	Yes	No
	2nd	7.9	1.7	1.68	0.84	No	No
	1st	6.1	2.9	1.28	0.64	No	No
	Ground	3.2	N/A	N/A	N/A	N/A	N/A

El Centro Array #6 - Maximum Displacements/Drifts							
T = 3.1 sec., K_{vert} = 16000 k/in., K_{linear} = 15.5 k/in., $K_{nonlinear}$ = 155 k/in., Yield Strength = 37.5 k, Post Yield Stiffness Ratio = 0.2	Level	δ_{XE}	Δ_X	S-3 Δ_a (1.0%)	S-1 Δ_a (0.5%)	S-3 Met	S-1 Met
	Penthouse/Roof	18.0	0.9	1.88	0.94	Yes	Yes
	11th	17.1	0.7	1.36	0.68	Yes	Yes
	10th	16.4	0.7	1.36	0.68	Yes	No
	9th	15.7	0.8	1.36	0.68	Yes	No
	8th	15.0	0.8	1.36	0.68	Yes	No
	7th	14.2	0.9	1.36	0.68	Yes	No
	6th	13.3	1.1	1.68	0.84	Yes	No
	5th	12.2	0.9	1.36	0.68	Yes	No
	4th	11.3	0.9	1.36	0.68	Yes	No
	3rd	10.4	0.5	1.36	0.68	Yes	Yes
	2nd	9.9	1.4	1.68	0.84	Yes	No
	1st	8.4	2.4	1.28	0.64	No	No
	Ground	6.0	N/A	N/A	N/A	N/A	N/A

El Centro Array #6 - Maximum Displacements/Drifts							
	Level	δ_{XE}	Δ_X	S-3 Δ_a (1.0%)	S-1 Δ_a (0.5%)	S-3 Met	S-1 Met
T = 4.51 sec., K_{vert} = 16000 k/in., K_{linear} = 6 k/in., $K_{nonlinear}$ = 60 k/in., Yield Strength = 37.5 k, Post Yield Stiffness Ratio = 0.2	Penthouse/Roof	25.5	0.7	1.88	0.94	Yes	Yes
	11th	24.8	0.6	1.36	0.68	Yes	Yes
	10th	24.2	0.6	1.36	0.68	Yes	Yes
	9th	23.6	0.6	1.36	0.68	Yes	Yes
	8th	22.9	0.68	1.36	0.68	Yes	Yes
	7th	22.3	0.67	1.36	0.68	Yes	Yes
	6th	21.6	0.68	1.68	0.84	Yes	Yes
	5th	20.9	0.68	1.36	0.68	Yes	Yes
	4th	20.2	0.67	1.36	0.68	Yes	Yes
	3rd	19.6	0.63	1.36	0.68	Yes	Yes
	2nd	18.9	0.8	1.68	0.84	Yes	Yes
	1st	18.1	0.6	1.28	0.64	Yes	Yes
	Ground	17.5	N/A	N/A	N/A	N/A	N/A

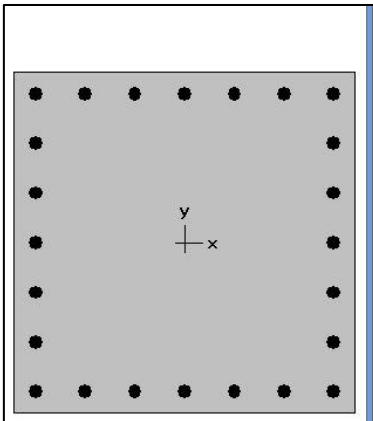
Base Isolator Dimensions/Connection:

DEVICE SIZE				MOUNTING PLATE DIMENSIONS					
Isolator Diameter, D_I (in)	Isolator Height, H (in)	Number of Rubber Layers, N	Lead Diameter D_L (in)	L (in)	t (in)	Hole Qty.	Hole Ø (in)	A (in)	B (in)
12.0	5-11	4-14	0-4	14	1	4	1 1/16	2	-
14.0	6-12	5-16	0-4	16	1	4	1 1/16	2	-
16.0	7-13	6-20	0-5	18	1	4	1 1/16	2	-
18.0	7-14	6-20	0-5	20	1	4	1 1/16	2	-
20.5	8-15	8-24	0-7	22.5	1	8	1 1/16	2	2
22.5	8-15	8-24	0-7	24.5	1	8	1 1/16	2	2
25.5	8-15	8-24	0-8	27.5	1.25	8	1 1/16	2	2
27.5	8-17	8-30	0-8	29.5	1.25	8	1 5/16	2.5	3
29.5	9-18	8-30	0-9	31.5	1.25	8	1 5/16	2.5	3
31.5	9-20	8-33	0-9	33.5	1.25	8	1 5/16	2.5	3
33.5	9-21	8-35	0-10	35.5	1.5	12	1 5/16	2.5	3.75
35.5	10-22	9-37	0-10	37.5	1.5	12	1 5/16	2.5	3.75
37.5	10-23	10-40	0-11	39.5	1.5	12	1 5/16	2.5	3.75
39.5	11-25	11-40	0-11	41.5	1.5	12	1 9/16	3	4.5
41.5	12-26	12-45	0-12	43.5	1.75	12	1 9/16	3	4.5
45.5	13-30	14-45	0-13	47.5	1.75	12	1 9/16	3	4.5
49.5	14-30	16-45	0-14	52.5	1.75	16	1 9/16	3	4.5
53.5	16-30	18-45	0-15	56.5	2	16	1 9/16	3	4.5
57.1	17-30	20-45	0-16	60	2	20	1 9/16	3	4.5
61.0	18-30	22-45	0-16	64	2	20	1 9/16	3	4.5



Proposed Structure: University of California – Davis (Sacramento) CA – Base Isolation Model

Column Design (Only one column shown)



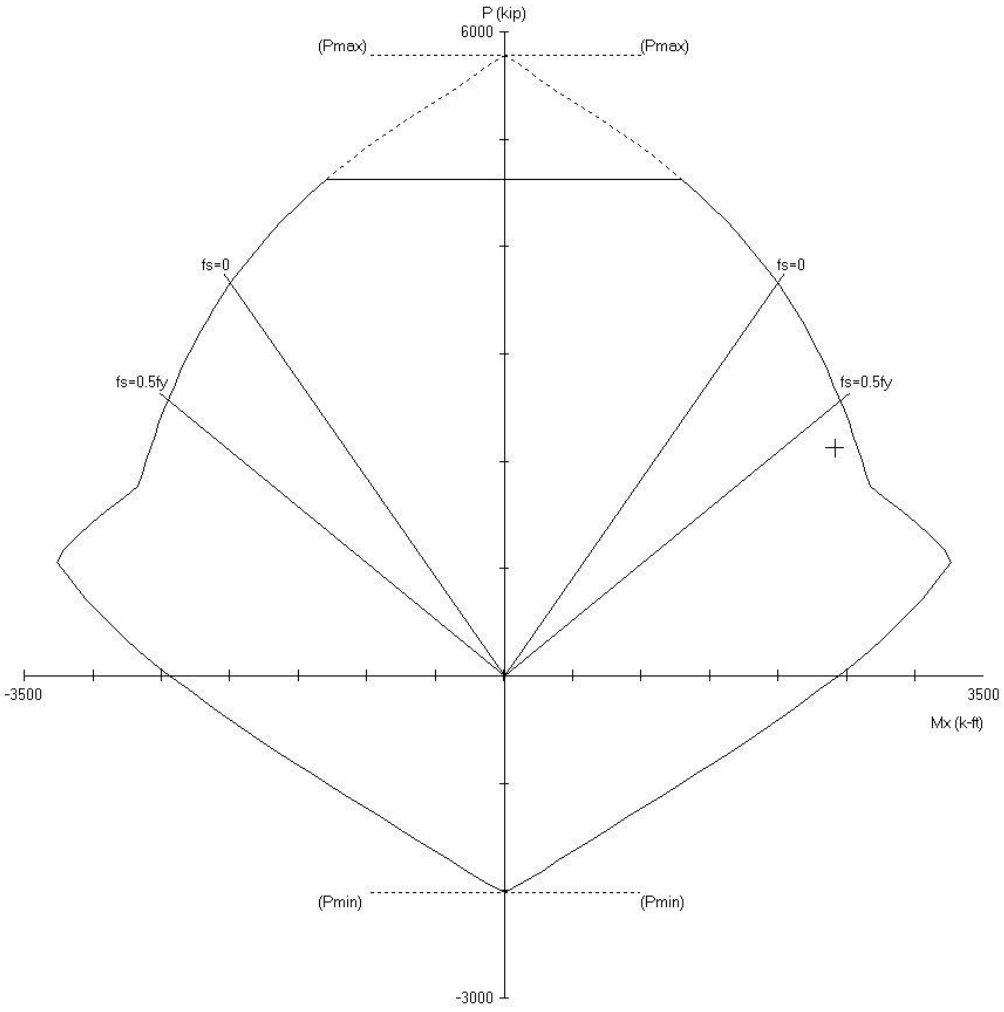
34 x 34 in
3.24% reinf.

MATERIAL:
=========
f'c = 7 ksi
Ec = 4768.97 ksi
fc = 5.95 ksi
Beta1 = 0.7
fy = 60 ksi
Es = 29000 ksi

SECTION:
========
Ag = 1156 in^2
Ix = 111361 in^4
Iy = 111361 in^4
Xo = 0 in
Yo = 0 in

REINFORCEMENT:
==============
24 #11 bars @ 3.239%
As = 37.44 in^2
Confinement: Tied
Clear Cover = 1.50 in
Min Clear Spacing = 3.52 in

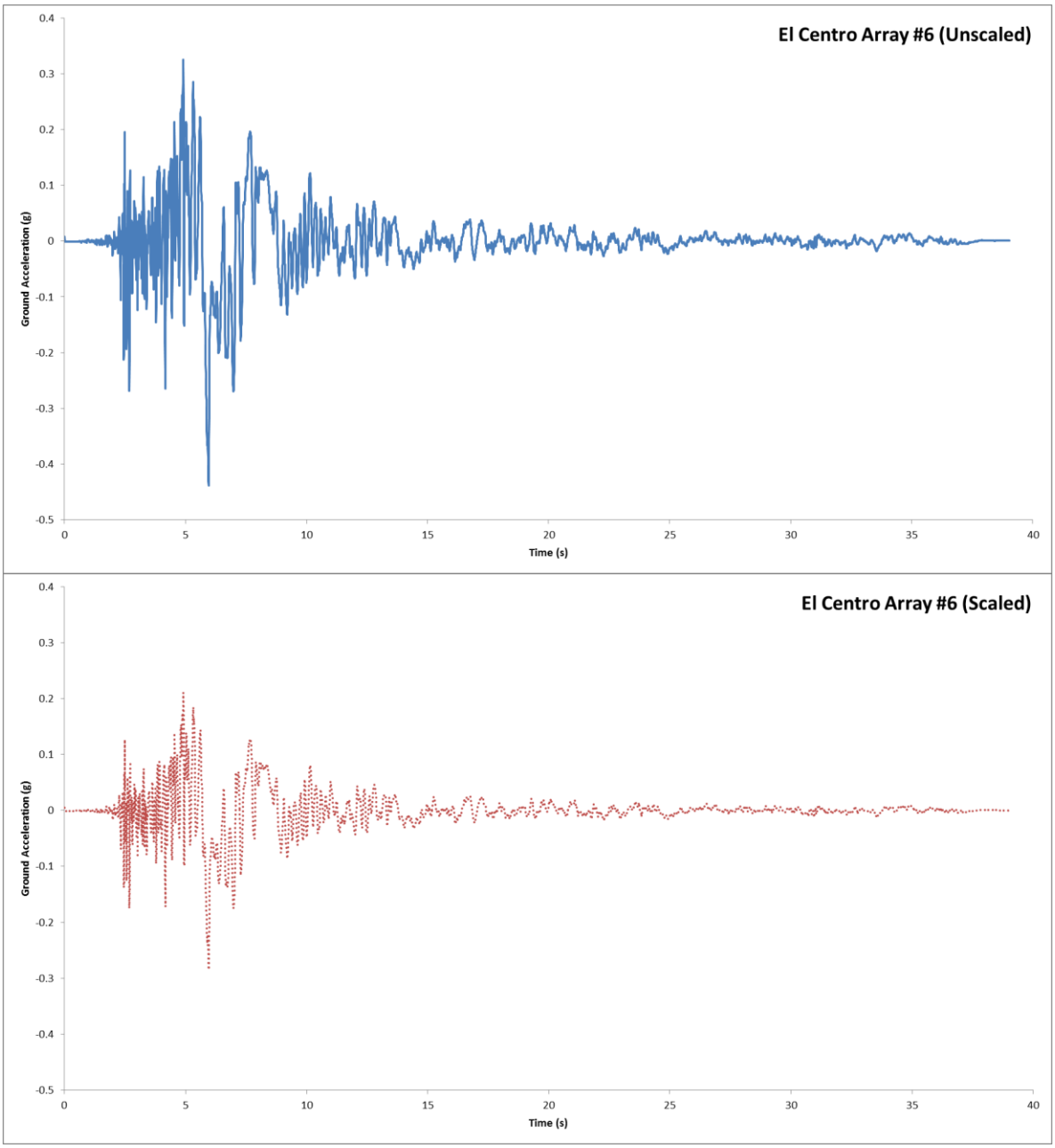
SLENDERNESS:
============

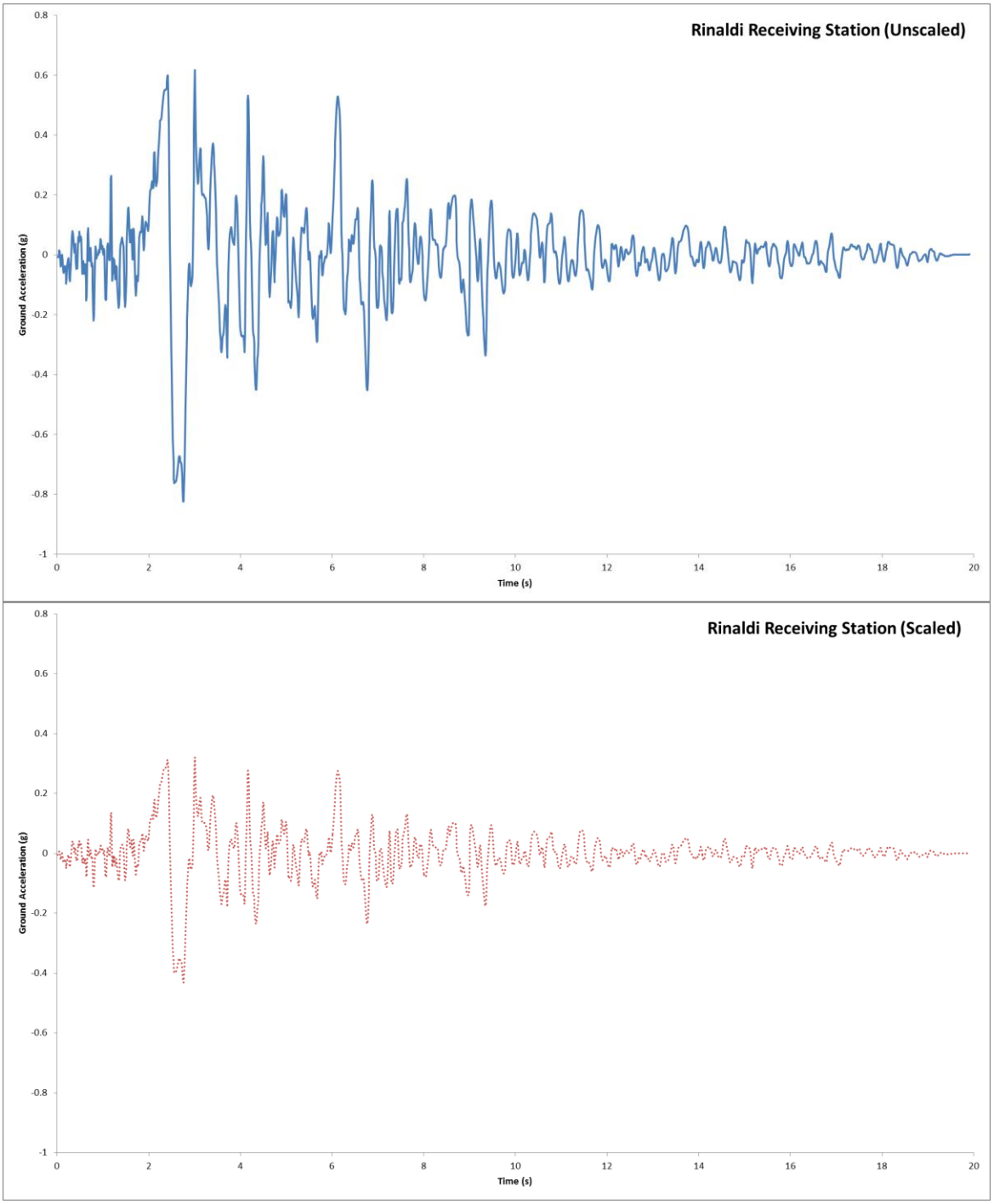


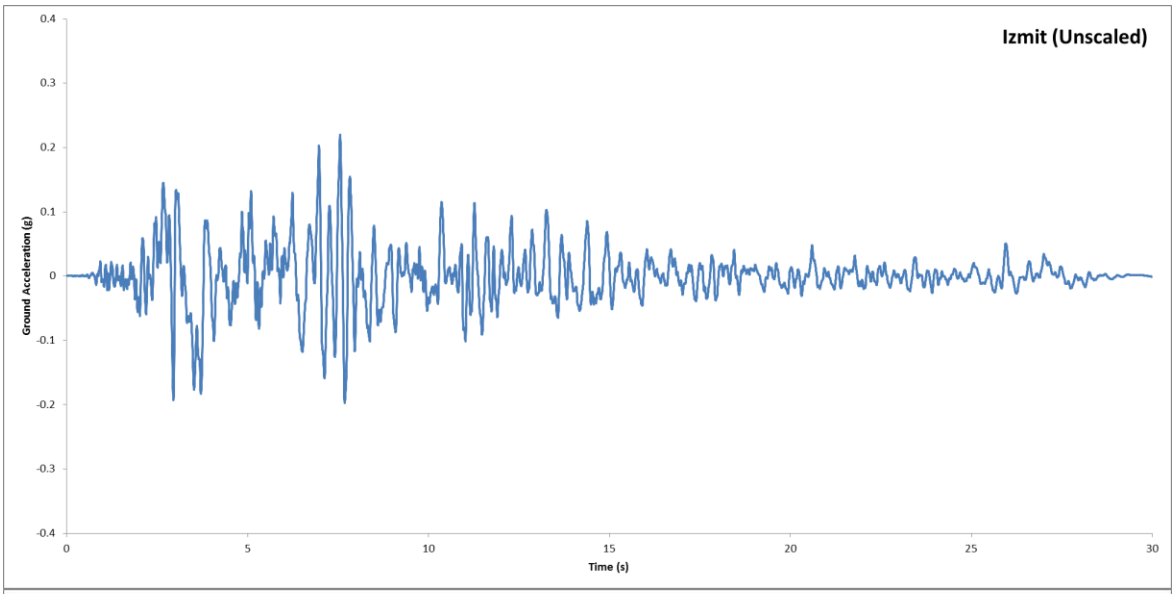
Appendix G: Earthquake Scaling for Time History Analysis

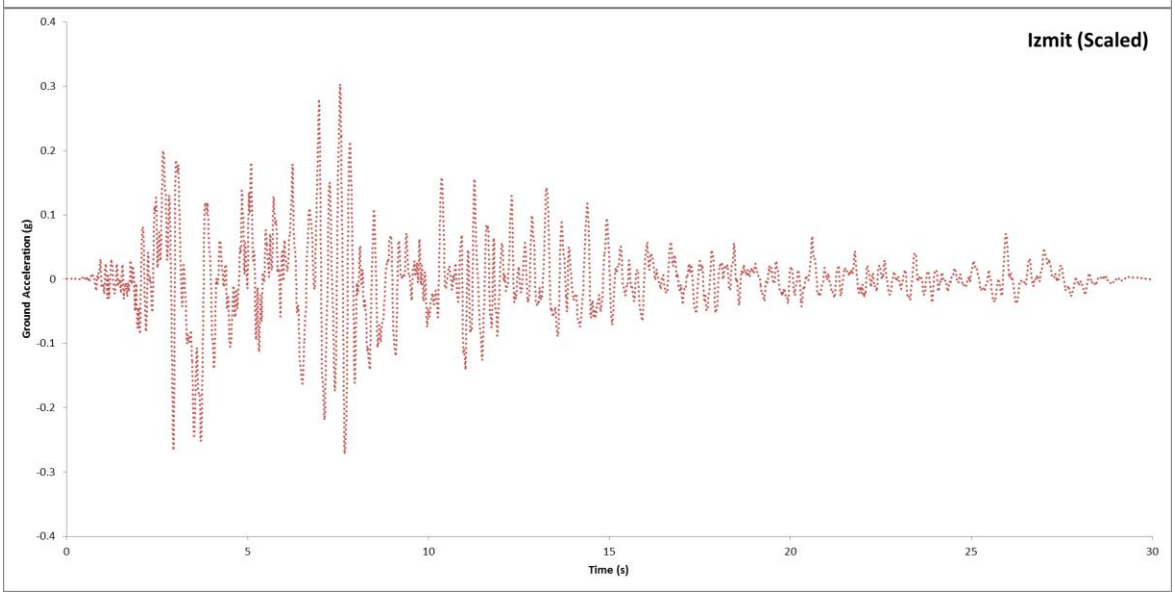
X-Direction				
Earthquake Name/Station	Magnitude	PGA (g)	PGV (cm/s)	Scale Factor
Imperial Valley-06/El Centro Array #6	6.53	0.4417	111.8402	0.6488
Imperial Valley-06/El Centro Array #7	6.53	0.4624	108.7935	0.7061
Northridge-01/Rinaldi Receiving Station	6.69	0.8698	167.051	0.5216
Northridge-01/Sylmar - Olive View	6.69	0.7326	122.7694	0.5929
Loma Prieta/Saratoga - Aloha	6.93	0.3761	55.5459	0.8603
Cape Mendocino/Petrolia	7.01	0.6296	81.8727	0.6844
Kocaeli, Turkey/Izmit	7.51	0.2198	29.7636	1.3784

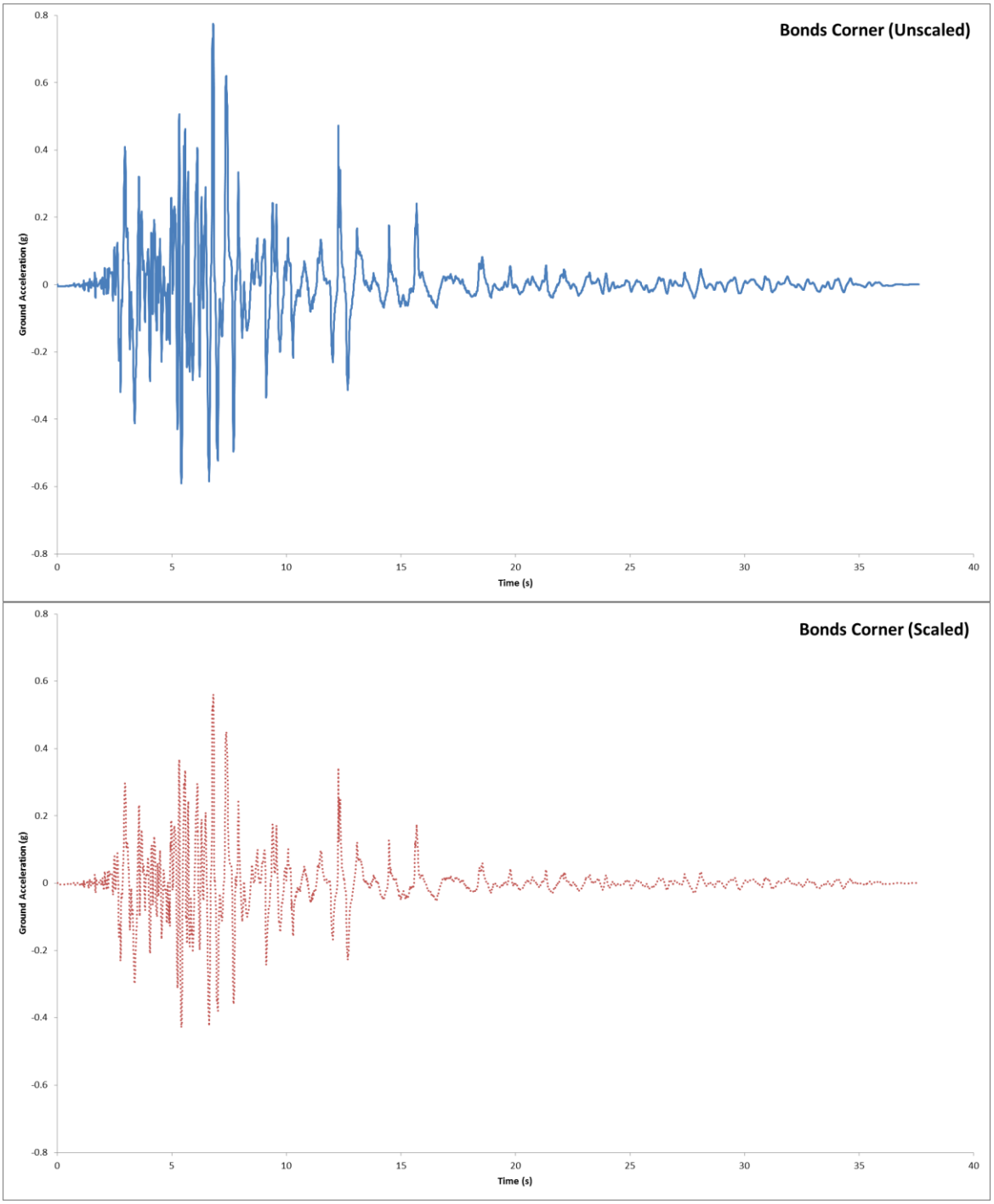
Y-Direction				
Earthquake Name/Station	Magnitude	PGA (g)	PGV (cm/s)	Scale Factor
Imperial Valley-06/Bonds Corner	6.53	0.7639	44.2457	0.7251
Imperial Valley-06/Chihuahua	6.53	0.2843	30.4074	1.3686
Northridge-01/LA - Sepulveda VA	6.69	0.7312	69.979	0.6127
Northridge-01/Northridge - Saticoy	6.69	0.4133	53.1713	0.7784
Loma Prieta/Corralitos	6.93	0.5136	45.4288	0.9611
Cape Mendocino/Cape Mendocino	7.01	1.4314	118.3109	0.5812
Kocaeli, Turkey/Yarimca	7.51	0.3119	72.9142	0.7245

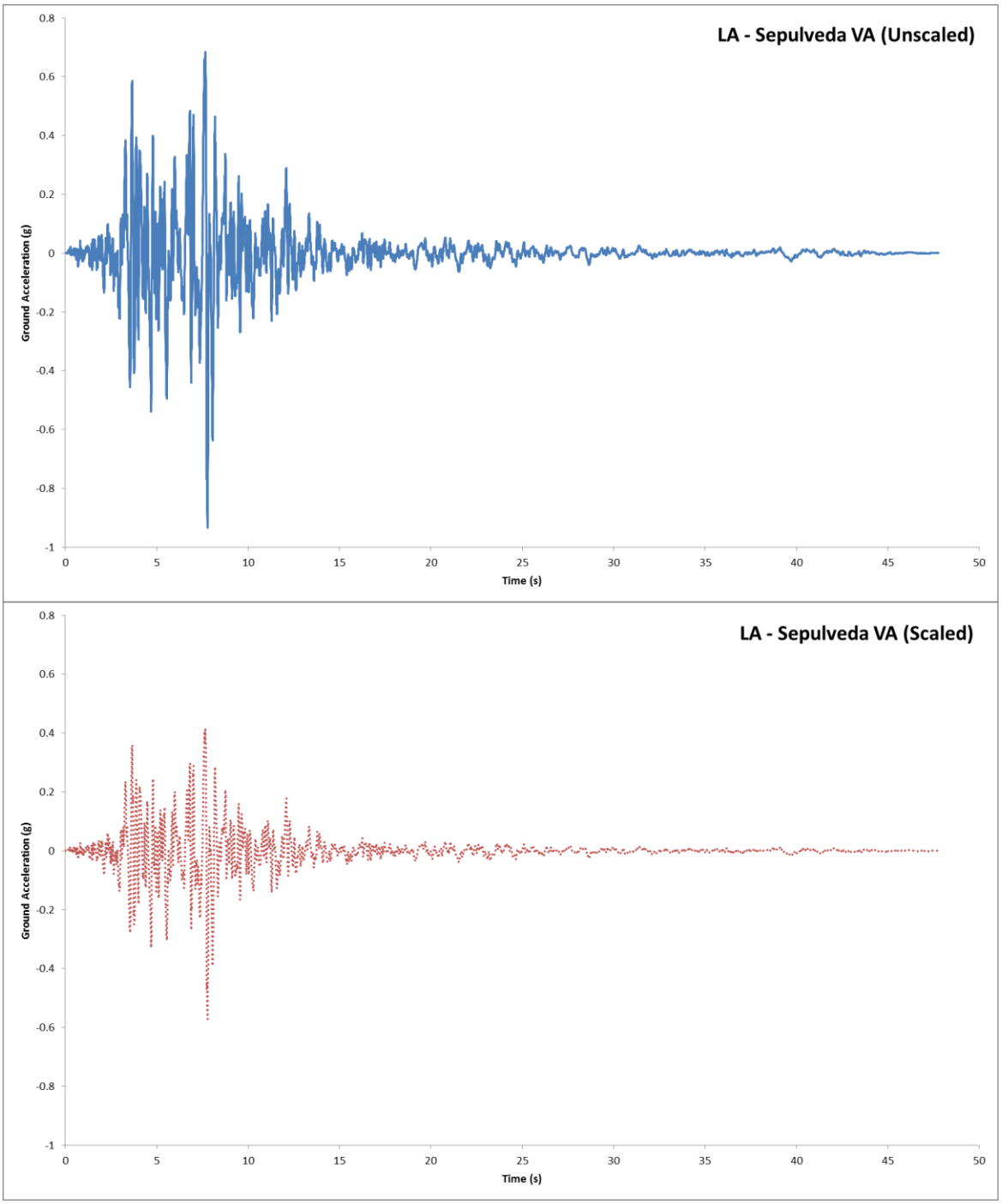

El Centro Array #6 (Unscaled)
Ground Acceleration (g)
Time (s)
El Centro Array #6 (Scaled)
Ground Acceleration (g)
Time (s)

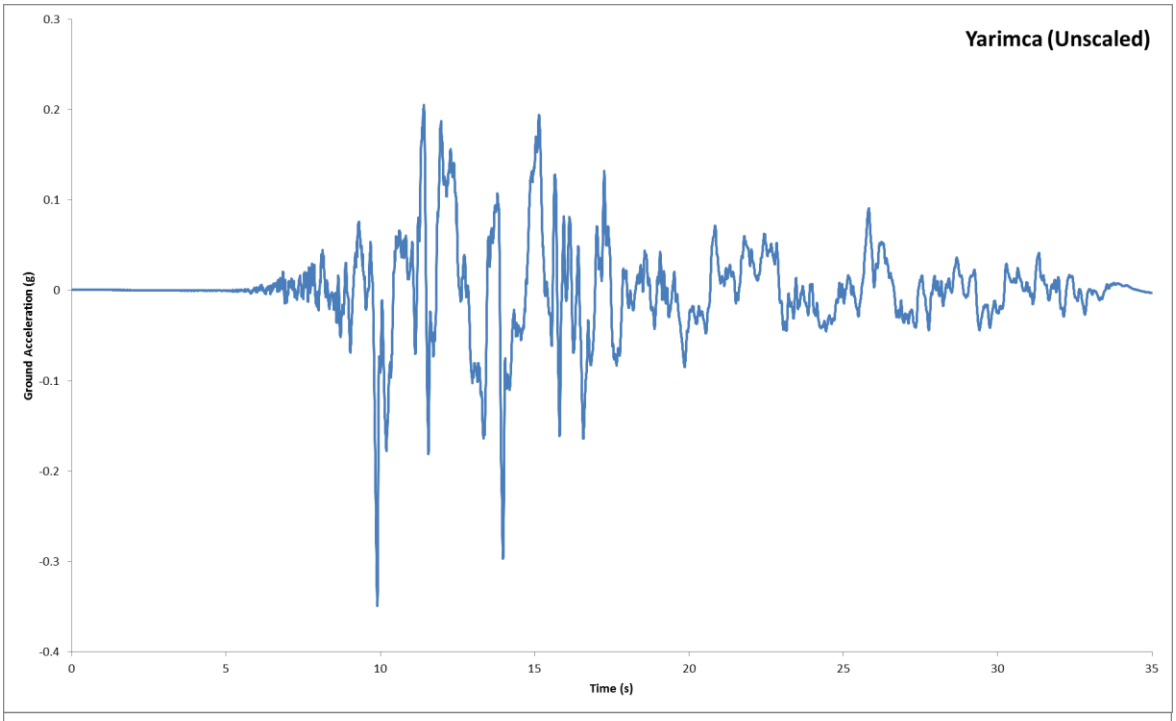

Rinaldi Receiving Station (Unscaled)
Ground Acceleration (g)
Time (s)
Rinaldi Receiving Station (Scaled)
Ground Acceleration (g)
Time (s)

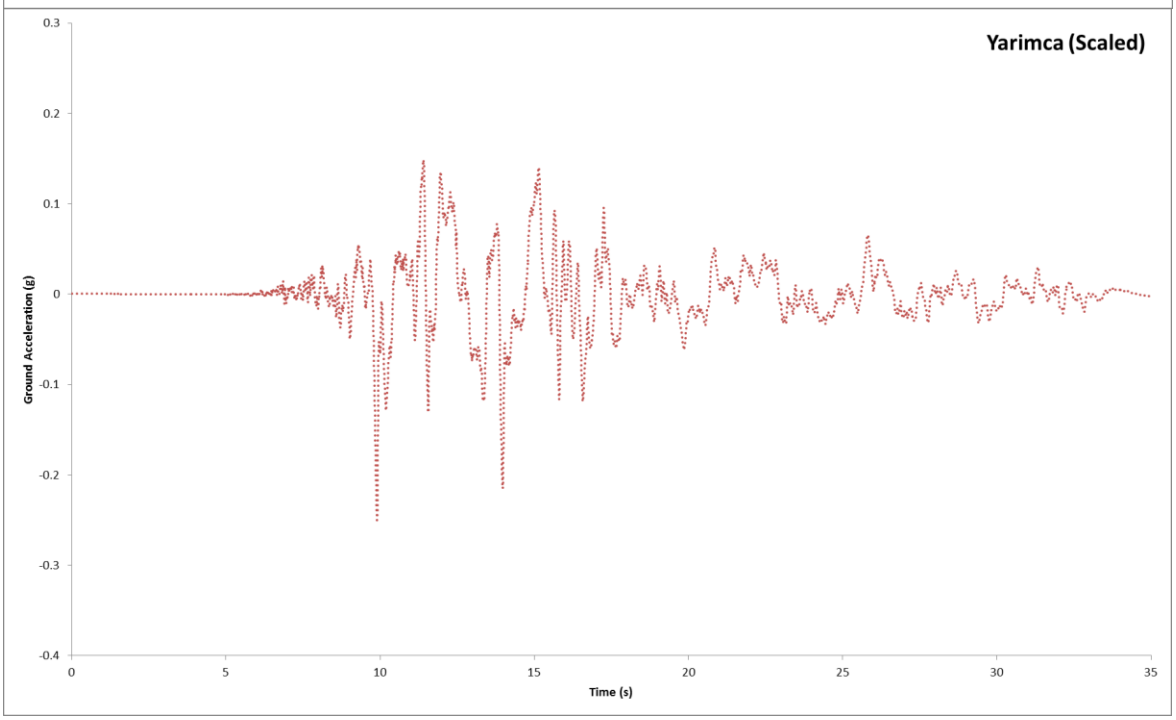

Izmit (Unscaled)
Ground Acceleration (g)
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
0
5
10
15
20
25
30
Time (s)

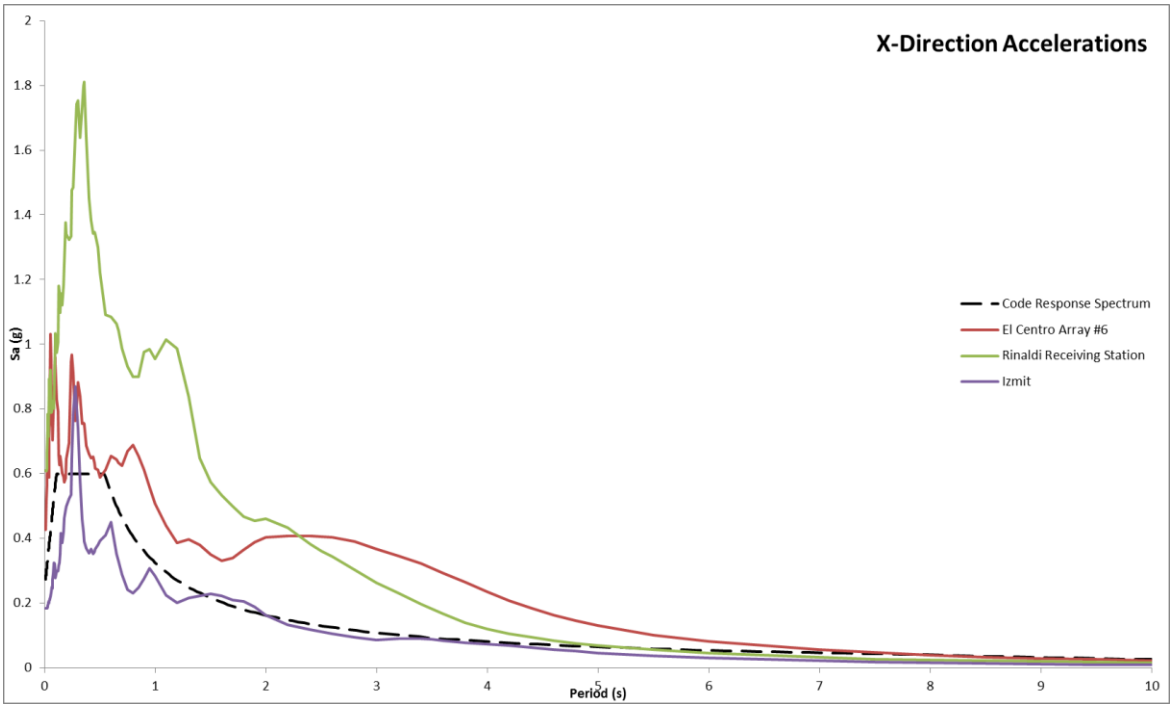

Izmit (Scaled)
Ground Acceleration (g)
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
0
5
10
15
20
25
30
Time (s)

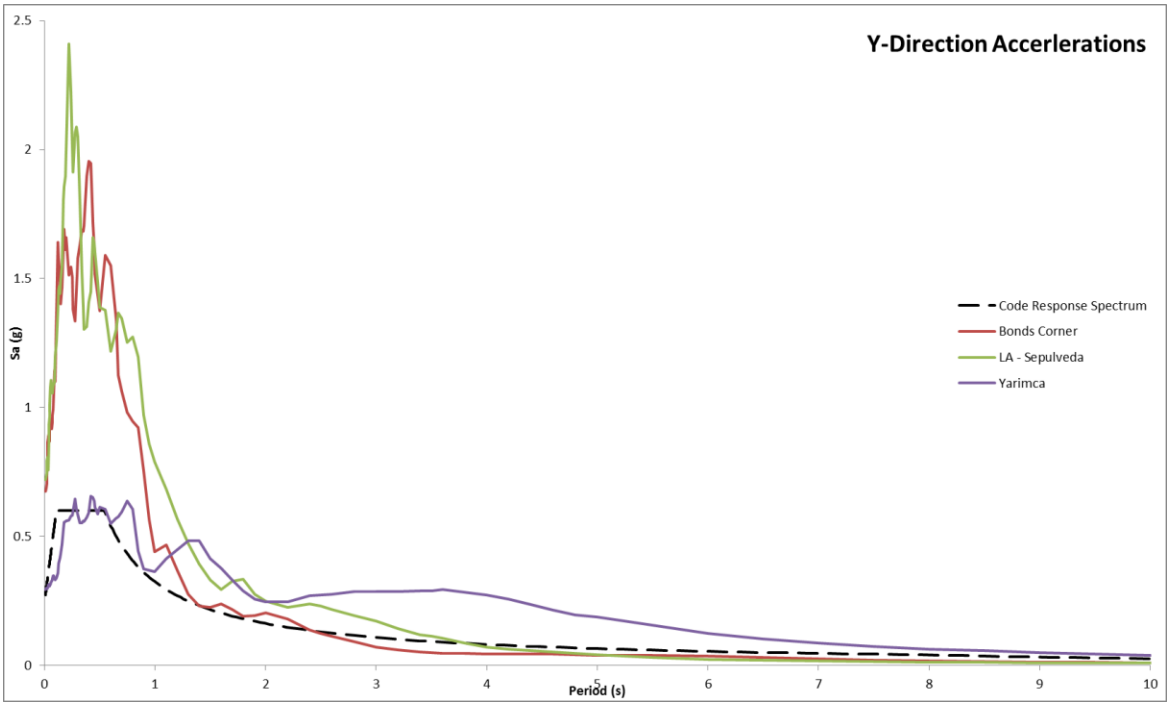

Bonds Corner (Unscaled)
Ground Acceleration (g)
Time (s)
Bonds Corner (Scaled)
Ground Acceleration (g)
Time (s)

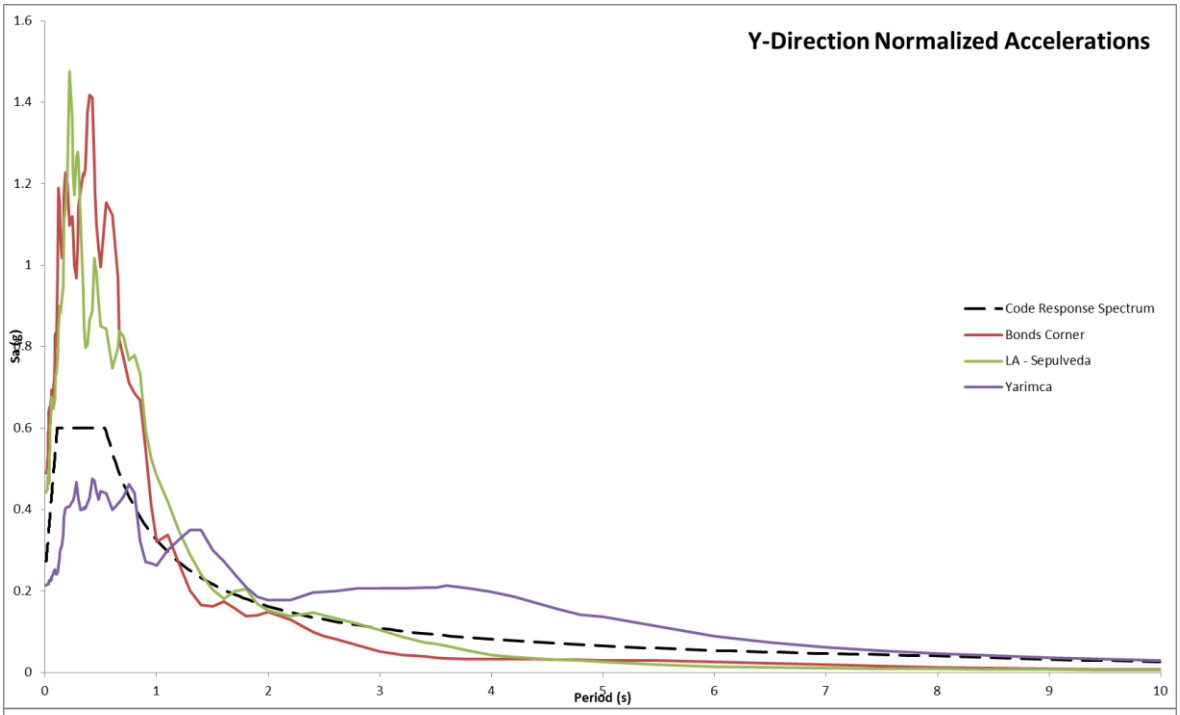

LA - Sepulveda VA (Unscaled)
Ground Acceleration (g)
Time (s)
LA - Sepulveda VA (Scaled)
Ground Acceleration (g)
Time (s)

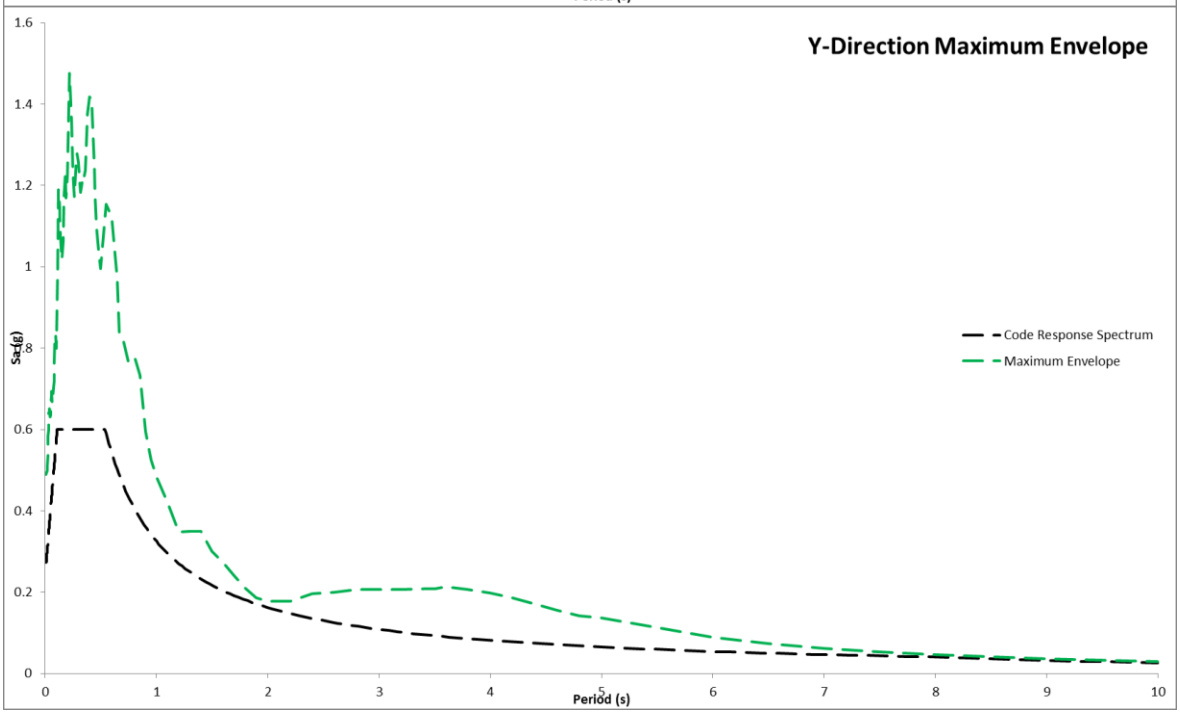

Yarimca (Unscaled)
Ground Acceleration (g)
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
0
5
10
15
20
25
30
35
Time (s)


Yarimca (Scaled)
Ground Acceleration (g)
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
0
5
10
15
20
25
30
35
Time (s)


X-Direction Accelerations
Sa (g)
Period (s)
Code Response Spectrum
El Centro Array #6
Rinaldi Receiving Station
Izmit


Y-Direction Accerlerations
Sa (g)
Period (s)
Code Response Spectrum
Bonds Corner
LA - Sepulveda
Yarimca


Y-Direction Normalized Accelerations
Sa(g)
Period (s)
Code Response Spectrum
Bonds Corner
LA - Sepulveda
Yarimca


Y-Direction Maximum Envelope
Sa(g)
Period (s)
Code Response Spectrum
Maximum Envelope

Appendix H: Construction Management Breadth

Existing Structure: Falls Church, VA

Superstructure:				
Description of Work	**Original Cost**	**Alterations**		**Revised Cost**
	Allocation	Change Orders	TRF	Allocation
Concrete:				
C-I-P Southland Concrete Corporation	5,020,000.00	11,243.00	57,031.00	5,088,274.00
OT Beyond Contractors Control	10,140.00			10,140.00
Concrete Housekeeping Pads	5,000.00			5,000.00
Crete-Seal Concrete Sealer	211,000.00			211,000.00
Undercut Unsuitable Soils	1,500.00			1,500.00
Allowance - ASI #1	2,662.00	(2,662.00)		-
Total Original Cost =	**5,250,302.00**	**Revised Cost =**		**5,315,914.00**
% of Total Building Cost =	**6.9%**	**% of Total Building Cost =**		**7.1%**

Building Enclosure/Façade:				
Description of Work	**Original Cost**	**Alterations**		**Revised Cost**
	Allocation	Change Orders	TRF	Allocation
Concrete:				
Arch Precase Concret - Arban & Carosi	1,340,000.00			1,340,000.00
Stainless Steel Gutter System	80,000.00			80,000.00
Masonry:				
Masonry - United Masonry	312,758.00	612.00	10,482.00	323,852.00
Stone Masonry - Neka	20,000.00		10,500.00	30,500.00
Metals:				
Misc. Metals - American Iron Workers	1,281,837.00	50,287.00	7,595.00	1,339,719.00
Misc. Metals	81,920.00			81,920.00
Expansion Joints - Construction Spec.	25,169.00			25,169.00
Thermal and Moisture Protection:				
Waterproofing - Prospect Waterproofing	178,951.00	52,198.00	83,539.00	314,688.00
Stucco	110,785.00			110,785.00
Roofing - Prospect Waterproofing	534,725.00	(160.00)		534,565.00
Fireproofing - Artic Fireproofing	113,651.00			113,651.00
Firestopping - Z & E Enterprises	240,250.00	2,276.00	632.00	243,158.00
Joint Sealants - Caulking	147,465.00			147,465.00
Doors and Windows:				
Glass and Glazing - Trainor Glass Co.	2,475,000.00	13,435.00	17,505.00	2,505,940.00
OT Beyond Contractors Control	3,000.00			3,000.00
1% Glass Breakage	25,000.00			25,000.00
Allowance - ASI #1	940.00	(940.00)		-
Specialties:				
Wall Protection - Construction Spec.	252,673.00			252,673.00
Louvers - Construction Spec.	117,513.00	(1,925.00)	1,600.00	117,188.00
Window Treatments	65,048.00			65,048.00
Window Washing Equipment	60,274.00		11,576.00	71,850.00
Total Original Cost =	**6,971,451.00**	**Revised Cost =**		**7,219,412.00**
% of Total Building Cost =	**9.2%**	**% of Total Building Cost =**		**9.6%**

Proposed Structure: Falls Church, VA: CA – Base Isolated Model (Only sample floor calculations are shown)

Ground Floor										
Concrete Costs										
Slab (5")	Materials:	$	109.00	per cu. yrds	x	393.7	cu. yrds	=	$	42,915.39
	Labor:	$	41.40	per cu. yrds	x	393.7	cu. yrds	=	$	16,299.97
Beams/ Girder (24"x24")	Materials:	$	109.00	per cu. yrds	x	153.1	cu. yrds	=	$	16,683.06
	Labor:	$	35.55	per cu. yrds	x	153.1	cu. yrds	=	$	5,441.13
Joists (12"x24")	Materials:	$	109.00	per cu. yrds	x	169.2	cu. yrds	=	$	18,439.17
	Labor:	$	87.00	per cu. yrds	x	169.2	cu. yrds	=	$	14,717.50
Columns (34"x34")	Materials:	$	202.00	per cu. yrds	x	72.2	cu. yrds	=	$	14,588.89
	Labor:	$	22.75	per cu. yrds	x	72.2	cu. yrds	=	$	1,643.06
Walls (12")	Materials:	$	109.00	per cu. yrds	x	37.5	cu. yrds	=	$	4,083.26
	Labor:	$	29.00	per cu. yrds	x	37.5	cu. yrds	=	$	1,086.37
Formwork Costs										
Slab (5")	Materials:	$	2.92	per sq. ft.	x	25513	sq. ft.	=	$	74,497.96
	Labor:	$	4.12	per sq. ft.	x	25513	sq. ft.	=	$	105,113.56
Beams/ Girder (24"x24")	Materials:	$	0.66	per sq. ft.	x	7178	sq. ft.	=	$	4,737.15
	Labor:	$	5.20	per sq. ft.	x	7178	sq. ft.	=	$	37,323.00
Joists (12"x24")	Materials:	$	0.99	per sq. ft.	x	9135	sq. ft.	=	$	9,043.65
	Labor:	$	5.45	per sq. ft.	x	9135	sq. ft.	=	$	49,785.75
Columns (34"x34")	Materials:	$	0.75	per sq. ft.	x	4260	sq. ft.	=	$	3,194.91
	Labor:	$	2.91	per sq. ft.	x	4260	sq. ft.	=	$	12,396.25
Walls (12")	Materials:	$	0.74	per sq. ft.	x	1966	sq. ft.	=	$	1,455.12
	Labor:	$	4.58	per sq. ft.	x	1966	sq. ft.	=	$	9,005.99
Mild Steel Reinforcing Costs										
	Materials:	$	980.00	per tons	x	67.5	tons	=	$	66,198.13
	Labor:	$	980.00	per tons	x	67.5	tons	=	$	66,198.13
							Total	**=**	**$**	**574,847.38**

4th Floor										
Concrete Costs										
Slab (5")	Materials:	$	109.00	per cu. yrds	x	275.2	cu. yrds	=	$	29,993.92
	Labor:	$	41.40	per cu. yrds	x	275.2	cu. yrds	=	$	11,392.19
Beams/ Girder (24"x24")	Materials:	$	109.00	per cu. yrds	x	162.9	cu. yrds	=	$	17,758.98
	Labor:	$	35.55	per cu. yrds	x	162.9	cu. yrds	=	$	5,792.03
Joists (12"x24")	Materials:	$	109.00	per cu. yrds	x	95.9	cu. yrds	=	$	10,448.86
	Labor:	$	87.00	per cu. yrds	x	95.9	cu. yrds	=	$	8,339.92
Columns (26"x26")	Materials:	$	202.00	per cu. yrds	x	53.7	cu. yrds	=	$	10,840.67
	Labor:	$	22.75	per cu. yrds	x	53.7	cu. yrds	=	$	1,220.92
Walls (12")	Materials:	$	109.00	per cu. yrds	x	68.8	cu. yrds	=	$	7,504.04
	Labor:	$	29.00	per cu. yrds	x	68.8	cu. yrds	=	$	1,996.49
Formwork Costs										
Slab (5")	Materials:	$	2.92	per sq. ft.	x	15850	sq. ft.	=	$	46,282.00
	Labor:	$	4.12	per sq. ft.	x	15850	sq. ft.	=	$	65,302.00
Beams/ Girder (24"x24")	Materials:	$	0.66	per sq. ft.	x	4945	sq. ft.	=	$	3,263.37
	Labor:	$	5.20	per sq. ft.	x	4945	sq. ft.	=	$	25,711.40
Joists (12"x24")	Materials:	$	0.99	per sq. ft.	x	5177	sq. ft.	=	$	5,124.74
	Labor:	$	5.45	per sq. ft.	x	5177	sq. ft.	=	$	28,211.93
Columns (26"x26")	Materials:	$	0.86	per sq. ft.	x	3355	sq. ft.	=	$	2,884.93
	Labor:	$	3.04	per sq. ft.	x	3355	sq. ft.	=	$	10,197.89
Walls (12")	Materials:	$	0.74	per sq. ft.	x	1883	sq. ft.	=	$	1,393.63
	Labor:	$	4.58	per sq. ft.	x	1883	sq. ft.	=	$	8,625.44
Mild Steel Reinforcing Costs										
	Materials:	$	980.00	per tons	x	38.7	tons	=	$	37,948.36
	Labor:	$	980.00	per tons	x	38.7	tons	=	$	37,948.36
							Total	**=**	**$**	**378,182.06**

Proposed Structure: Falls Church, VA: CA – Fixed Model (Only sample floor calculations are shown)

Ground Floor										
Concrete Costs										
Slab (5")	Materials:	$	109.00	per cu. yrds	x	393.7	cu. yrds	=	$	42,915.39
	Labor:	$	41.40	per cu. yrds	x	393.7	cu. yrds	=	$	16,299.97
Beams/ Girder (24"x36")	Materials:	$	109.00	per cu. yrds	x	249.7	cu. yrds	=	$	27,219.72
	Labor:	$	35.55	per cu. yrds	x	249.7	cu. yrds	=	$	8,877.63
Joists (12"x24")	Materials:	$	109.00	per cu. yrds	x	169.2	cu. yrds	=	$	18,439.17
	Labor:	$	87.00	per cu. yrds	x	169.2	cu. yrds	=	$	14,717.50
Columns (36"x36")	Materials:	$	202.00	per cu. yrds	x	90.3	cu. yrds	=	$	18,236.11
	Labor:	$	22.75	per cu. yrds	x	90.3	cu. yrds	=	$	2,053.82
Walls (16")	Materials:	$	109.00	per cu. yrds	x	49.9	cu. yrds	=	$	5,442.99
	Labor:	$	26.40	per cu. yrds	x	49.9	cu. yrds	=	$	1,318.30
Formwork Costs										
Slab (5")	Materials:	$	2.92	per sq. ft.	x	25513	sq. ft.	=	$	74,497.96
	Labor:	$	4.12	per sq. ft.	x	25513	sq. ft.	=	$	105,113.56
Beams/ Girder (24"x36")	Materials:	$	0.66	per sq. ft.	x	8483	sq. ft.	=	$	5,598.45
	Labor:	$	5.20	per sq. ft.	x	8483	sq. ft.	=	$	44,109.00
Joists (12"x24")	Materials:	$	0.99	per sq. ft.	x	9135	sq. ft.	=	$	9,043.65
	Labor:	$	5.45	per sq. ft.	x	9135	sq. ft.	=	$	49,785.75
Columns (36"x36")	Materials:	$	0.75	per sq. ft.	x	6390	sq. ft.	=	$	4,792.37
	Labor:	$	2.91	per sq. ft.	x	6390	sq. ft.	=	$	18,594.38
Walls (16")	Materials:	$	0.74	per sq. ft.	x	1966	sq. ft.	=	$	1,455.12
	Labor:	$	4.58	per sq. ft.	x	1966	sq. ft.	=	$	9,005.99
Mild Steel Reinforcing Costs										
	Materials:	$	980.00	per tons	x	74.3	tons	=	$	72,817.94
	Labor:	$	980.00	per tons	x	74.3	tons	=	$	72,817.94
							Total	=	**$**	**623,152.70**

4th Floor										
Concrete Costs										
Slab (5")	Materials:	$	109.00	per cu. yrds	x	275.2	cu. yrds	=	$	29,993.92
	Labor:	$	41.40	per cu. yrds	x	275.2	cu. yrds	=	$	11,392.19
Beams/ Girder (24"x36")	Materials:	$	109.00	per cu. yrds	x	265.6	cu. yrds	=	$	28,947.13
	Labor:	$	35.55	per cu. yrds	x	265.6	cu. yrds	=	$	9,441.01
Joists (12"x24")	Materials:	$	109.00	per cu. yrds	x	95.9	cu. yrds	=	$	10,448.86
	Labor:	$	87.00	per cu. yrds	x	95.9	cu. yrds	=	$	8,339.92
Columns (28"x28")	Materials:	$	202.00	per cu. yrds	x	67.1	cu. yrds	=	$	13,550.83
	Labor:	$	22.75	per cu. yrds	x	67.1	cu. yrds	=	$	1,526.15
Walls (16")	Materials:	$	109.00	per cu. yrds	x	68.8	cu. yrds	=	$	7,504.04
	Labor:	$	26.40	per cu. yrds	x	68.8	cu. yrds	=	$	1,817.49
Formwork Costs										
Slab (5")	Materials:	$	2.92	per sq. ft.	x	15850	sq. ft.	=	$	46,282.00
	Labor:	$	4.12	per sq. ft.	x	15850	sq. ft.	=	$	65,302.00
Beams/ Girder (24"x36")	Materials:	$	0.66	per sq. ft.	x	5844	sq. ft.	=	$	3,856.71
	Labor:	$	5.20	per sq. ft.	x	5844	sq. ft.	=	$	30,386.20
Joists (12"x24")	Materials:	$	0.99	per sq. ft.	x	5177	sq. ft.	=	$	5,124.74
	Labor:	$	5.45	per sq. ft.	x	5177	sq. ft.	=	$	28,211.93
Columns (28"x28")	Materials:	$	0.86	per sq. ft.	x	3913	sq. ft.	=	$	3,365.27
	Labor:	$	3.04	per sq. ft.	x	3913	sq. ft.	=	$	11,895.83
Walls (16")	Materials:	$	0.74	per sq. ft.	x	1883	sq. ft.	=	$	1,393.63
	Labor:	$	4.58	per sq. ft.	x	1883	sq. ft.	=	$	8,625.44
Mild Steel Reinforcing Costs										
	Materials:	$	980.00	per tons	x	42.6	tons	=	$	41,743.20
	Labor:	$	980.00	per tons	x	42.6	tons	=	$	41,743.20
							Total	=	**$**	**410,891.70**

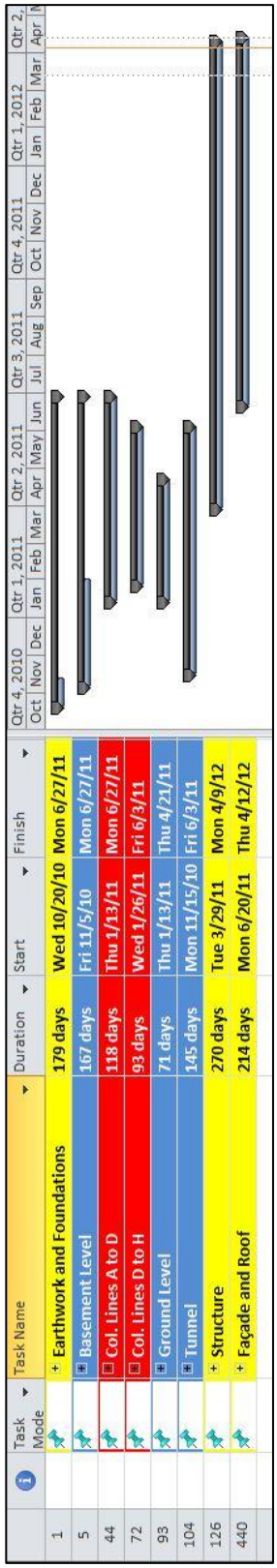
Proposed Structure: Falls Church, VA: CA – Base Isolated Model (Only sample floor calculations are shown)

Schedule Calculations for S-1 Base Isolated Structure					
	Ground Floor	**Daily Output**	**(units/day)**	**Quantity**	**Days Required**
Formwork	Slab	500	sq. ft	25513	51.0
	Beam/Girders	395	sq. ft	7178	18.2
	Joists	377	sq. ft	9135	24.2
	Columns	460	sq. ft	4260	9.3
	Walls	450	sq. ft	1966	4.4
	Mild Steel Reinforcing	2.3	tons	68	29.4
Placement	Slab	95	cubic yrds	394	4.1
	Beam/Girders	90	cubic yrds	153	1.7
	Joists	60	cubic yrds	169	2.8
	Columns	140	cubic yrds	72	0.5
	Walls	110	cubic yrds	37	0.3
	4th Floor	**Daily Output**	**(units/day)**	**Quantity**	**Days Required**
Formwork	Slab	500	sq. ft	15850	31.7
	Beam/Girders	395	sq. ft	4945	12.5
	Joists	377	sq. ft	5177	13.7
	Columns	460	sq. ft	3355	7.3
	Walls	450	sq. ft	1883	4.2
	Mild Steel Reinforcing	2.3	tons	39	16.8
Placement	Slab	95	cubic yrds	275	2.9
	Beam/Girders	90	cubic yrds	163	1.8
	Joists	60	cubic yrds	96	1.6
	Columns	140	cubic yrds	54	0.4
	Walls	110	cubic yrds	69	0.6
	Penthouse/Roof	**Daily Output**	**(units/day)**	**Quantity**	**Days Required**
Formwork	Slab	500	sq. ft	15850	31.7
	Beam/Girders	395	sq. ft	4945	12.5
	Joists	377	sq. ft	5177	13.7
	Columns	460	sq. ft	4637	10.1
	Walls	450	sq. ft	2603	5.8
	Mild Steel Reinforcing	2.3	tons	39	17.1
Placement	Slab	95	cubic yrds	275	2.9
	Beam/Girders	90	cubic yrds	163	1.8
	Joists	60	cubic yrds	96	1.6
	Columns	92	cubic yrds	36	0.4
	Walls	110	cubic yrds	47	0.4

Proposed Structure: Falls Church, VA: CA – Fixed Model (Only sample floor calculations are shown)

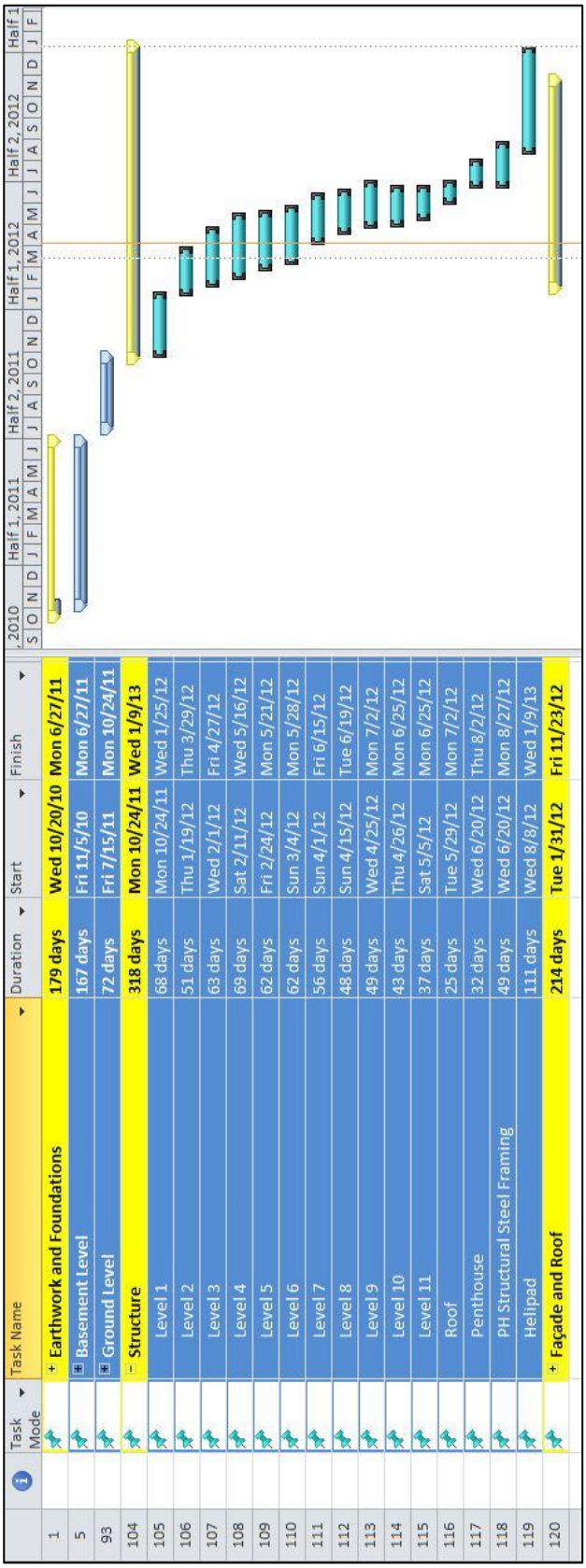
Schedule Calculations for S-1 Fixed Base Structure					
	Ground Floor	Daily Output	(units/day)	Quantity	Days Required
Formwork	Slab	500	sq. ft	25513	51.0
	Beam/Girders	395	sq. ft	8483	21.5
	Joists	377	sq. ft	9135	24.2
	Columns	460	sq. ft	6390	13.9
	Walls	450	sq. ft	1966	4.4
	Mild Steel Reinforcing	2.3	tons	74	32.3
Placement	Slab	95	cubic yrds	394	4.1
	Beam/Girders	90	cubic yrds	250	2.8
	Joists	60	cubic yrds	169	2.8
	Columns	140	cubic yrds	90	0.6
	Walls	120	cubic yrds	50	0.4
	4th Floor	Daily Output	(units/day)	Quantity	Days Required
Formwork	Slab	500	sq. ft	15850	31.7
	Beam/Girders	395	sq. ft	5844	14.8
	Joists	377	sq. ft	5177	13.7
	Columns	440	sq. ft	3913	8.9
	Walls	450	sq. ft	1883	4.2
	Mild Steel Reinforcing	2.3	tons	43	18.5
Placement	Slab	95	cubic yrds	275	2.9
	Beam/Girders	90	cubic yrds	266	3.0
	Joists	60	cubic yrds	96	1.6
	Columns	140	cubic yrds	67	0.5
	Walls	120	cubic yrds	69	0.6
	Penthouse/Roof	Daily Output	(units/day)	Quantity	Days Required
Formwork	Slab	500	sq. ft	15850	31.7
	Beam/Girders	395	sq. ft	5844	14.8
	Joists	377	sq. ft	5177	13.7
	Columns	440	sq. ft	5410	12.3
	Walls	450	sq. ft	2603	5.8
	Mild Steel Reinforcing	2.3	tons	43	18.8
Placement	Slab	95	cubic yrds	275	2.9
	Beam/Girders	90	cubic yrds	266	3.0
	Joists	60	cubic yrds	96	1.6
	Columns	92	cubic yrds	45	0.5
	Walls	120	cubic yrds	47	0.4

Existing Structure: Falls Church, VA: CA – Base Model



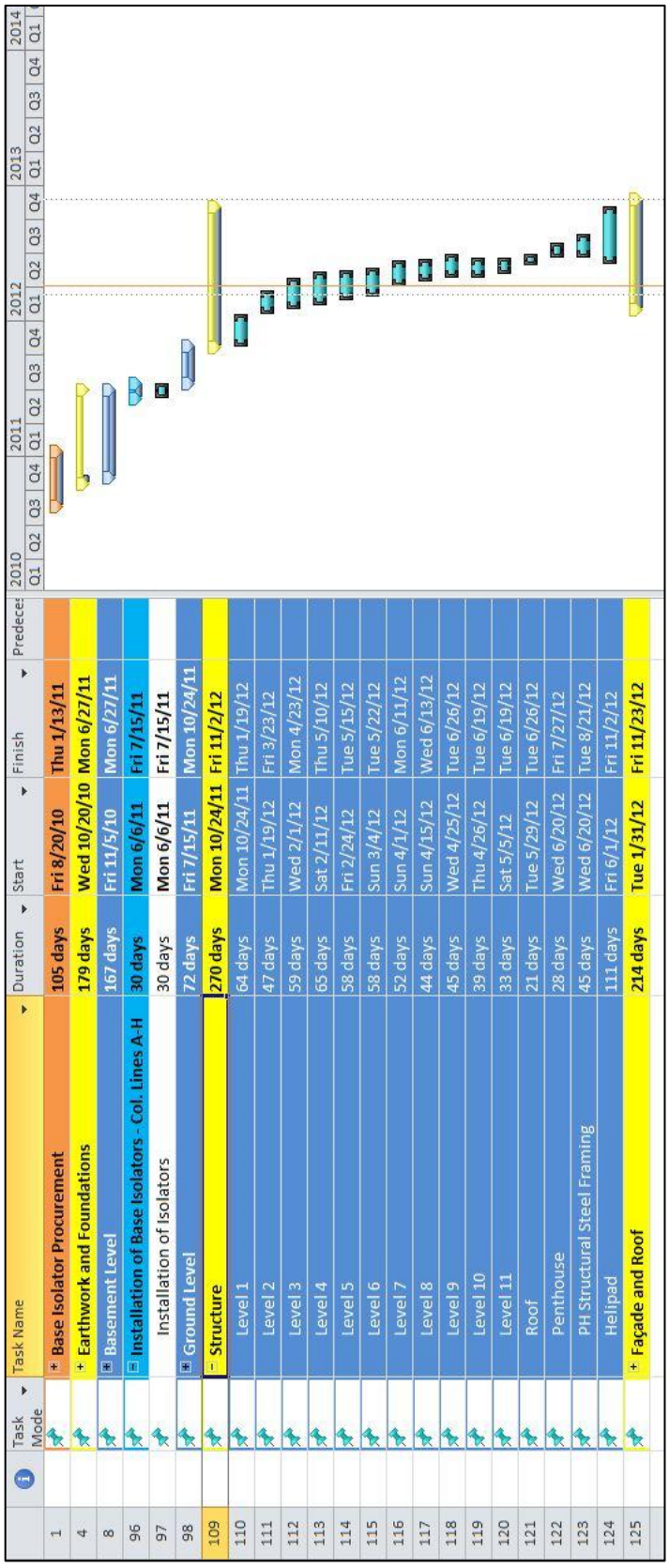
	Task Mode	Task Name	Duration	Start	Finish
1		+ Earthwork and Foundations	179 days	Wed 10/20/10	Mon 6/27/11
5		+ Basement Level	167 days	Fri 11/5/10	Mon 6/27/11
44		- Col. Lines A to D	118 days	Thu 1/13/11	Mon 6/27/11
72		- Col. Lines D to H	93 days	Wed 1/26/11	Fri 6/3/11
93		+ Ground Level	71 days	Thu 1/13/11	Thu 4/21/11
104		+ Tunnel	145 days	Mon 11/15/10	Fri 6/3/11
126		+ Structure	270 days	Tue 3/29/11	Mon 4/9/12
440		+ Façade and Roof	214 days	Mon 6/20/11	Thu 4/12/12

Proposed Structure: Falls Church, VA: CA – Fixed Model



	Task Mode	Task Name	Duration	Start	Finish
1		+ Earthwork and Foundations	179 days	Wed 10/20/10	Mon 6/27/11
5		⊞ Basement Level	167 days	Fri 11/5/10	Mon 6/27/11
93		⊞ Ground Level	72 days	Fri 7/15/11	Mon 10/24/11
104		− Structure	318 days	Mon 10/24/11	Wed 1/9/13
105		Level 1	68 days	Mon 10/24/11	Wed 1/25/12
106		Level 2	51 days	Thu 1/19/12	Thu 3/29/12
107		Level 3	63 days	Wed 2/1/12	Fri 4/27/12
108		Level 4	69 days	Sat 2/11/12	Wed 5/16/12
109		Level 5	62 days	Fri 2/24/12	Mon 5/21/12
110		Level 6	62 days	Sun 3/4/12	Mon 5/28/12
111		Level 7	56 days	Sun 4/1/12	Fri 6/15/12
112		Level 8	48 days	Sun 4/15/12	Tue 6/19/12
113		Level 9	49 days	Wed 4/25/12	Mon 7/2/12
114		Level 10	43 days	Thu 4/26/12	Mon 6/25/12
115		Level 11	37 days	Sat 5/5/12	Mon 6/25/12
116		Roof	25 days	Tue 5/29/12	Mon 7/2/12
117		Penthouse	32 days	Wed 6/20/12	Thu 8/2/12
118		PH Structural Steel Framing	49 days	Wed 6/20/12	Mon 8/27/12
119		Helipad	111 days	Wed 8/8/12	Wed 1/9/13
120		+ Façade and Roof	214 days	Tue 1/31/12	Fri 11/23/12

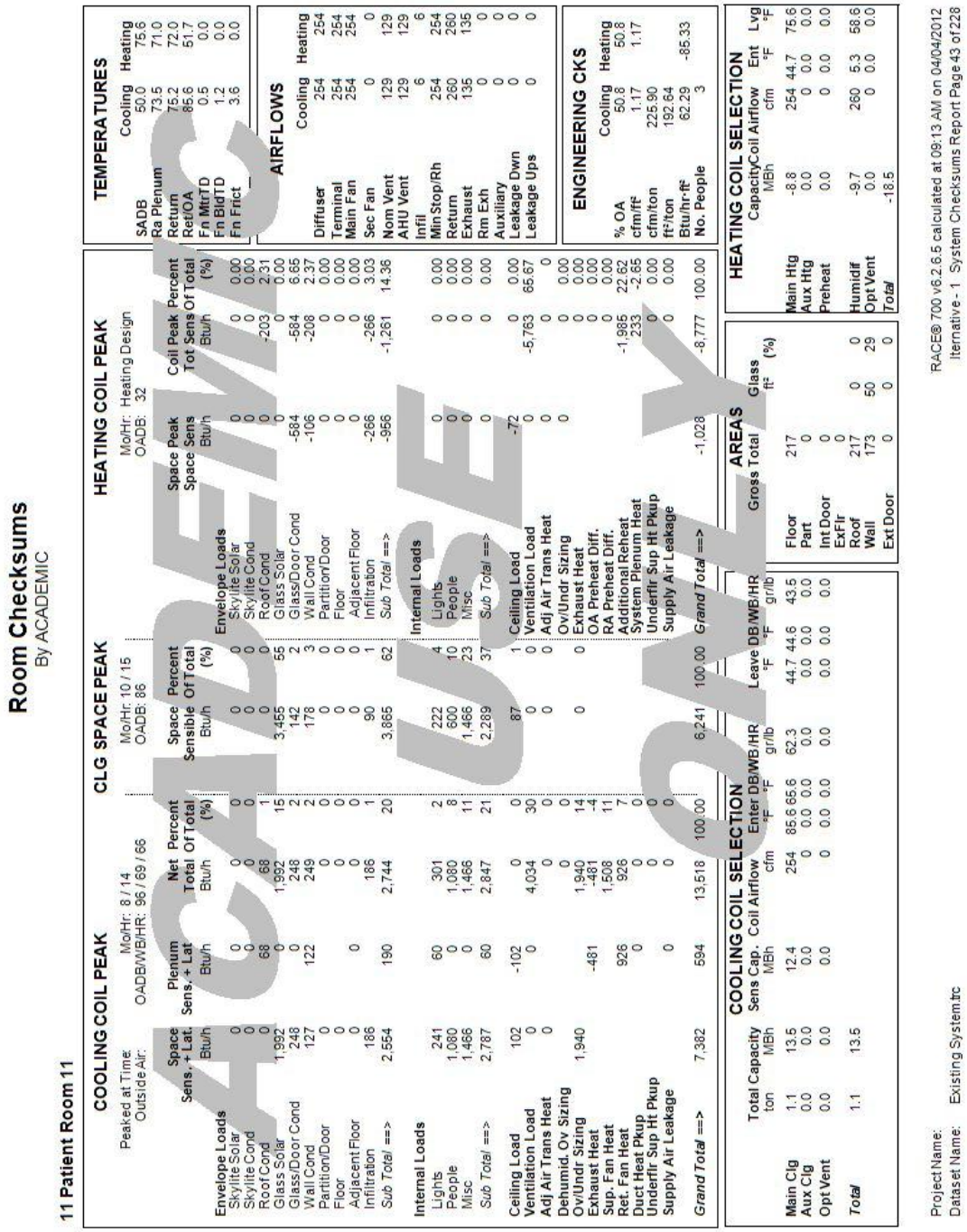
Proposed Structure: Falls Church, VA: CA – Base Isolation Model



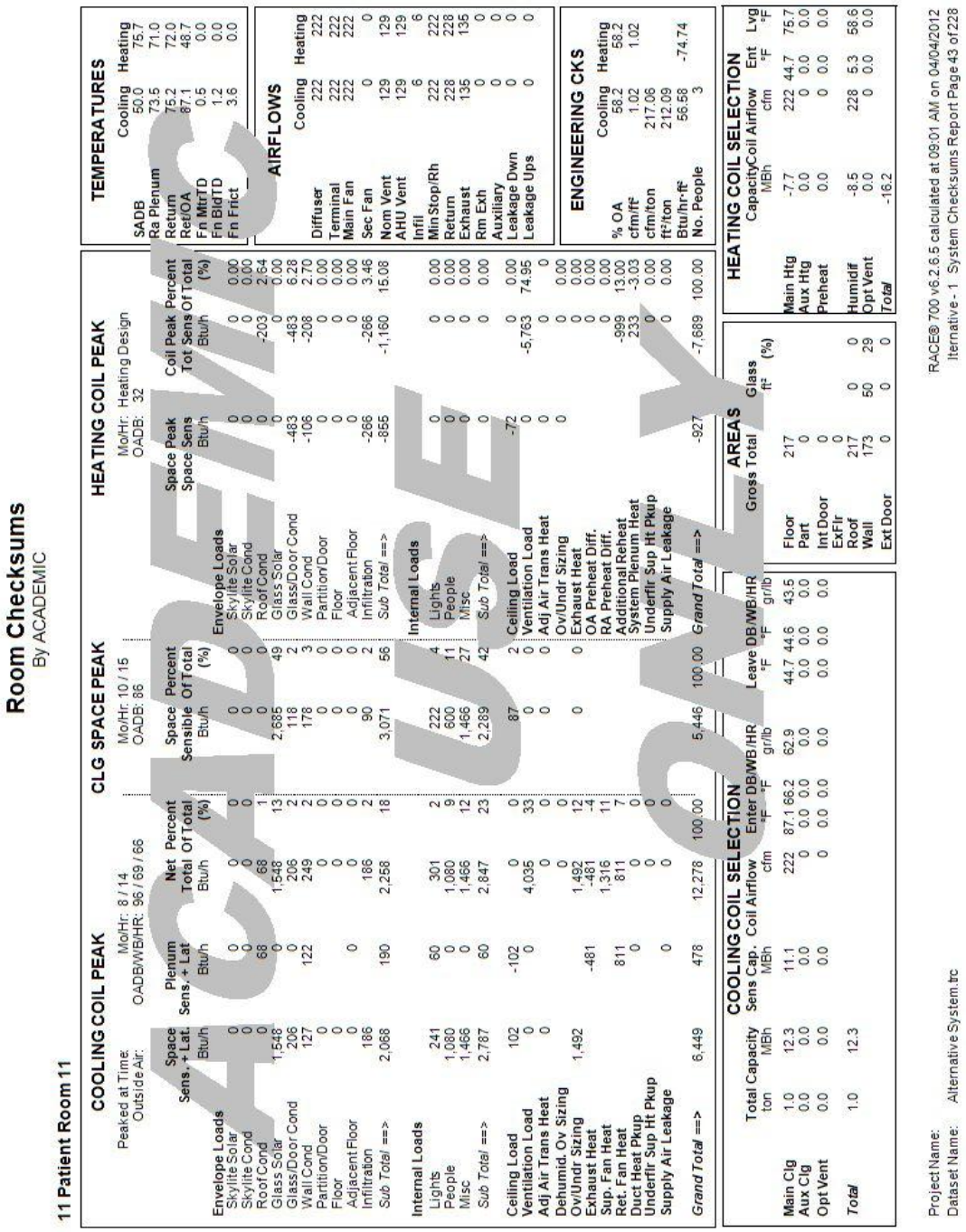
	Task Mode	Task Name	Duration	Start	Finish	Predecessors
1		+ Base Isolator Procurement	105 days	Fri 8/20/10	Thu 1/13/11	
4		+ Earthwork and Foundations	179 days	Wed 10/20/10	Mon 6/27/11	
8		+ Basement Level	167 days	Fri 11/5/10	Mon 6/27/11	
96		- Installation of Base Isolators - Col. Lines A-H	30 days	Mon 6/6/11	Fri 7/15/11	
97		Installation of Isolators	30 days	Mon 6/6/11	Fri 7/15/11	
98		+ Ground Level	72 days	Fri 7/15/11	Mon 10/24/11	
109		- Structure	270 days	Mon 10/24/11	Fri 11/2/12	
110		Level 1	64 days	Mon 10/24/11	Thu 1/19/12	
111		Level 2	47 days	Thu 1/19/12	Fri 3/23/12	
112		Level 3	59 days	Wed 2/1/12	Mon 4/23/12	
113		Level 4	65 days	Sat 2/11/12	Thu 5/10/12	
114		Level 5	58 days	Fri 2/24/12	Tue 5/15/12	
115		Level 6	58 days	Sun 3/4/12	Tue 5/22/12	
116		Level 7	52 days	Sun 4/1/12	Mon 6/11/12	
117		Level 8	44 days	Sun 4/15/12	Wed 6/13/12	
118		Level 9	45 days	Wed 4/25/12	Tue 6/26/12	
119		Level 10	39 days	Thu 4/26/12	Tue 6/19/12	
120		Level 11	33 days	Sat 5/5/12	Tue 6/19/12	
121		Roof	21 days	Tue 5/29/12	Tue 6/26/12	
122		Penthouse	28 days	Wed 6/20/12	Fri 7/27/12	
123		PH Structural Steel Framing	45 days	Wed 6/20/12	Tue 8/21/12	
124		Helipad	111 days	Fri 6/1/12	Fri 11/2/12	
125		+ Façade and Roof	214 days	Tue 1/31/12	Fri 11/23/12	

Appendix I: Mechanical/Building Enclosure Breadth

Existing Glazing: Sacramento, California



Alternate Glazing: Sacramento, California



Room Checksums
By ACADEMIC

11 Patient Room 11

COOLING COIL PEAK

Peaked at Time: Mo/Hr: 8 / 14
Outside Air: OADB/WB/HR: 96 / 69 / 66

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)
Envelope Loads	0	0	0	0
Skylite Solar	0	0	0	0
Skylite Cond	0	0	0	0
Roof Cond	0	68	68	1
Glass Solar	1,548	0	1,548	13
Glass/Door Cond	206	0	206	2
Wall Cond	127	122	249	2
Partition/Door	0		0	0
Floor	0		0	0
Adjacent Floor	0	0	0	0
Infiltration	186		186	2
Sub Total ==>	2,068	190	2,258	18
Internal Loads				
Lights	241	60	301	2
People	1,080	0	1,080	9
Misc	1,466	0	1,466	12
Sub Total ==>	2,787	60	2,847	23
Ceiling Load	102	-102	0	0
Ventilation Load	0	0	4,035	33
Adj Air Trans Heat	0		0	0
Dehumid. Ov Sizing			0	0
Ov/Undr Sizing	1,492		1,492	12
Exhaust Heat		-481	-481	-4
Sup. Fan Heat			1,316	11
Ret. Fan Heat		811	811	7
Duct Heat Pkup		0	0	0
Underfir Sup Ht Pkup				0
Supply Air Leakage		0	0	0
Grand Total ==>	6,449	478	12,278	100.00

CLG SPACE PEAK

Mo/Hr: 10 / 15
OADB: 86

	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads	0	0
Skylite Solar	0	0
Skylite Cond	0	0
Roof Cond	0	0
Glass Solar	2,685	49
Glass/Door Cond	118	2
Wall Cond	178	3
Partition/Door	0	0
Floor	0	0
Adjacent Floor	0	0
Infiltration	90	2
Sub Total ==>	3,071	56
Internal Loads		
Lights	222	4
People	600	11
Misc	1,466	27
Sub Total ==>	2,289	42
Ceiling Load	87	2
Ventilation Load	0	0
Adj Air Trans Heat	0	0
Ov/Undr Sizing	0	0
Exhaust Heat		
OA Preheat Diff.		
RA Preheat Diff.		
Additional Reheat		
System Plenum Heat		
Underfir Sup Ht Pkup		
Supply Air Leakage		
Grand Total ==>	5,446	100.00

HEATING COIL PEAK

Mo/Hr: Heating Design
OADB: 32

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads	0	0	0.00
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	-203	2.64
Glass Solar	0	0	0.00
Glass/Door Cond	-483	-483	6.28
Wall Cond	-106	-208	2.70
Partition/Door	0	0	0.00
Floor	0	0	0.00
Adjacent Floor	0	0	0.00
Infiltration	-266	-266	3.46
Sub Total ==>	-855	-1,160	15.08
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	0	0	0.00
Sub Total ==>	0	0	0.00
Ceiling Load	-72	0	0.00
Ventilation Load	0	-5,763	74.95
Adj Air Trans Heat	0	0	0
Ov/Undr Sizing	0		0.00
Exhaust Heat		0	0.00
OA Preheat Diff.		0	0.00
RA Preheat Diff.		0	0.00
Additional Reheat		-999	13.00
System Plenum Heat		233	-3.03
Underfir Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	-927	-7,689	100.00

TEMPERATURES

	Cooling	Heating
SADB	50.0	75.7
Ra Plenum	73.5	71.0
Return	75.2	72.0
Ret/OA	87.1	48.7
Fn MtrTD	0.5	0.0
Fn BldTD	1.2	0.0
Fn Frict	3.6	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	222	222
Terminal	222	222
Main Fan	222	222
Sec Fan	0	0
Nom Vent	129	129
AHU Vent	129	129
Infil	6	6
MinStop/Rh	222	222
Return	228	228
Exhaust	135	135
Rm Exh	0	0
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	58.2	58.2
cfm/ft²	1.02	1.02
cfm/ton	217.06	
ft²/ton	212.09	
Btu/hr-ft²	56.58	-74.74
No. People	3	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB/HR °F gr/lb	Leave DB °F	Leave WB/HR °F gr/lb
Main Clg	1.0	12.3	11.1	222	87.1	66.2 62.9	44.7	44.6 43.5
Aux Clg	0.0	0.0	0.0	0	0.0	0.0 0.0	0.0	0.0 0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0 0.0	0.0	0.0 0.0
Total	1.0	12.3						

AREAS

	Gross Total ft²	Glass ft² (%)
Floor	217	
Part	0	
Int Door	0	
ExFlr	0	
Roof	217	0 0
Wall	173	50 29
Ext Door	0	0 0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-7.7	222	44.7	75.7
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Humidif	-8.5	228	5.3	58.6
Opt Vent	0.0	0	0.0	0.0
Total	-16.2			

Project Name:
Dataset Name: Alternative System.trc

RACE® 700 v6.2.6.5 calculated at 09:01 AM on 04/04/2012
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Alternate Glazing Cut Sheet: Sacramento, California (Courtesy of Oldcastle)

ARCHITECTURAL GUIDE SPECIFICATION
SECTION 08 81 00 GLASS GLAZING

Note to Specifiers:

The specifications below are suggested as desirable inclusions in glass and glazing specifications (section 08 81 00), but are not intended to be complete. An appropriate and qualified Architect or Engineer must verify suitability of a particular product for use in a particular application as well as review final specifications. Oldcastle BuildingEnvelope™ assumes no responsibility or liability for the information included or not included in these specifications.

PRODUCTS

Approved Glass Fabricator
Oldcastle BuildingEnvelope™

Glass Description
FLOAT GLASS

1. USA - Annealed float glass shall comply with ASTM C1036, Type I, Class 1 (clear), Class 2 (tinted), Quality-Q3. Canada - Annealed float glass shall comply with CAN/CGSB-12.3-M, Quality-Glazing.

2. USA- Heat-strengthened float glass shall comply with ASTM C1048, Type I, Class 1 (clear), Class 2 (tinted), Quality Q3, Kind HS. Canada - Heat-strengthened float glass shall comply with CAN/CGSB-12.9-M, Type 2-Heat-Strengthened Glass, Class A-Float Glass.

3. USA - Tempered float glass shall comply with ASTM C1048, Type I, Class 1 (clear), Class 2 (tinted), Quality Q3, Kind FT. Canada - Tempered float glass shall comply with CAN/CGSB-12.1-M, Type 2-Tempered Glass, Class B-Float Glass.

4. USA - Laminated glass to comply with ASTM C1172. Canada - Laminated glass to comply with CAN/CGSB-12.1-M, Type 1-Laminated Glass, Class B-Float Glass.

5. Glass shall be annealed, heat-strengthened or tempered as required by codes, or as required to meet thermal stress and wind loads.

Sealed Insulating Glass (IG) Vision Glass (Vertical)

GENERAL

1. IG units consist of glass lites separated by a dehydrated airspace that is hermetically dual sealed with a primary seal of polyisobutylene (PIB), or thermo plastic spacer (TPS) and a secondary seal of silicone or an organic sealant depending on the application.

2. USA - Insulating glass units are certified through the Insulating Glass Certification Council (IGCC) to ASTM E2190. Canada - Insulating Glass units are certified through the Insulating Glass Manufacturers Alliance (IGMA) to either the IGMAC certification program to CAN/CGSB-12.8, or through the IGMA program to ASTM E2190.

IG VISION UNIT PERFORMANCE CHARACTERISTICS

1. Exterior Lite
1/4" Oldcastle BuildingEnvelope™ SunGlass® Low-E #2

2. Interior Lite
1/4" Clear

3. 1/2" Cavity
1/2 inch (90% Argon Fill)

4. Performance Characteristics

Thermal		Optical	
Winter U-factor/U-value:	0.24	Visible Light Transmittance:	50%
Summer U-factor/U-value:	0.21	Visible Light Reflectance (outside):	8%
Solar Heat Gain Coefficient:	0.24	Visible Light Reflectance (inside):	11%
Shading Coefficient:	0.28	Total Solar Transmittance:	20%
Relative Heat Gain (Btu/hr-ft²):	58	Total Solar Reflectance (outside):	28%
Light to Solar Gain:	2.08	Ultraviolet Transmittance:	4%

Contact Oldcastle BuildingEnvelope™ at 866-Oldcastle (653-2278) for samples or additional information concerning performance, strength, deflection, thermal stress or application guidelines. GlasSelect® calculates center of glass performance data using the Lawrence Berkeley National Laboratory (LBNL) Window 5.2 program (version 5.2.17) with Environmental Conditions set at NFRC 100-2001. Gas Library ID#1 (Air) is used for Insulating Glass units with air. Gas Library ID#9 (10% Air/90% Argon) is used for Insulating Glass units with argon. Monolithic glass data is from the following sources: 1. LBNL International Glazing Database (IGDB) version 18.1; 2. Vendor supplied spectral data files. Laminated glass data is from the following sources: 1. LBNL International Glazing Database (IGDB) version 18.1; 2. LBNL Optics 5 (version 5.1 Maintenance Pack 2); 3. Vendor supplied spectral data files; 4. Vendor supplied data. Thermal values are in Imperial units.