T.C. WILLIAMS HIGH SCHOOL

ALEXANDRIA, VA

CHRISTOPHER B. DEKER

STRUCTURAL OPTION

APPENDIX C – STRUCTURAL CALCS

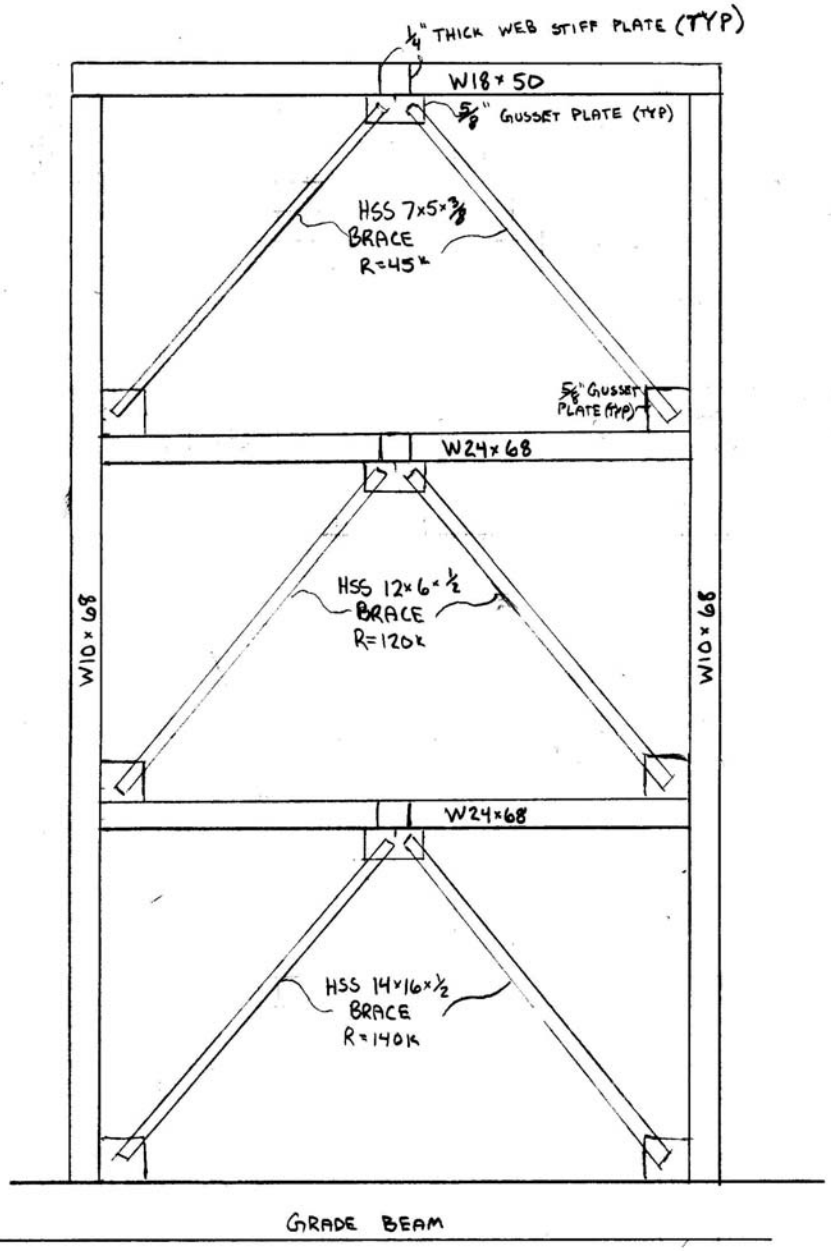
09 APRIL 2008

FACULTY CONSULTANT: PROF PARFITT

APPENDIX C – STRUCTURAL CALCULATIONS

SPOT CHECK - BRACED FRAME

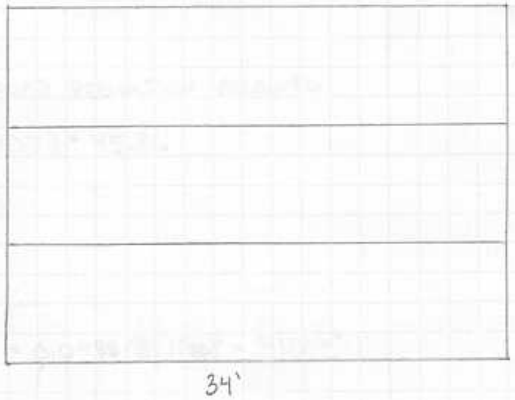
BRACE 1 DETAILS



SCALE: NOT TO SCALE

COMPOSITE JOIST DESIGN - FOR STRENGTH

JOIST GEOMETRY
1) JOIST DEPTH ~ 20"
2) JOIST SPAN ~ 34'0"
3 JOICE SPACING ~ 7.67'



DESIGN LOADS
1) NONCOMPOSITE DL
a) CONCRETE ~ 43 PSF
b) JOIST (EST) ~ 4.5 PSF
c) DECK ~ 2.5 PSF
TOTAL = 50 PSF = 383 PLF

2) CONSTRUCTION LL ~ 20.0 PSF

3) COMPISITE DL
a) MECHANICAL ~ 7 PSF
b) ELECTRICAL ~ 4 PSF
c) FIREPROOFING ~ 2 PSF
d) CEILING MISC ~ 3 PSF
TOTAL = 16 PSF = 123 PLF

4) COMPOSITE LL
a) DESIGN LL ~ 50.0 PSF
b) REDUCTION FACTOR ~ 0.907
c) REDUCED DESIGN LL ~ 46 PSF
TOTAL = 46 PSF = 353 PLF

TOTAL LOADING = 859 PLF
COMPOSITE = 476 PLF

JOIST DESIGN SUMMARY

20 VC 1200 / 353 / 123

JOIST WEIGHT = 21 PLF
USE 18-3/4" SHEAR STUDS
USE 2 ROWS BRIDGING
W360=1210 > 353 PLF ✓OK
TL=1200 > 859 PLF ✓OK

CONCRETE AND DECK
1) DECK ~ 2VL1 - 19 GAUGE
2) CONCRETE UNIT WEIGHT ~ 145 PSF
3) CONCRETE COMPRESSIVE STRENGTH ~ 4 KSI
4) SLAB THICKNESS ABOVE DECK ~ 2½"

DEFLECTION
1) LIVE LOAD = (34)(12)/360 = 1.13"
2) TOTAL LOAD = (34)(12)/240 = 1.70"

LIVE LOAD REDUCTION

$L = L_o(0.25 + \frac{15}{A_L})$

$L_o = 50$ PSF
$A_T = 7.67' \times 34' = 260$ SF
$A_L = 521$ SF > 400 SF MIN ∴ LIVE LOAD REDUCTION ALLOWED

$L = 50^{PSF}(0.25 + \frac{15}{521}) = 50(0.907) = 45.36$

$L = 46$ PSF

DEFLECTIONS

$I_{EST\ NONCOMP} = 0.0488(W_{LJ})d^2_{JOIST} = 0.0488(21)(20)^2 = \underline{410\ IN^4}$

$W_{LJ} = 21$ PLF
$d_{JOIST} = 20"$

$\Delta_{EST\ NON\ COMP\ DL} = \frac{1.15(5)W_{NON\ COMP\ DL}(SPAN)^4(1728)}{384 E_s I_{EST\ NONCOMP}} = \frac{1.15(5)(383)(33.667')^4(1728)}{384(29,000,000)(410)}$

$\underline{\Delta_{EST\ NC\ DL} = 1.07" = L/381}$

$\Delta_{COMP\ DL} = \frac{W_{C\ DL}}{W_{L/360}} \cdot \left[\frac{L}{360}\right] = \frac{123}{1210} \cdot \left(\frac{33.667'(12")}{360}\right) = \underline{0.114"} = L/3579$

$\Delta_{COMP\ LL} = \frac{W_{C\ LL}}{W_{L/360}} \cdot \left[\frac{L}{360}\right] = \frac{353}{1210} \cdot \left(\frac{33.667'(12")}{360}\right) = \underline{0.327"} = L/1246$

$\Delta_{TL} = \Delta_{EST\ NC\ DL} + \Delta_{C\ DL} + \Delta_{C\ LL} = 1.07" + 0.114" + 0.327" = \underline{1.51"}$

$\boxed{\Delta_{TL} = 1.51" < \Delta_{TL\ MAX} = 1.70"\ \checkmark OK}$

SUMMARY

20 VC 1200 / 353 / 123

VC SERIES STEEL JOIST DEPTH — TOTAL LOAD ALLOWED — COMP LL ACTUAL — COMP DL ACTUAL

JOIST WEIGHT = 21 PLF JOIST BEARING DEPTH = 5"
USE 18 - 3/4" SHEAR STUDS
USE 2 ROWS BRIDGING

$\Delta_{EST\ NC\ DL} = 1.07"$
$\Delta_{COMP\ DL} = 0.114"$
$\Delta_{COMP\ LL} = 0.327"$

VULCRAFT

WEIGHT TABLE AND DESIGN GUIDE
VULCRAFT COMPOSITE STEEL JOISTS, VC SERIES

Based on Allowable Tensile Stress of 30,000 psi

Joist Span	Joist Depth	Slab Design: Normal Weight Concrete (145 pcf) f'c = 3.0 ksi																		
		tc (in)	2.00	2.00	2.00	2.00	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	3.00	3.00	3.00	3.00
		hr (in)	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0	3.0	3.0	3.0	3.0
		Js (ft)	3.5	4.0	4.0	4.5	5.0	6.0	6.5	7.0	8.0	8.5	9.0	10.0	10.0	10.0	10.0	11.0	12.0	12.0	12.0
		Total Uniformly Distributed Joist Load in Pounds Per Linear Foot																			
(ft)	(in)	TL	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1800	2000	2200	2400	2700	3000
32	12	Wtj (plf)	10	11	13	15	16	18	20	23	25	27	28	30	33	37	41	43	46	59	71
		W360 (plf)	271	348	389	452	580	657	724	766	890	957	1022	1021	1112	1245	1365	1712	1706	1916	2202
		N-ds	20-1/2	24-1/2	26-1/2	30-1/2	32-1/2	34-1/2	36-1/2	32-5/8	24-3/4	26-3/4	30-3/4	30-3/4	34-3/4	40-3/4	48-3/4	48-3/4	50-3/4	60-3/4	60-3/4
	14	Wtj (plf)	9	11	12	13	14	17	18	19	23	24	26	27	29	34	37	39	40	46	57
		W360 (plf)	304	374	442	505	635	753	836	916	982	1037	1107	1191	1273	1406	1560	1905	1910	2094	2384
		N-ds	20-1/2	22-1/2	26-1/2	28-1/2	28-1/2	32-1/2	34-1/2	36-1/2	20-3/4	20-3/4	24-3/4	26-3/4	26-3/4	34-3/4	40-3/4	42-3/4	44-3/4	50-3/4	60-3/4
	16	Wtj (plf)	9	10	11	13	13	15	17	19	21	23	24	26	26	29	34	36	39	46	47
		W360 (plf)	338	417	496	581	717	787	924	1029	1066	1166	1232	1334	1340	1550	1699	2053	2282	2526	2518
		N-ds	18-1/2	20-1/2	22-1/2	26-1/2	24-1/2	28-1/2	32-1/2	34-1/2	18-3/4	20-3/4	22-3/4	24-3/4	24-3/4	29-3/4	34-3/4	34-3/4	42-3/4	48-3/4	50-3/4
	18	Wtj (plf)	9	9	11	12	13	13	15	17	20	22	23	23	25	28	31	32	36	41	47
		W360 (plf)	364	438	531	611	779	854	928	1010	1124	1248	1366	1379	1452	1684	1792	2115	2340	2625	2908
		N-ds	18-1/2	20-1/2	22-1/2	24-1/2	24-1/2	26-1/2	28-1/2	30-1/2	18-3/4	18-3/4	20-3/4	20-3/4	22-3/4	26-3/4	30-3/4	32-3/4	36-3/4	42-3/4	50-3/4
	20	Wtj (plf)	8	9	10	12	12	13	14	15	20	21	22	22	23	26	28	30	34	38	43
		W360 (plf)	399	467	538	685	789	932	999	1084	1180	1282	1407	1417	1562	1796	1957	2251	2435	2701	3031
		N-ds	18-1/2	20-1/2	20-1/2	22-1/2	20-1/2	24-1/2	26-1/2	26-1/2	18-3/4	18-3/4	20-3/4	20-3/4	22-3/4	24-3/4	26-3/4	28-3/4	32-3/4	38-3/4	44-3/4
	22	Wtj (plf)	8	9	10	11	12	13	14	15	19	20	21	22	22	24	27	29	30	36	40
		W360 (plf)	395	489	570	718	880	966	1049	1138	1220	1327	1441	1579	1594	1775	2039	2304	2517	2953	3013
		N-ds	18-1/2	18-1/2	20-1/2	22-1/2	20-1/2	22-1/2	24-1/2	26-1/2	16-3/4	18-3/4	18-3/4	20-3/4	22-3/4	24-3/4	26-3/4	26-3/4	28-3/4	38-3/4	38-3/4
	24	Wtj (plf)	8	9	10	11	12	12	13	14	18	19	20	21	22	24	26	28	29	33	38
		W360 (plf)	426	513	643	693	875	1000	1079	1172	1236	1349	1466	1591	1747	1930	2091	2331	2554	2919	3241
		N-ds	18-1/2	18-1/2	20-1/2	20-1/2	20-1/2	20-1/2	24-1/2	26-1/2	16-3/4	14-3/4	16-3/4	18-3/4	20-3/4	22-3/4	24-3/4	24-3/4	26-3/4	32-3/4	38-3/4
	26	Wtj (plf)	8	9	10	11	12	12	13	14	18	18	19	20	21	23	24	27	29	32	35
		W360 (plf)	428	521	647	710	890	967	1102	1197	1240	1349	1475	1594	1736	1925	2135	2373	2731	2955	3147
		N-ds	18-1/2	18-1/2	20-1/2	20-1/2	18-1/2	20-1/2	20-1/2	24-1/2	12-3/4	16-3/4	16-3/4	16-3/4	18-3/4	22-3/4	24-3/4	24-3/4	26-3/4	28-3/4	32-3/4
	28	Wtj (plf)	8	9	9	10	12	12	13	14	18	18	19	20	21	22	24	27	29	32	34
		W360 (plf)	464	537	651	780	903	1048	1176	1280	1320	1439	1563	1599	1728	1902	2113	2533	2758	2940	3169
		N-ds	18-1/2	18-1/2	18-1/2	20-1/2	18-1/2	18-1/2	20-1/2	22-1/2	12-3/4	16-3/4	16-3/4	14-3/4	16-3/4	20-3/4	22-3/4	22-3/4	24-3/4	26-3/4	30-3/4
34	14	Wtj (plf)	10	11	13	15	16	18	20	22	25	27	28	30	33	36	42	43	45	56	67
		W360 (plf)	289	349	416	491	618	702	774	817	936	1019	1095	1086	1194	1345	1493	1803	1797	2051	2359
		N-ds	22-1/2	22-1/2	28-1/2	32-1/2	32-1/2	34-1/2	38-1/2	28-5/8	24-3/4	26-3/4	28-3/4	28-3/4	32-3/4	40-3/4	48-3/4	48-3/4	48-3/4	64-3/4	64-3/4
	16	Wtj (plf)	9	11	12	13	14	17	19	21	23	24	25	27	29	34	37	39	44	50	55
		W360 (plf)	312	384	452	525	652	773	858	948	998	1061	1149	1241	1330	1462	1651	1965	2164	2267	2490
		N-ds	20-1/2	22-1/2	24-1/2	26-1/2	29-1/2	34-1/2	34-1/2	38-1/2	22-3/4	24-3/4	24-3/4	26-3/4	28-3/4	34-3/4	40-3/4	40-3/4	48-3/4	56-3/4	64-3/4
	18	Wtj (plf)	9	10	11	13	14	16	17	19	22	23	24	26	27	30	34	37	42	47	50
		W360 (plf)	340	420	507	581	714	840	925	1029	1061	1166	1240	1339	1448	1568	1723	2046	2299	2524	2647
		N-ds	20-1/2	22-1/2	22-1/2	26-1/2	25-1/2	30-1/2	34-1/2	34-1/2	20-3/4	20-3/4	22-3/4	24-3/4	26-3/4	28-3/4	38-3/4	36-3/4	42-3/4	48-3/4	56-3/4
	20	Wtj (plf)	9	10	11	12	13	15	16	18	21	22	23	25	26	30	31	36	38	42	47
		W360 (plf)	360	456	539	643	771	900	984	1070	1210	1241	1363	1452	1545	1685	1791	2267	2323	2590	2854
		N-ds	20-1/2	22-1/2	22-1/2	24-1/2	24-1/2	26-1/2	28-1/2	34-1/2	18-3/4	18-3/4	20-3/4	22-3/4	24-3/4	26-3/4	32-3/4	36-3/4	36-3/4	44-3/4	50-3/4
	22	Wtj (plf)	9	10	11	12	13	14	15	17	20	21	22	23	24	29	30	33	38	42	44
		W360 (plf)	384	498	557	690	822	881	1031	1115	1219	1262	1396	1544	1560	1760	1889	2314	2568	2887	2910
		N-ds	20-1/2	22-1/2	22-1/2	24-1/2	22-1/2	24-1/2	26-1/2	28-1/2	18-3/4	18-3/4	18-3/4	20-3/4	22-3/4	24-3/4	28-3/4	30-3/4	36-3/4	42-3/4	44-3/4
	24	Wtj (plf)	9	10	10	11	12	14	15	16	20	21	21	22	24	28	29	31	35	40	44
		W360 (plf)	401	508	608	701	856	924	1073	1147	1240	1372	1404	1553	1721	1814	1951	2432	2563	2853	3189
		N-ds	20-1/2	22-1/2	22-1/2	22-1/2	22-1/2	22-1/2	26-1/2	28-1/2	16-3/4	18-3/4	18-3/4	18-3/4	20-3/4	22-3/4	26-3/4	28-3/4	30-3/4	36-3/4	42-3/4
	25	Wtj (plf)	9	10	10	11	12	14	15	16	19	20	21	22	22	26	28	29	33	38	42
		W360 (plf)	418	517	625	708	844	950	1079	1171	1249	1376	1521	1537	1708	1896	2003	2445	2611	2798	3087
		N-ds	20-1/2	22-1/2	22-1/2	22-1/2	20-1/2	22-1/2	18-5/8	26-1/2	16-3/4	16-3/4	18-3/4	18-3/4	18-3/4	22-3/4	24-3/4	26-3/4	28-3/4	32-3/4	36-3/4
	28	Wtj (plf)	9	10	10	11	12	14	15	16	19	19	21	22	22	26	26	28	32	38	42
		W360 (plf)	441	531	625	721	905	1006	1092	1182	1254	1382	1507	1652	1668	1937	2201	2433	2567	2977	3308
		N-ds	20-1/2	20-1/2	22-1/2	22-1/2	20-1/2	18-5/8	18-5/8	18-5/8	14-3/4	16-3/4	16-3/4	18-3/4	18-3/4	22-3/4	24-3/4	24-3/4	24-3/4	32-3/4	36-3/4
	30	Wtj (plf)	9	9	10	11	12	14	14	16	19	19	21	22	22	23	26	28	31	35	38
		W360 (plf)	440	534	667	725	897	981	1130	1136	1220	1345	1464	1585	1713	1984	2111	2354	2754	2918	3137
		N-ds	20-1/2	20-1/2	22-1/2	22-1/2	20-1/2	18-5/8	22-1/2	18-5/8	14-3/4	14-3/4	14-3/4	16-3/4	18-3/4	20-3/4	22-3/4	22-3/4	26-3/4	26-3/4	32-3/4
Bridging Rows			2					1													

Joist weights to the left of the heavy red line have 2 1/2 inch depth bearings. Joist weights between the heavy red and black lines have 5 inch depth bearings.
Joist weights between the heavy black and blue lines require 7 1/2 inch depth bearings.

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EXTERIOR 14" CMU

TRY UNGROUTED 14" CMU ~ 72 PSF
- FULLY BEDDED

$I = 1700\ IN^4/FT$
$A = 64\ IN^2/FT$

(3) CONDITIONS
1. STABILITY
2. COMPRESSIVE
3. TENSILE

$W = 14.8\ PSF \approx 15 PSF$

LOAD COMBINATION: 0.9 D + 1.6 W
1.4 D - SW ONLY

1. STABILITY

$P_u = 1.4(72 \cdot 65) = 6552\ PLF$

$P_n = 0.8\left[0.8 A_n f'_m \left(1 - \left(\frac{70r}{h}\right)^2\right)\right] = 13,124\ PLF$

$r = \sqrt{I/A} = \sqrt{1700/64} = 5.15$

$h/r = 65 \times 12 / 5.15 = 151.5$

$\phi P_n = (0.6)(13,124) = 7875 > P_u = 6,552$ ✓ OK

2. COMPRESSIVE

$f_b = \frac{P_u}{A} + \frac{M_u c}{I}$

$= 6552/64 = 102\ PSI$

$F_b = \phi\, 0.8 f'_m = 720\ PSI > f_b = 102\ PSI$ ✓ OK

3. TENSILE : $f_t = -\frac{P_u}{A} + \frac{M_u c}{I}$

$P_u = 0.9 D = 0.9(72 \times (50 + 15/2)) = 8726\ lb$

$M_w^{MID} = \frac{wh^2}{8} = \frac{(15)(15)^2}{8} = 422\ LB\ FT = 5063\ IN \cdot lb$

$M_u = 1.6(5063) = 8100\ IN \cdot lb$

$f_t = \left(-8726/64\right) + \left(\frac{8100 \times 13.625/2}{1700}\right) = -58.2 + 32.5$ ✓

NO TENSION ✓ OK

USE 14" HOLLOW UNGROUTED CMU (FULLY BEDDED)

EXTERIOR 8" CMU

TRY 8" FULLY GROUTED CMU w/ #5 @ 16" O.C.

$f'_m = 1500^{psi}$

$f_y = 40{,}000^{psi} \Rightarrow F_s = 20{,}000^{psi}$

1) $R = 0.25 f'_m A_n$

$= 0.25(1500)(7.63 \times 16" - 0.31")$

$= 45{,}634^{lb}$ PER 16" $\Rightarrow$ $34{,}225^{lb/FT}$

2) PURE FLEX

$d = 7.625/2 = 3.81"$

$jd = d - k_d/3 \simeq 7/8\, d = 3.33"$

$M = A_s F_s jd = (0.31)(20{,}000)(3.33) = 20{,}646^{IN\cdot lb/16"}$

$M = 15{,}485^{IN\cdot lb/FT}$

3) BALANCE POINT

$n = E_s/E_m$

$E_m = 900 f'_m = 900(1500) = 1{,}350{,}000^{psi}$

$n = \frac{29000000}{1350000} = 21.48$

$k_b = n/(F_s/F_b) + n = \frac{21.48}{(\frac{20{,}000}{500} + 21.48)} = 0.349$

$T = A_s F_s = (0.31)(20{,}000) = 6200^{lb}$

$C = \frac{1}{2} F_b k_b d_b = \frac{1}{2}(500)(0.349)(3.81)(16) = 5319^{lb}$

$P = C - T = 5{,}319 - 6{,}200 = -881^{lb/16"}$

$P_b = -661^{lb/FT}$

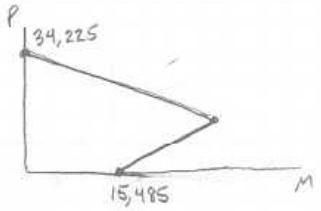
$M = T(d - h/2) + C(h/2 - k_b d/3)$

$= 6{,}200(0) + 5319(\frac{7.63}{2} - \frac{0.349 \times 3.81}{3}) = 17{,}934^{IN\cdot lb/16"}$

$M_b = 13{,}450^{IN\cdot lb/FT}$

$P_b = 661^{lb/FT}$

$M_b = 13{,}450^{IN\cdot lb/FT}$



EXTERIOR 8" CMU

DETERMINE (P,M)@ MID HT

LOAD = 0.6D + W

$P = 0.6(80 \times (60 + 15/2)) = 3240$ lb/ft

$M = wh^2/8 = (15)(15)^2/8 = 422.5$ ft-lb $= 5063$ in-lb/ft

(P,M) = (3240, 5063) ✓ OK

USE 8" CMU FULLY GROUTED REINFORCED 16" O.C.

ROOF JOISTS
NOT SUPPORTING MECH UNITS.

$l = 25'$
$DL = 25$ PSF
$LL = 20$ PSF
SPACING $= 5'$

$L = 1.6(20)(5) = 160^{PLF}$
$T = 1.2(25)(5) + 1.6(20)(5) = 310^{PLF}$

USE 18K3
$TL = 441 > 310^{PLF}$ ✓ OK
$LL = 214 > 160^{PLF}$ ✓ OK

CHECK DEFLECTION

$I_j = 26.767(W_{LL})(L^2)(10^{-6})$
$W_{LL} = 214$
$L = 24.67'$

$I_j = 86\ IN^4$

$\Delta_L = L/360 = 0.88"$
$\Delta_T = L/240 = 1.25"$

$\Delta_L = \frac{5(0.160)(25)^4(1728)}{384(29000)(86)} = 0.57" < 0.83"$ ✓ OK

$\Delta_T = \frac{5(0.310)(25)^4(1728)}{384(29000)(86)} = 1.09" < 1.25"$ ✓ OK

USE 18K3 SPACED 5' O.C. (SPAN = 25')

USE TYPE B 1.5" 18 GAGE DECKING

ROOF JOISTS SUPPORTING MECHANICAL UNITS

SPAN = 25'
DL = 25 PSF
LL = 150 PSF - (CONS. FOR MECH UNITS)
SPACING = 8'

$TL = 1.2(25) + 1.6(150) = 270\ PSF$
$TL = 810\ PLF < 825\ PLF\ MAX$

$V_{MAX} = w(\frac{l}{2}) = 810(\frac{25}{2}) = 10{,}125\ lb$

$M_{MAX} = \frac{wl^2}{8} = \frac{810(25)^2}{8} = 759.4\ IN{\cdot}K$

TRY 24 KCS 3
$I = 301\ IN^4$

$V = 10{,}800 > 10{,}125\ lbs$ ✓ OK
$M = 1080 > 759\ IN{\cdot}K$ ✓ OK

CHECK DEFLECTION

$\Delta_L = \frac{L}{360} = 0.83"$
$\Delta_T = \frac{L}{240} = 1.25"$

$\Delta_L = \frac{5(0.720)(25)^4(1728)}{384(29000)(301)} = 0.73" < 0.83"$ ✓ OK
(1.6(150)(3'))

$\Delta_T = \frac{5(0.810)(25)^4(1728)}{384(29000)(301)} = 0.82" < 1.25"$ ✓ OK

USE 24 KCS 3 SPACED 3' O.C. (SPAN = 25')

USE TYPE B 1.5" 18 GAGE DECKING

ROOF JOISTS - SLOPPED

$l = 12'$
$DL = 25\ PSF$
$LL = 20\ PSF$
$SPACING = 5'$

$L = 1.6 \times 20 \times 5 = 160^{PLF}$
$T = 1.2(25)(5) + 1.6(20)(5) = 310^{PLF}$

USE 10K1
$TL = 825 > 310^{PLF}$ ✓ OK
$LL = 455 > 160^{PLF}$ ✓ OK

CHECK DEFLECTION

$I_j = 26.767(W_{LL})(L^3)(10^{-6})$
$W_{LL} = 455$
$L = 11.67$

$I_j = 19.36\ in^4$

$\Delta_{LIVE} = L/360 = 0.40"$
$\Delta_{TOTAL} = L/240 = 0.60"$

$\Delta_T = \frac{5(0.310)(12)^4(1728)}{384(29000)(19.36)} = 0.26" < 0.60"$ ✓ OK

$\Delta_L = \frac{5(0.160)(12)^4(1728)}{384(29000)(19.36)} = 0.14" < 0.40"$ ✓ OK

USE 10K1 SPACED 5' O.C. (SPAN = 12')

USE TYPE B 1.5" - 22 GAGE DECKING

SEISMIC

IMP CAT III - $I_E = 1.25$

SEIS CAT II - SUG = II

SITE CLASS - D

ALEXANDRIA, VA 22302

$S_S = 15.3\%$ $F_a = 1.6$
$S_1 = 5.0\%$ $F_v = 2.4$

$S_{MS} = F_a S_S = (1.6)(0.153) = 0.2448$

$S_{M1} = F_v S_1 = (2.4)(0.05) = 0.120$

$S_{DS} = \frac{2}{3} S_{MS} = (\frac{2}{3})(0.2448) = \underline{0.1632}$

$S_{D1} = \frac{2}{3} S_{M1} = (\frac{2}{3})(0.120) = \underline{0.080}$

FOR $S_{DS} = 0.1632$ & SUG II ⇒ SDC = A
FOR $S_{D1} = 0.80$ & SUG II ⇒ SDC = B - CONTROLS

SEIS. DES. CAT. B

USE INTERMEDIATE REINFORCED SHEAR WALLS (REINF SPACING ≤ 48")
R = 4.0

BUILDING HEIGHT - 75'

DETERMINE T

$S_{D1} = 0.80 \leq 0.1 \Rightarrow C_u = 1.7$

$T_a = C_T h_n^x = 0.02 (75)^{0.75} = 0.51$

$T = C_u T_a = 1.7(0.51) = \underline{0.867 s}$

DETERMINE C_s

$C_s \leq S_{D1} / (\frac{R}{I} \times T) = 0.08 / (\frac{4.0}{1.25} \times 0.867) = 0.029$ - CONTROLS

$C_s \geq 0.044 S_{DS} I = 0.044 (0.1632)(1.25) = 0.009$

$C_s = S_{DS} / (\frac{R}{I}) = 0.1632 / (\frac{4.0}{1.25}) = 0.051$

$C_s = 0.029$

BUILDING WEIGHT

DEAD LOAD
- SLAB + DECK - 45 PSF
- JOISTS - 2 PSF
- MECHANICAL - 7 PSF
- ELECTRICAL - 4PSF
- FIREPROOFING - 2 PSF

TOTAL = 60 PSF

NO STORAGE
ROOF SNOW (FLAT) < 30 PSF

EXT WALLS - 80 PSF

INT WALLS - 35 PSF

FLOOR 2, 3, 4, 5

AREA = 20,830 SF/FL

EXT WALLS = (15')(380') = 5700 SF/FL

INT WALLS = (10'8")(1288') = 13,740 SF/FL

WEIGHT = (20,830)(60PSF) + (5700)(80 PSF) + (13,740)(35 PSF)

= 2,200 K / FLOOR

ROOF

AREA = 20,830 SF

EXT WALLS = (7.5')(380') = 2850 SF

INT WALLS = (3.167)(1288') = 4080 SF

WEIGHT = (20,830)(60PSF) + (2850)(80PSF) + (4080)(35PSF)

= 1,620 K

TOTAL WEIGHT = 10,420 K

C_s = 0.029

BASE SHEAR

$V = C_s \cdot W = 302^k$

$\boxed{V = 302^k}$

VERT DIST OF FORCES

$F_x = C_{vx} \cdot V$

$C_{vx} = \frac{w_x h_x^k}{\sum w_i h_i^k}$; $T = 0.867s \Rightarrow k = 1.18$

$\sum w_i h_i^k = 2200(15)^{1.18} + 2200(30)^{1.18} + 2200(45)^{1.18} + 2200(60)^{1.18} + 1620(75)^{1.18}$

$\sum w_i h_i^k = 912{,}000$ 'K

$C_2 = \frac{2200(15)^{1.18}}{912{,}000} = 0.059$

$C_3 = \frac{2200(30)^{1.18}}{912{,}000} = 0.133$

$C_4 = \frac{2200(45)^{1.18}}{912{,}000} = 0.215$

$C_5 = \frac{2200(60)^{1.18}}{912{,}000} = 0.302$

$C_{RF} = \frac{1620(75)^{1.18}}{912{,}000} = 0.290$

$F_2 = (0.059)(302^k)$

$F_3 = (0.133)(302^k)$

$F_4 = (0.215)(302^k)$

$F_5 = (0.302)(302^k)$

$F_{RF} = (0.290)(302^k)$

$F_2 = 17.8^k$

$F_3 = 40.3^k$

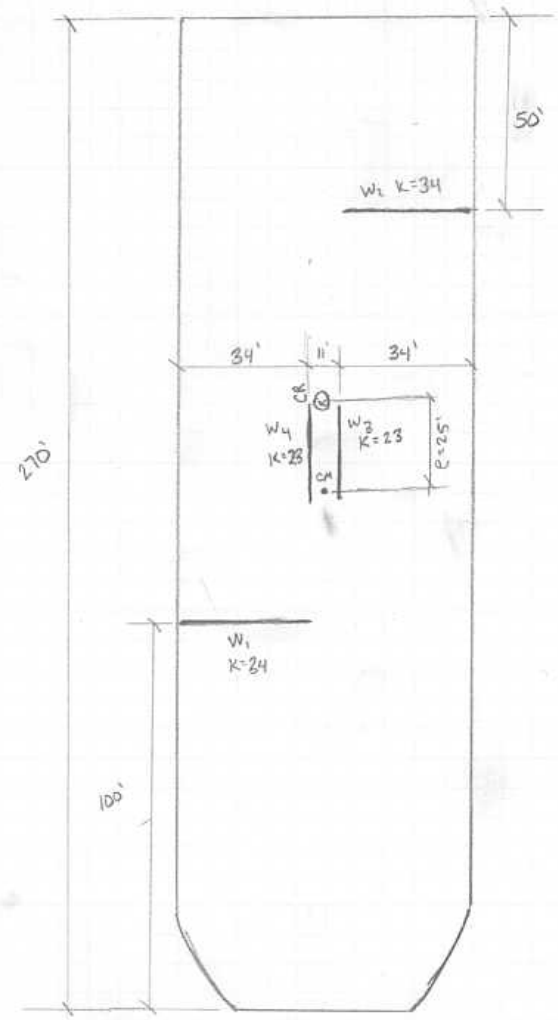
$F_4 = 65.0^k$

$F_5 = 91.3^k$

$F_{RF} = 87.5^k$

MASONRY SHEAR WALLS

TORSION DESIGN



MASONRY SHEAR WALLS

TORSION

LOCATE CR

$\bar{X} = \frac{\Sigma x_i L_i}{\Sigma L_i} = \frac{(100')(34') + (220')(34')}{34' + 34'} = 160'$

$\bar{X} = 160'$

ECCENTRICITY

$e = 135' - 160' = 25'$

$e_x = 25'$

$e_y = 0'$

POLAR MOMENTS OF INERTIA

$J = \Sigma K_i y_i^2 + \Sigma K_i x_i^2$ x_i, y_i MEASURED FROM CR

$J = (2)(23)(5.5)^2 + (34)(60)^2 + (34)(60)^2$

$J = 246,192$ FT.K

TORSIONAL SHEAR

$F_{wi} = K_i x_i \times \frac{V_{DIAPH} \cdot e_x}{J}$

$F_{W1} = (34)(60)\frac{V(25')}{246,192} = 0.207\, V_{DIAPH}$

$F_{W2} = 0.207\, V_{DIAPH}$

$F_{W3} = (23)(5.5)\frac{V(25')}{246,192} = 0.0128\, V_{DIAPH}$

$F_{W4} = 0.0128\, V_{DIAPH}$

$V_{D2} = 75.2^K$

$V_{D3} = 86.8^K$

$V_{D4} = 94.6^K$

$V_{D5} = 100.4^K$

$V_{DR} = 52.8^K$

$F_{W1F2} = 15.58^K$

$F_{W1F3} = 17.98^K$

$F_{W1F4} = 19.60^K$

$F_{W1F5} = 20.80^K$

$F_{W1RF} = 10.94^K$

$F_{W2F2} =$

$F_{W2F3} =$

$F_{W2F4} =$

$F_{W2F5} =$

$F_{W2RF} =$

$\approx 1^K$ EACH (NEGLIGIBLE)

DIRECT SHEAR

$V_{W1} = V_{W2} = V_{DIAPH} \times \frac{K_i}{K_1 + K_2} = 0.5\, V_{DIAPH}$

$V_{W1F2} = 37.6^K$

$V_{W1F3} = 43.4^K$

$V_{W1F4} = 47.3^K$

$V_{W1F5} = 50.2^K$

$V_{W1RF} = 26.4^K$

TOTAL SHEARS

MAX SHEARS @

$V_{F2} = 53.2^K$

$V_{F3} = 61.4^K$

$V_{F4} = 66.9^K$

$V_{F5} = 71.0^K$

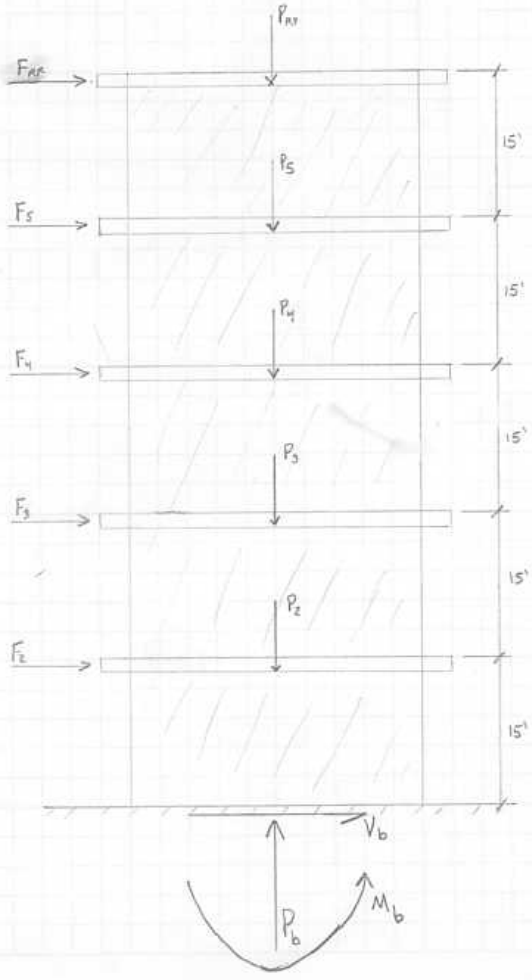
$V_{RF} = 37.3^K$

MASONRY SHEAR WALLS

FLOORS 2,3,4,5 - FORCES DIST ON STIFFNESS
ROOF - FORCES DIST BY TRIB AREA

E-W RESISTING WALLS
- 2 EQUAL WALLS W/ 2 EQUAL TRIB AREAS
- EACH WALL TAKES $\frac{1}{2}^{TH}$ LOAD
- WIND CONTROLS IN THIS DIRECTION

FACTORED LOAD				
$F_2 = 75.2^K$		$F_2 = 53.2^K$	$V_b = 205^K$	
$F_3 = 86.8^K$	$\frac{1}{2}$	$F_3 = 61.4^K$	$M_b = 8986^{FT.K}$	
$F_4 = 94.6^K$	=>	$F_4 = 66.9^K$	$= 107,838^{IN.K}$	
$F_5 = 100.4^K$	+ TORSION	$F_5 = 71.0^K$		
$F_{RF} = 52.8^K$		$F_{RF} = 37.3^K$		



STRENGTH DESIGN

EQUATIONS: $\varepsilon_{si} = \varepsilon_{mu}\left(\frac{d-c}{c}\right)$

$f_{si} = \varepsilon_{si} \cdot E_s \Rightarrow \leq 60{,}000$

$T_{si} = A_s f_{si}$

$a = 0.80\,c$

$C_m = 0.8(f'm)(a)(t)$

$C + T = 0$

CONSTANTS: $f'm = 1500^{psi}$

$f_y = 60{,}000^{psi}$

$t = 7.625"$

$l = 408"$

$E_{mu} = 0.0025$

$E_s = 29 \times 10^6$

$A_s = 0.31"$

$d_b = 404"$

FULLY GROUTED

FROM EXCELL SPREADSHEET

$C = 73.024$ IN

FOR #5 REINF @ 8" O.C.

$a = 58.42"$

$C_m = -534{,}536$

$C + T = 0$

$M_n = 134{,}576{,}975^{IN\cdot lb} \Rightarrow \phi M_n = 121{,}120^{IN\cdot K}$

$M_u = 107{,}838^{IN\cdot K} \leq \phi M_n = 121{,}120^{IN\cdot K}$ ✓ OK

USE #5 @ 8" O.C. VERT

SHEAR DESIGN

$M_u = 107{,}838^{IN\cdot K}$

$V_u = 205^K$

$d = 404"$

CHECK $\frac{M_u}{V_u d} = \frac{107{,}838}{205(404)} = 1.3 > 1.0$

$\therefore V_n \leq 4 A_n \sqrt{f'm} = 4(7.625 \times 404)\sqrt{1500}$

$V_n = 447^K$

$V_s = 0.5\left(\frac{A_v}{s}\right) f_y d_v$

$\frac{A_v}{s} = \frac{205{,}000}{0.5(60{,}000)(404)} = 0.0169$

USE #4 REINF, $A_s = 0.20$ IN

$S_{req} = \frac{0.20}{0.0169} = 11.83$ IN $\Rightarrow$ USE #4 @ 8" O.C. HORIZ.

$\frac{M_n}{M_u} = \frac{134{,}577}{107{,}838} = 1.25 \Rightarrow M_n = 1.25 M_u$

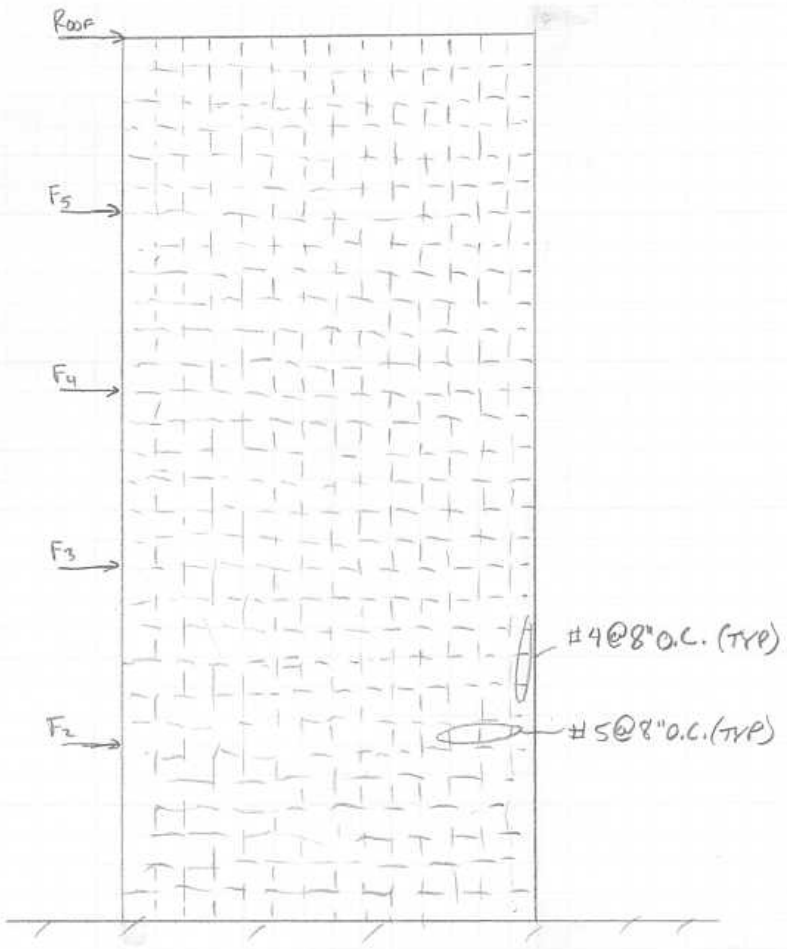
$\phi V_n \geq 1.25 \times 1.25\, V_u = 1.56 V_u$

$\phi = 0.80$

$V_n = 1.95(V_u) = 400^K$

$V_n = V_m = 447^K \geq 400^K$ ✓ OK

USE 34' LENGTH FULLY GROUTED 8"CMU, TYPE S MORTAR
w/ #5@8" O.C. VERT REINF
#4@8" O.C. HORIZ REINF



SHEAR WALL DRIFT

$\Delta = \frac{Vh}{AG}$ – SHEAR

A (FULLY GROUTED) = 7.625" × 34' × 12 = 3,111 in²

$G = 0.4E_m = (0.4)(900f'm) = (0.4)(900)(1500)$
$G = 540$ KSI

$V_{F2} = 53.2^K$ @ 15' ⇒ $V_{h2} = 9,576$ K-IN
$V_{F3} = 61.4^K$ @ 30' ⇒ $V_{h3} = 22,104$ K-IN
$V_{F4} = 66.9^K$ @ 45' ⇒ $V_{h4} = 36,126$ K-IN
$V_{F5} = 71.0^K$ @ 60' ⇒ $V_{h5} = 51,120$ K-IN
$V_{FF} = 37.3^K$ @ 75' ⇒ $V_{hf} = 33,570^{K\cdot IN}$

$AG_T = 1.68 \times 10^6$ KIPS

$\Delta_T = \Sigma\Delta_i$

$\Delta_2 = 0.0057$
$\Delta_3 = 0.0132$
$\Delta_4 = 0.0215$
$\Delta_5 = 0.0304$
$\Delta_{FF} = 0.0200$

$\Delta_5 = 0.091"$ – SHEAR

$\Delta_{BENDING} = \frac{wH^4}{8EI_w}$

$E = 900(1500) = 1.35 \times 10^6$

$I_w = \frac{7.625(34 \times 12)^3}{12} = 43.16 \times 10^6$

$w = 3866.166$ PLF
$H = 75$ FT

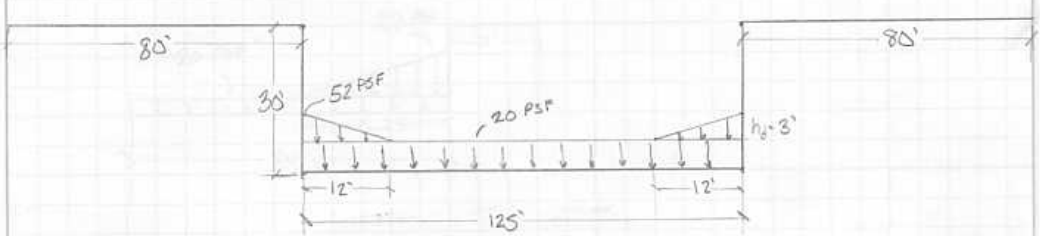
$\Delta_B = \frac{(3866.166)(75)^4(1728)}{8(1.35 \times 10^6)(43.16 \times 10^6)} = 0.454"$ – BENDING

$\Delta_{TOTAL} = 0.454" + 0.091"$

$\boxed{\Delta_{TOTAL} = 0.55"}$

$h/400 = 75 \times 12/400 = 2.25"$ ✓ ok

SNOW DRIFT



$\gamma = 0.13 P_g + 14$
$= 0.13(25) + 14 = 17.25$ NOT TO SCALE

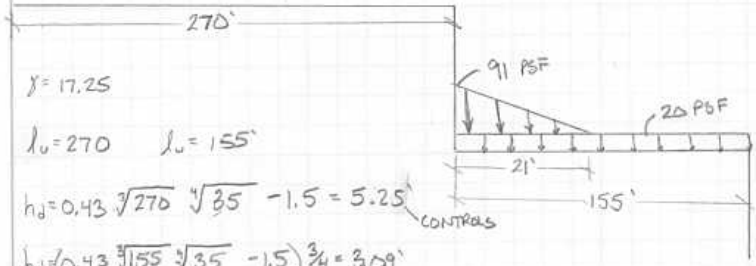
$h_d = 0.43 \sqrt[3]{l_u} \sqrt[4]{P_g + 10} - 1.5$
$l_u = 80'$, $P_g = 25'$

$h_d = (0.43 \sqrt[3]{125} \sqrt[4]{35} - 1.5) \frac{3}{4}$
$= 2.90'$

$h_d = 0.43 \sqrt[3]{80} \sqrt[4]{35} - 1.5 = 3'$ - CONTROLS

$h_d \times \gamma =$ 52 PSF

$h_d = 3' < h_c = 30'$ $\therefore w = 4 h_d = 12'$



$\gamma = 17.25$

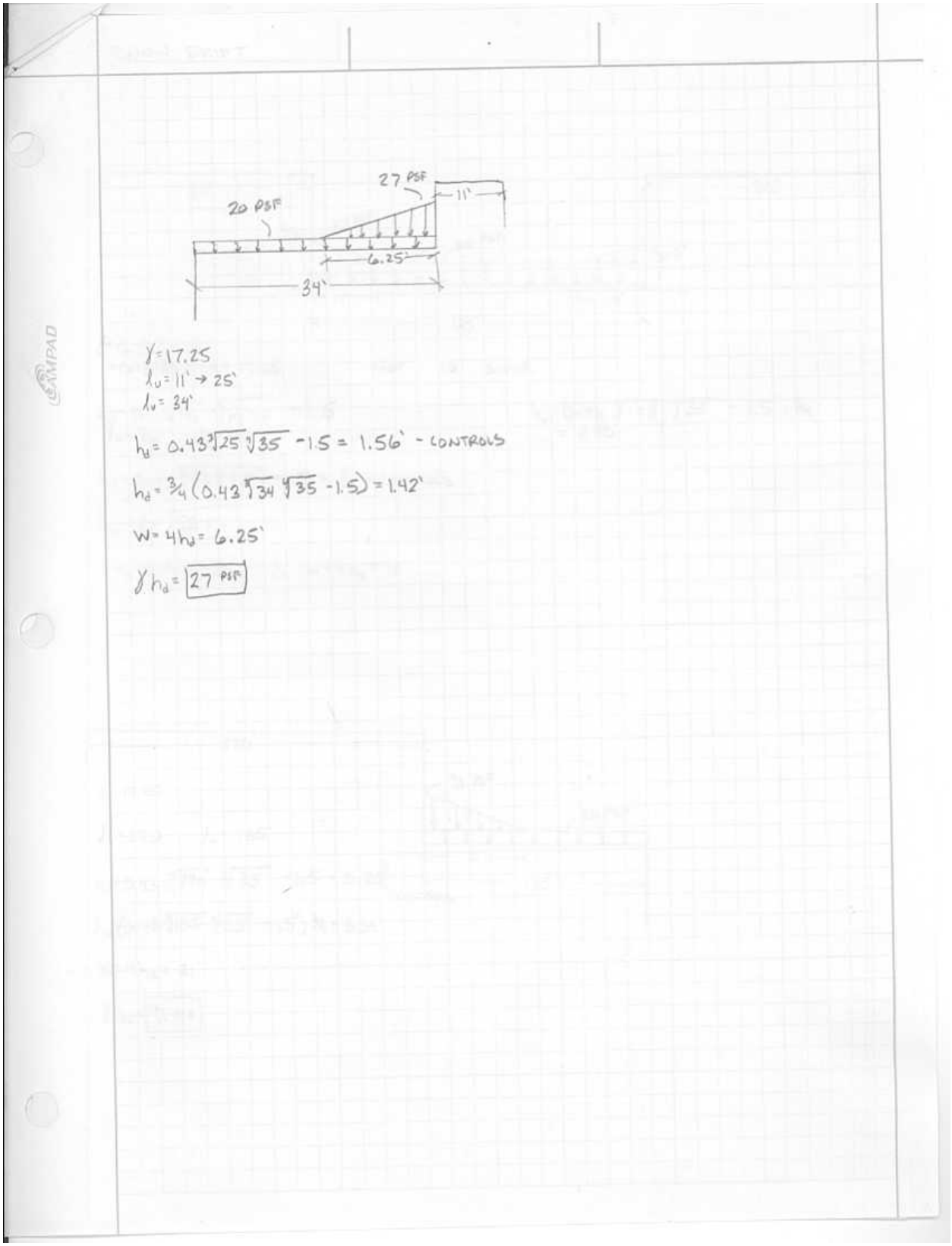
$l_u = 270$ $l_u = 155'$

$h_d = 0.43 \sqrt{270} \sqrt[4]{35} - 1.5 = 5.25'$ CONTROLS

$h_d = (0.43 \sqrt[3]{155} \sqrt[4]{35} - 1.5) \frac{3}{4} = 3.09'$

$w = 4 h_d = 21'$

$\gamma h_d =$ 91 PSF


27 PSF
11'
20 PSF
6.25'
34'
γ = 17.25
l_u = 11' → 25'
l_u = 34'
$h_d = 0.43\sqrt[3]{25}\sqrt{35} - 1.5 = 1.56'$ - CONTROLS
$h_d = \frac{3}{4}(0.43\sqrt[3]{34}\sqrt{35} - 1.5) = 1.42'$
$w = 4h_d = 6.25'$
γh_d = 27 PSF

SPREAD FOOTING (TYP)

W10x54 STEEL COLUMN
24" x 24" STEEL BASE PLATE
$f'_c = 3000$ PSI
$q_a = 6{,}000$ PSF

$P_D = 165^K$
$P_L = 130^K$
$P = P_D + P_L = 295^K$

FOOTING SIZE

$q_a \geq P/A \Rightarrow 6{,}000 \geq \frac{295^K}{B^2}$

$B = 7.01 \Rightarrow$ USE $\underline{B = 8'}$ ✓ OK

$P_u = 1.2P_D + 1.6P_L$

$P_u = 406^K$

$q = P_u/A = \frac{406^K}{(8')^2} = 6.34^{KSF}$

$q = 44.06$ PSI

$V_c = \phi 4\sqrt{f'_c} = 0.75(4)(\sqrt{3000}) = 164$ PSI

TWO WAY SHEAR STRESS

$$d^2\left(V_c + \frac{q}{4}\right) + d\left(V_c + \frac{q}{2}\right)w = \frac{q}{4}\left(BL - w^2\right)$$

$$d^2\left(164^{PSI} + \frac{44.06}{4}\right) + d\left(164^{PSI} + \frac{44.06}{2}\right)(24") = \frac{44.06}{4}\left[(96)^2 - (24)^2\right]$$

$d = 13.82" \Rightarrow h = d + 3" + d_b = 13.82 + 3 + 0.625"$

$h = 17.5"$

USE $h = 18"$
$d = 14.375"$

CHECK WIDE BEAM SHEAR

$V_u = 6.34^{KSF}\left(\frac{8'-2'}{2} - 1.20'\right) = 11.41^K$

$\phi V_n > V_u$ ✓ OK

$\phi V_n = \phi 2\sqrt{f'_c}\, b.d$
$= 0.75(2)\sqrt{3000}\,(24")(14.375") = 28.34^K$

$\ell = \frac{8'-2'}{2} = 3'$

$M_u = \frac{q\ell^2}{2} = \frac{(6.34)(3')^2}{2} = 28.5^{'k}$

$a = \frac{A_s f_y}{0.85 f'_c b} = \frac{A_s (60)}{0.85(3^{ksi})(12")}$

$a = 1.96 A_s$

$M_u = \phi M_n = \phi A_s f_y (d - a/2)$

$28.5^{'k}(12"/') = 0.9 A_s (60)(14.375" - \frac{1.96 A_s}{2})$

$A_s = 0.455\ in^2$

USE #5 @ 8" O.C. $A_s = 0.46\ in^2$

$\rho = \frac{A_s}{bh} = \frac{0.46\ in^2}{(12")(12")} = 0.0032 \geq 0.0018$ ✓ ok

$a = 1.96 A_s = 1.96(0.46\ in^2) = 0.902"$

$c = \frac{a}{0.85} = \frac{0.902"}{0.85} = 1.06"$

$\varepsilon_s = \frac{0.003}{c}(d-c) = \frac{0.003}{1.06}(14.375 - 1.06) = 0.038^{in}/_{in} \geq 0.005^{in}/_{in}$ ✓ ok

$\therefore \phi = 0.90$

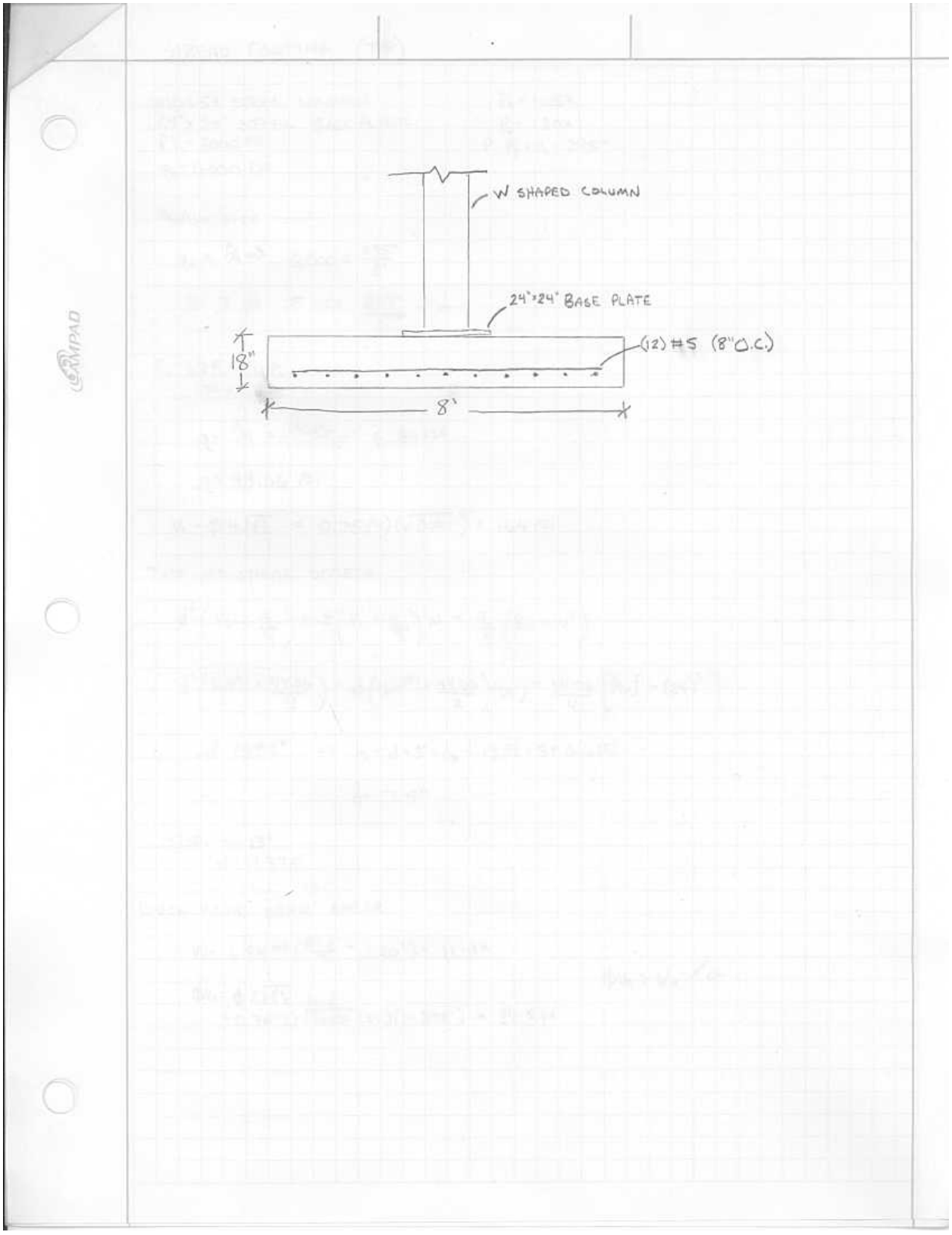
USE (12) #5 EACH DIRECTION

$\phi B_n = \phi\, 0.85 f'_c A_1 \sqrt{A_2/A_1}$

$A_1 = 24" \times 24" = 576\ in^2$
$A_2 = 96" \times 96" = 9216\ in^2$

$\sqrt{\frac{9216}{576}} = 4.0 > 2 \quad \therefore \sqrt{\frac{A_2}{A_1}} = 2$

$\phi B_n = 0.65(0.85)(3^{ksi})(576\ in^2)(2)$
$\phi B_n = 1909^{k} \geq P_u = 406^{k}$ ✓ ok


W SHAPED COLUMN
24"x24" BASE PLATE
(12) #5 (8" O.C.)
18"
8'

STRIP FOUNDATION (TYP)

TOTAL WEIGHT EXT. WALL SYSTEM

8" CMU - 80 PSF
14" CMU - 72 PSF
4" BRICK - 39 PSF
} TOTAL = 191 PSF

WALL SYSTEM = 28'
P = 14.325 KLF
f'_c = 3000 PSI
q_a = 6000 PSF

191 PSF × 75 FT = 14,325 PLF

DL = 14.325 KLF (SELF WEIGHT)

P = 14.325 KLF

$q_a = P/A \Rightarrow 6\ KSF = \frac{14.325}{B} \Rightarrow B \geq 2.39'$

USE B = 5' ← CONTROLED BY SHAPE OF WALL

$P_u = 1.4\ P_D = 1.4(14.325) = 20.\ KLF$

$q = P/A = \frac{20}{5} = 4.00\ KSF$

REINFORCED FOOTING OPTION

WIDE BEAM SHEAR

$\phi V_c = \phi\ 2\sqrt{f'_c}\ bd$
$= 0.75(2)\sqrt{3000}\ (12")d$
$= 985.9d$

$V_u = 4.00^{KSF}(1')(2.5' - 14"(\frac{1'}{12"}))$
$= 5.33^K$

$V_u = \phi V_n$
$5{,}333 = 985.9d$
$d = 5.4"$

$h = d + 3" + 0.5\ d_b$
$= 5.4" + 3" + 0.25" = 8.65"$

USE h = 12"
d = 8.75"

$l = \frac{5' - 14"(\frac{1'}{12"})}{2} = 1.92'$

$M_u = \frac{wl^2}{2} = \frac{4(1.92)^2}{2} = 7.37^{IK}$

$a = \frac{A_s f_y}{0.85 f'_c b} = \frac{A_s(60^{KSI})}{0.85(3^{KSI})(12")} = 1.96\ A_s$

STRIP FOUNDATION (TYP) (CONT.)

$M_u = \phi M_n = \phi A_s f_y (d - a/2)$

$7.37^{k'} (12^{in}/_{ft}) = 0.9 A_s (60^{ksi})(8.75^{in} - \frac{1.96 A_s}{2})$

$A_s = 0.192 \, in^2$

~~USE #4 @ 12" O.C. $A_s = 0.20 \, in^2$~~

$\rho = A_s/bh = 0.20/(12)(12) = 0.0014 < 0.0018$

USE #5 @ 12" O.C. $A_s = 0.31 \, in^2/ft$

$\rho = A_s/bh = 0.0022 \geq 0.0018$ ✓ OK

$a = 1.96 A_s = 1.96(0.31) = 0.608"$

$c = \frac{a}{0.85} = \frac{0.608}{0.85} = 0.715"$

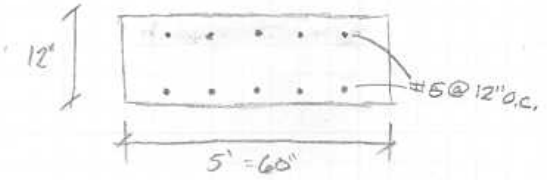
$\varepsilon_s = \frac{0.003}{c}(d - c) = \frac{0.003}{0.715}(8.75 - 0.715) = 0.0337 \geq 0.005 \, in/in$

$\therefore \phi = 0.9$

LONGITUDIAL SHRINKAGE & TEMPERATURE

$A_s = 0.0018 \, bh = 0.259 \, in^2$

USE #5 @ 12" O.C. $A_s = 0.31 \, in^2/ft$



VIBRATION (1 OF 3)

JOIST ~ 22VC 1600 (34' SPAN)

JOIST SW = 24 PLF
FLOOR THICKNESS = 2½ + 2" DECK = 4½"
CONCRETE: W_c = 145 PCF
f'_c = 4,000 PSI

SLAB + DECK WEIGHT = 46.25 PSF

DETERMINE I_j
W = 1600 PLF

$M_{ALL} = \frac{WL_r^2}{8} = (1.6)(34-0.33)^2/8 = 226.7^{IK}$

$A_{BOT} = \frac{M_{ALL}}{(d-1)f_{ALL}} = \frac{226.7(12)}{(22-1)(30)} = 4.32\ IN^2$

$A_{TOP} = 1.25\ A_{BOT} = 1.25(4.05) = 5.40\ IN^2$

$A_{CHORD} = 4.32\ IN^2 + 5.40\ IN^2 = 9.72\ IN^2$

$\bar{y}_c = 0.5 + \frac{A_{BOT}(d-1)}{A_{CHORD}} = 0.5 + \frac{4.32(22-1)}{9.72} = 9.83"$

$I_{CHORD} = A_{TOP}(\bar{y}_c - 0.5)^2 + A_{BOT}(d - \bar{y}_c - 0.5)^2 = 5.40(9.83-0.5)^2 + 4.32(22-9.83-0.5)^2$
$= 1059\ IN^4$

$n = E_s/1.35E_c = \frac{29\times10^6}{1.35(145)^{1.5}(33)\sqrt{4000}} = 5.9$

$\bar{y}_c = \frac{\Sigma A_y}{\Sigma A} = \frac{(92/5.9)(2.5)(2.0) + 9.72(4.5+9.83)}{(92/5.9)(2.5) + 9.72} = 4.46"$

$I_{comp} = \Sigma I + \Sigma Ad^2 = \frac{(92/5.9)(2.5)^3}{12} + 9.72(9.83+4.5-4.46)^2 + 992 + (92/5.9)(2.5)(4.46-2)^2$

$I_{comp} = 2262\ IN^4$

$L/D = 18.55 \therefore C_r = 0.90(1-e^{-0.28(L/D)})^{2.8} = 0.89$

$\gamma = 1/C_r - 1 = 1/0.89 - 1 = 0.12$

$I_j = \frac{1}{\left(\frac{\gamma}{I_{CHORD}}\right) + \left(\frac{1}{I_{comp}}\right)} = 1801\ IN^4$

$I_j = 1801\ IN^4$

VIBRATION (2 OF 3)

DETERMINE Δ_j

$W_j = 7.666(46.25 + 11 + 4) + 24 = 494$ PLF

$\Delta_j = \frac{5(0.494)(34)^4(1728)}{(384)(29\times10^3)(1801)} = 0.284"$

DETERMINE W_j

$W_j = 494/7.666 = 64.5$ PSF

$D_s = 12de^3/12n = (12)(3.5)^3/(12)(5.9) = 7.27$

$D_j = I_j/S = 1801/7.666 = 235$

$B_j = C_j(D_s/D_j)^{0.25}L_j = 2.0(7.27/235)^{0.25}(34') = 29.0$ $\quad 2/3(69) = 46.0$

$W_j = 64.5(29)(34) = 63{,}600^{lb}$

W21×50

DETERMINE I_g

$b = 0.4L_j = 163"$ ← CONTROLS
$= 23(12) = 276"$

$\bar{y} = \frac{\Sigma Ay}{\Sigma A} = \frac{(14.7)(20.8/2 + 4.5 + 2.5) + (163/5.9)(2.5)(1.25) + (163/2/5.9)(2)(3.5)}{(14.7) + (163/5.9)(2.5) + (163/2/5.9)(2)} = 3.94"$

$I_{comp} = \Sigma I + \Sigma Ad^2 = \frac{(163/5.9)(2.5)^3}{12} + \frac{(163/2/5.9)(2.0)^3}{12} + 984 + (163/5A)(2.5)(3.94 - 1.25)^2$
$+ (163/2/5.9)(2.0)(3.94 - 3.5)^2 + 14.7(20.8/2 + 2.5 + 4.5 - 3.94)^2$

$I_{comp} = 4198\ in^4$

$I_g = I_{NC} + \frac{(I_{comp} - I_{NC})}{4} = 984 + \frac{(4198 - 984)}{4} = 1788\ in^4$

DETERMINE Δ_g

$W_g = W_j/S\ L_j + SW = (494/7.666)(34') + 50 + 373^{WALL} = 2614$ PLF

$\Delta_g = \frac{5(2.614)(23)^4(1728)}{384(29\times10^3)(1788)} = 0.313"$

$\Delta_g' = L_g/B_j(\Delta_g) = 23/29(0.313) = 0.248"$

VIBRATION (3 OF 3)

DETERMINE W_g

$w_g = 2583/34 = 76.0^{PSF}$

$D_j = I_j/5 = 235$

$D_g = I_g/L_j = 1788/34 = 52.6$

$B_g = C_g (D_j/D_g)^{0.25} (23') = 53.5$

$C_g = 1.10$

$W_g = (76.0)(53.5)(23) = 93{,}520^{lb} = \underline{93.52^k}$

DETERMINE W

$$W = \frac{\Delta_j}{\Delta_j + \Delta_g} W_j + \frac{\Delta_g}{\Delta_j + \Delta_g} W_g = 77.55^k$$

$W = 77.55^k$

DETERMINE f_n

$$f_n = 0.18 \sqrt{\frac{g}{\Delta_j + \Delta_g}} \quad g = 386.4 \Rightarrow f_n = 4.85^{Hz}$$

EVALUATION

$P_o = 65\ lb$

$\beta = 0.03$

$a_j/g = 0.005g$

$$\frac{a_p}{g} = \frac{P_o e^{(-0.35 f_n)}}{\beta W} = 0.0050 = 0.005g \quad \checkmark OK$$

CONSIDERING THE NUMBERS FOR LL & DL ARE VERY CONSERVATIVE FOR A SCHOOL, AND A SCHOOL WOULD FUNCTION MUCH DIFFERENTLY THAN AN OFFICE BUILDING, THERE SHOULD BE NO VIBRATION ISSUES.

WIND DESIGN

BUILDING HEIGHT = 75'
BUILDING WIDTH = 80'
BUILDING LENGTH = 270'

I_w = 1.15
CAT III
V = 90 MPH
K_d = 0.85 (W/ LOAD COMBO'S) (ELSE 1.0)
EXPOSURE: B
CASE 2
K_{0-15} = 0.57
K_{30} = 0.70
K_{45} = 0.785
K_{60} = 0.85
K_{75} = 0.91

K_{zt} = 1.0
G_f = 0.85
R = 1.0
h = 75'
PARTIALLY ENCLOSED
G_{Cpi} = 0.18 ±
R_i = 1.0

C_p VALUES:
WINDWARD : C_p = 0.8
N-S LEEWARD : C_p = -0.24 ~ L/B = 3.375
E-W LEEWARD : C_p = -0.50
SIDEWALLS : C_p = -0.70

$q_z = 0.00256\ K_z \cdot K_{zt} \cdot K_d \cdot V^2 I$ (lb/ft²)

$= 0.00256\ K_z (1.0)(1.0)(90^2)(1.15)$

$q_z = 23.85\ K_z$

WINDWARD = $q_{z\,0-15}$ = 13.60
$q_{z\,30}$ = 16.70
$q_{z\,45}$ = 18.72
$q_{z\,60}$ = 20.27
$q_{z\,75}$ = 21.70

LEEWARD N-S
$P = 21.70(0.85 \times -0.50) + 3.906$
P = -5.3 PSF

LEEWARD E-W
$P = 21.70(0.85 \times -0.24) + 3.906$
P = -0.5 PSF

PRESSURES $P = q_z(G_f C_p) - q_H(G_{Cpi})$

WINDWARD
$P_{0-15} = (13.60)(0.85 \times 0.80) - (21.70)(-0.18) = 13.2$ PSF
$P_{30} = (16.70)(0.68) + 3.906 = 15.8$ PSF
$P_{45} = (18.72)(0.68) + 3.906 = 16.7$ PSF
$P_{60} = (20.27)(0.68) + 3.906 = 17.7$ PSF
$P_{75} = (21.70)(0.68) + 3.906 = 18.7$ PSF

WIND FORCES TO FLOOR

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

$K_{zt} = 1.0$
$K_d = 0.85$
$V = 90$
$I = 1.15$

$K_{z,15} = 0.57$
$K_{z,30} = 0.70$
$K_{z,45} = 0.785$
$K_{z,60} = 0.85$
$K_{z,75} = 0.91$

$q_z = 20.27\, K_z$

$q_{z,15} = 11.55$
$q_{z,30} = 14.19$
$q_{z,45} = 15.91$
$q_{z,60} = 17.23$
$q_{z,75} = 18.45$

$P = q_z (G_f C_p) - q_h (G_f C_{pi})$

WINDWARD
$P_{15} = (11.55)(0.85 \cdot 0.90) - (18.45)(-0.18)$
$P_{30} = (14.19)(0.68) + (3.32)$
$P_{45} = (15.91)(0.68) + (3.32)$
$P_{60} = (17.23)(0.68) + (3.32)$
$P_{75} = (18.45)(0.68) + (3.32)$

LEEWARD
$P_{N-S} = (18.45)(0.85 \cdot -0.50) - (18.45)(-0.18) = -4.52$
$P_{E-W} = (18.45)(0.85 \cdot -0.24) - (18.45)(-0.18) = -0.44$

TOTAL PRESSURE FORCE N-S (PSF)
$P_{15} = 15.7$
$P_{30} = 17.5$
$P_{45} = 18.7$
$P_{60} = 19.6$
$P_{75} = 20.4$

TOTAL PRESSURE FORCE E-W (PSF)
$P_{15} = 11.6$
$P_{30} = 13.4$
$P_{45} = 14.6$
$P_{60} = 15.5$
$P_{75} = 16.3$

TOTAL WIND FORCE TO FLOOR (LC: 1.6W)

N-S
WIDTH = 80'

$F_2 = (1.6)(80' \times 15')(15.7) = 30.1^k$

$F_3 = (1.6)(80' \times 15')(17.5) = 33.6^k$

$F_4 = (1.6)(80' \times 15')(18.7) = 35.9^k$

$F_5 = (1.6)(80' \times 15')(19.6) = 37.6^k$

$F_{RF} = (1.6)(80' \times 7.5')(20.4) = 19.6^k$

E-W
WIDTH = 270'

$F_2 = (1.6)(270' \times 15')(11.6) = 75.2^k$

$F_3 = (1.6)(270' \times 15')(13.4) = 86.8^k$

$F_4 = (1.6)(270' \times 15')(14.6) = 94.6^k$

$F_5 = (1.6)(270' \times 15')(15.5) = 100.4^k$

$F_{RF} = (1.6)(270' \times 7.5')(16.3) = 52.8^k$

COMPONENTS & CLADDING

$K_{15} = 0.70$ $\quad G_f C_p = +0.6 \text{ - } C\&C$
$K_{30} = 0.70$
$K_{45} = 0.785$
$K_{60} = 0.85$
$K_{75} = 0.91$

$q_z = 20.27 K_z$

$q_{z\,15} = 14.19$
$q_{z\,30} = 14.19$
$q_{z\,45} = 15.91$
$q_{z\,60} = 17.23$
$q_{z\,75} = 18.45$

$P = q_z (G_f C_p) - q_H (G_f C_{pi})$

$P_{15} = (14.19)(0.6) - (18.45)(-0.18) = 11.8$ PSF
$P_{30} = (14.19)(0.6) + (3.32) = 11.8$ PSF
$P_{45} = (15.91)(0.6) + (3.32) = 12.9$ PSF
$P_{60} = (17.23)(0.6) + (3.32) = 13.7$ PSF
$P_{75} = (18.45)(0.6) + (3.32) = 14.4$ PSF

$P_{15} = 11.8$ PSF
$P_{30} = 11.8$ PSF
$P_{45} = 12.9$ PSF
$P_{60} = 13.7$ PSF
$P_{75} = 14.4$ PSF

Masonry Shear Wall - Strength Design	
f'm (psi) =	1500
fy (psi) =	60000
Thickness =	7.625
Length =	408
Emu =	0.0025
Es =	2.9E+07
As =	0.31

c = 73.024																							
d1	4	Es1	-0.00236	fs1	-68,529	-60,000	Ts1	-18,600	Mn	468,899
d2	12	Es2	-0.00209	fs2	-60,586	-60,000	Ts2	-18,600	320,099
d3	20	Es3	-0.00182	fs3	-52,644	-52,644	Ts3	-16,319	150,296
d4	28	Es4	-0.00154	fs4	-44,701	-44,701	Ts4	-13,857	16,762
d5	36	Es5	-0.00127	fs5	-36,758	-36,758	Ts5	-11,395	77,377
d6	44	Es6	-0.00099	fs6	-28,816	-28,816	Ts6	-8,933	132,121
d7	52	Es7	-0.00072	fs7	-20,873	-20,873	Ts7	-6,471	147,469
d8	60	Es8	-0.00045	fs8	-12,931	-12,931	Ts8	-4,008	123,422
d9	68	Es9	-0.00017	fs9	-4,988	-4,988	Ts9	-1,546	59,980
d10	76	Es10	0.000102	fs10	2,955	2,955	Ts10	916	42,857
d11	84	Es11	0.000376	fs11	10,897	10,897	Ts11	3,378	185,090
d12	92	Es12	0.00065	fs12	18,840	18,840	Ts12	5,840	366,718
d13	100	Es13	0.000924	fs13	26,782	26,782	Ts13	8,303	587,741
d14	108	Es14	0.001197	fs14	34,725	34,725	Ts14	10,765	848,159
d15	116	Es15	0.001471	fs15	42,668	42,668	Ts15	13,227	1,147,973
d16	124	Es16	0.001745	fs16	50,610	50,610	Ts16	15,689	1,487,182
d17	132	Es17	0.002019	fs17	58,553	58,553	Ts17	18,151	1,865,787
d18	140	Es18	0.002293	fs18	66,495	60,000	Ts18	18,600	2,060,701
d19	148	Es19	0.002567	fs19	74,438	60,000	Ts19	18,600	2,209,501
d20	156	Es20	0.002841	fs20	82,381	60,000	Ts20	18,600	2,358,301
d21	164	Es21	0.003115	fs21	90,323	60,000	Ts21	18,600	2,507,101
d22	172	Es22	0.003388	fs22	98,266	60,000	Ts22	18,600	2,655,901
d23	180	Es23	0.003662	fs23	106,208	60,000	Ts23	18,600	2,804,701
		a = 58.4192		Cm = -534,536						

Sum =	3

Mn =	134,576,975	
(0.9) Mn =	121,119,278	in lb
=	121,119	k in

d24	188
d25	196
d26	204
d27	212
d28	220
d29	228
d30	236
d31	244
d32	252
d33	260
d34	268
d35	276
d36	284
d37	292
d38	300
d39	308
d40	316
d41	324
d42	332
d43	340
d44	348
d45	356
d46	364
d47	372
d48	380
d49	388
d50	396
d51	404

Es24	0.003936
Es25	0.00421
Es26	0.004484
Es27	0.004758
Es28	0.005032
Es29	0.005306
Es30	0.00558
Es31	0.005853
Es32	0.006127
Es33	0.006401
Es34	0.006675
Es35	0.006949
Es36	0.007223
Es37	0.007497
Es38	0.007771
Es39	0.008044
Es40	0.008318
Es41	0.008592
Es42	0.008866
Es43	0.00914
Es44	0.009414
Es45	0.009688
Es46	0.009962
Es47	0.010236
Es48	0.010509
Es49	0.010783
Es50	0.011057
Es51	0.011331

fs24	114,151	60,000
fs25	122,094	60,000
fs26	130,036	60,000
fs27	137,979	60,000
fs28	145,921	60,000
fs29	153,864	60,000
fs30	161,807	60,000
fs31	169,749	60,000
fs32	177,692	60,000
fs33	185,634	60,000
fs34	193,577	60,000
fs35	201,520	60,000
fs36	209,462	60,000
fs37	217,405	60,000
fs38	225,347	60,000
fs39	233,290	60,000
fs40	241,232	60,000
fs41	249,175	60,000
fs42	257,118	60,000
fs43	265,060	60,000
fs44	273,003	60,000
fs45	280,945	60,000
fs46	288,888	60,000
fs47	296,831	60,000
fs48	304,773	60,000
fs49	312,716	60,000
fs50	320,658	60,000
fs51	328,601	60,000

Ts24	18,600	2,953,501
Ts25	18,600	3,102,301
Ts26	18,600	3,251,101
Ts27	18,600	3,399,901
Ts28	18,600	3,548,701
Ts29	18,600	3,697,501
Ts30	18,600	3,846,301
Ts31	18,600	3,995,101
Ts32	18,600	4,143,901
Ts33	18,600	4,292,701
Ts34	18,600	4,441,501
Ts35	18,600	4,590,301
Ts36	18,600	4,739,101
Ts37	18,600	4,887,901
Ts38	18,600	5,036,701
Ts39	18,600	5,185,501
Ts40	18,600	5,334,301
Ts41	18,600	5,483,101
Ts42	18,600	5,631,901
Ts43	18,600	5,780,701
Ts44	18,600	5,929,501
Ts45	18,600	6,078,301
Ts46	18,600	6,227,101
Ts47	18,600	6,375,901
Ts48	18,600	6,524,701
Ts49	18,600	6,673,501
Ts50	18,600	6,822,301
Ts51	18,600	6,971,101