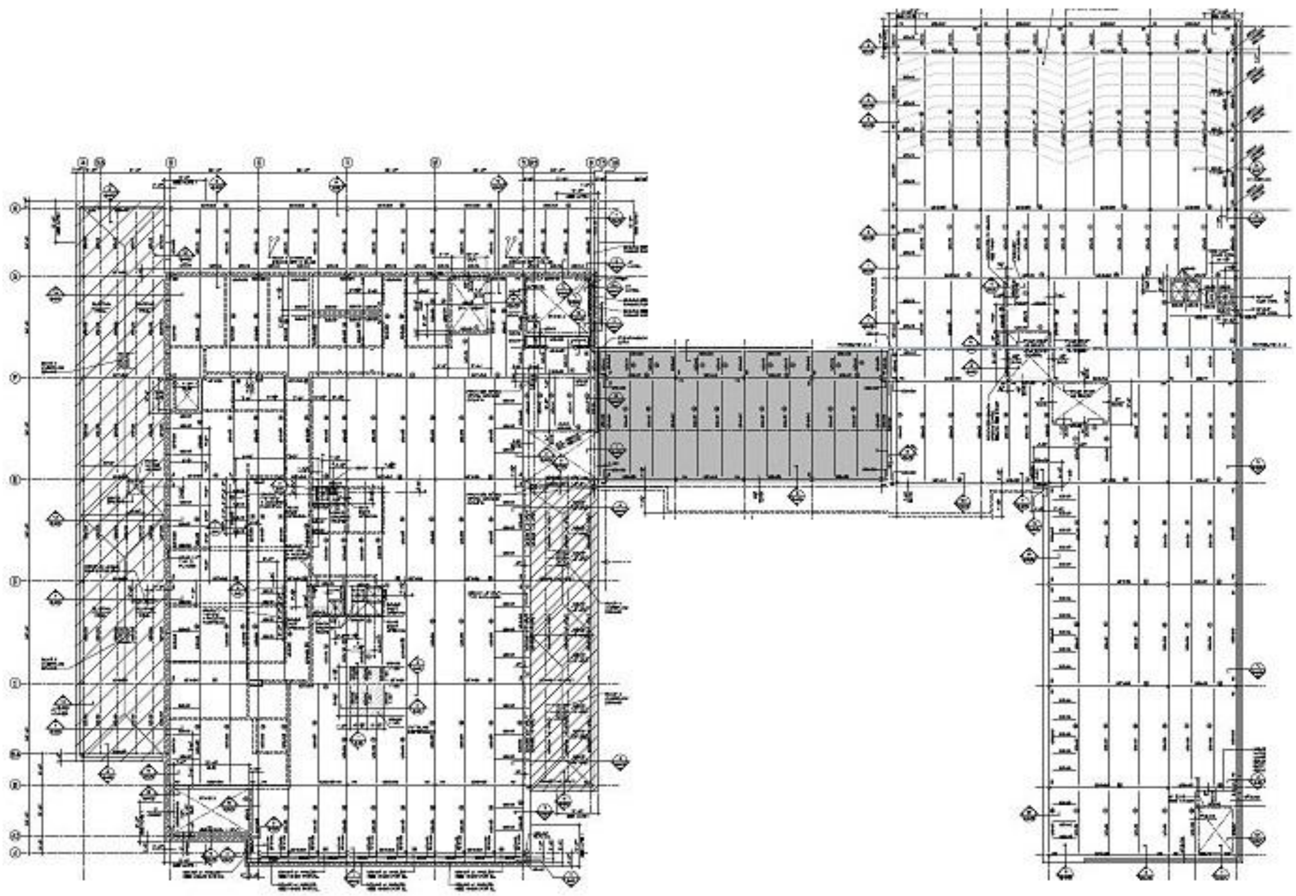
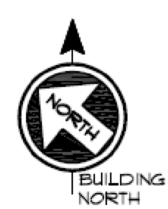
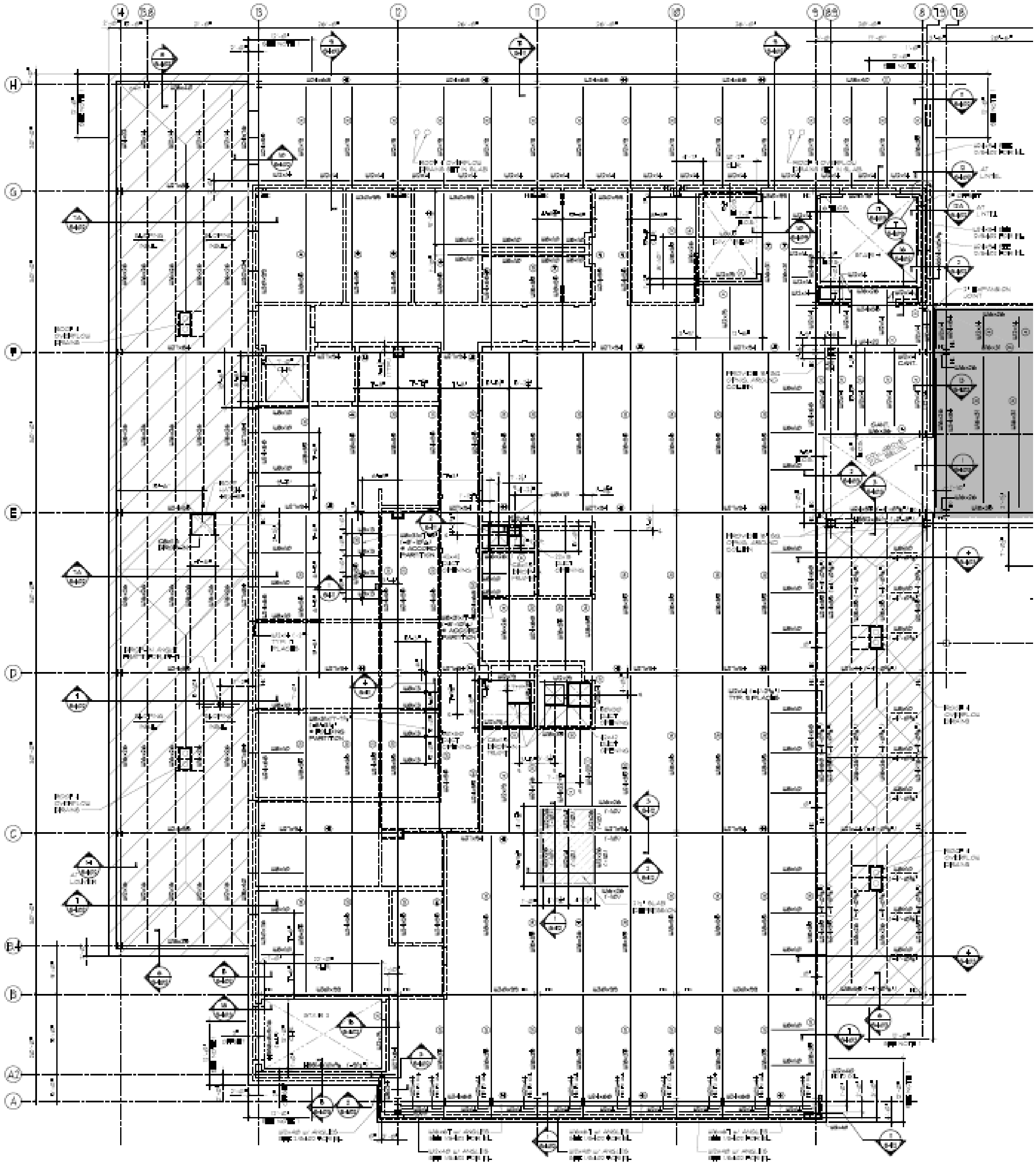
Appendix A: Typical Floor Plans

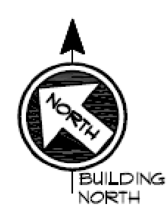


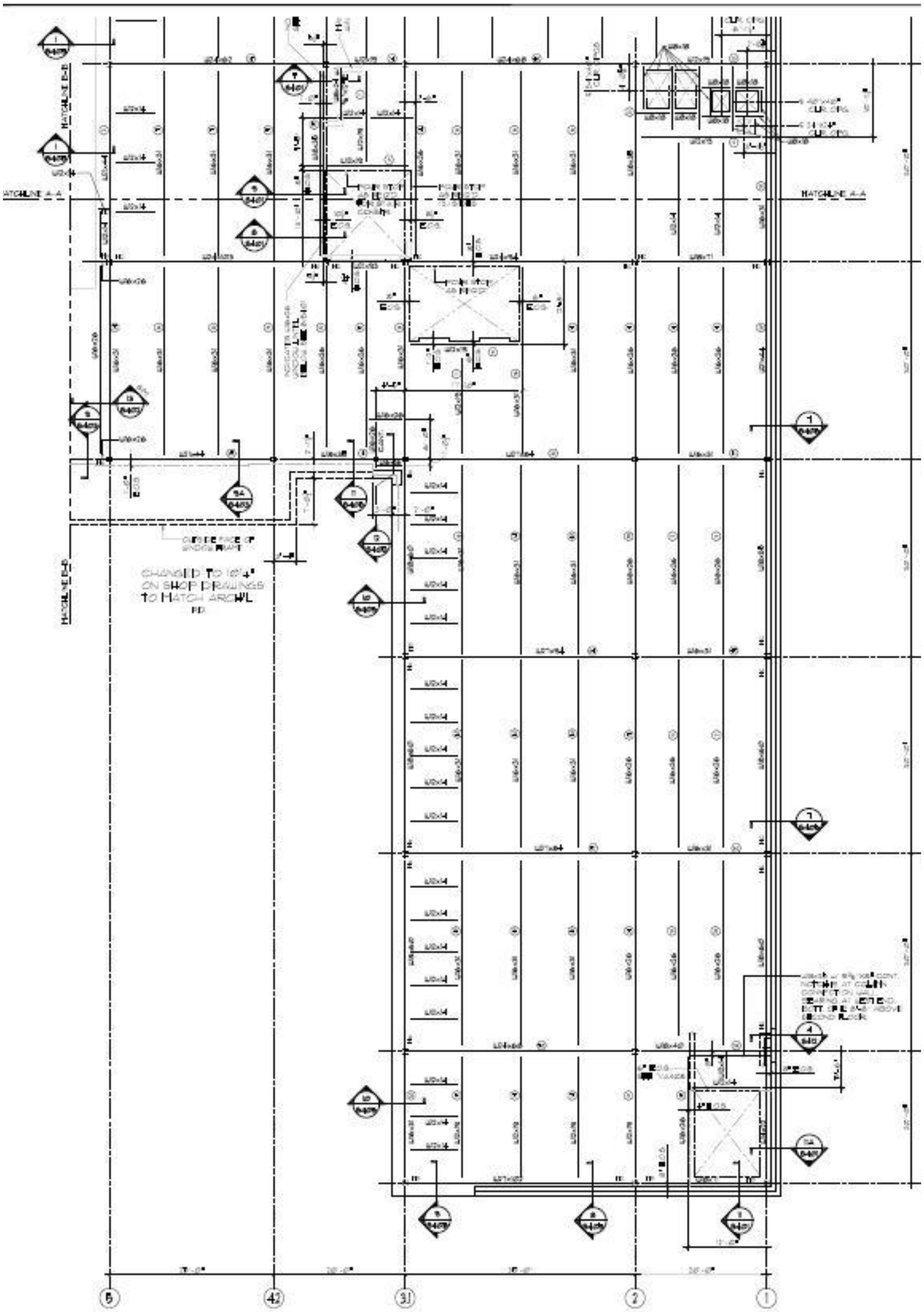
Framing Plan of the 2nd Floor, Courtesy of Highland Associates

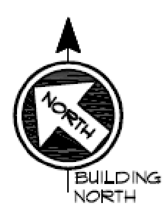




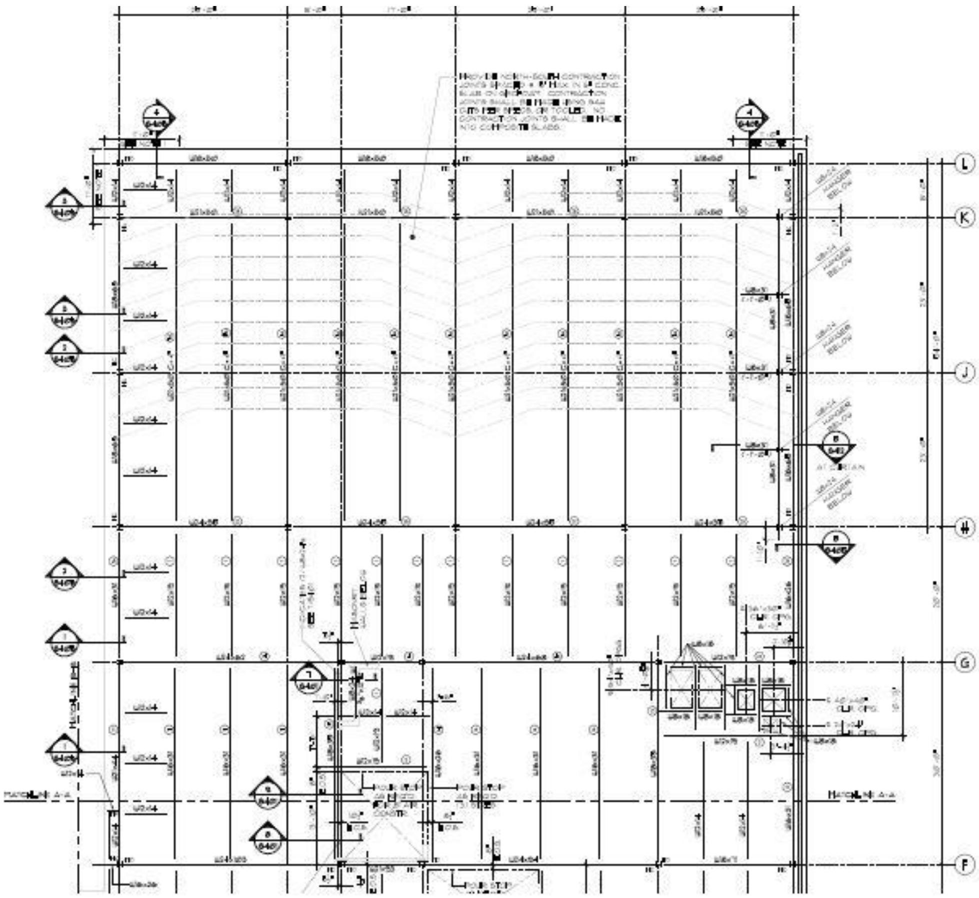
2nd Story frame, west wing, Courtesy of Highland Associates



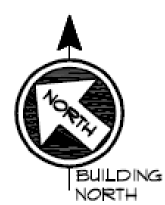


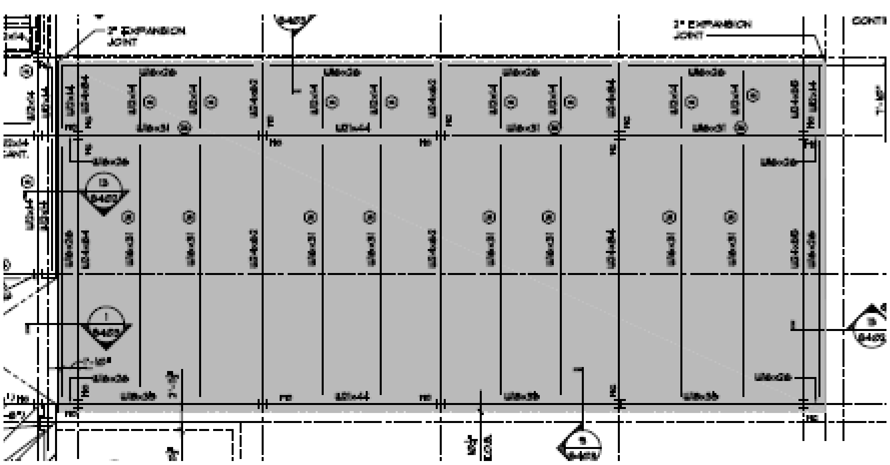


2nd Story frame, east wing (south), Courtesy of Highland Associates

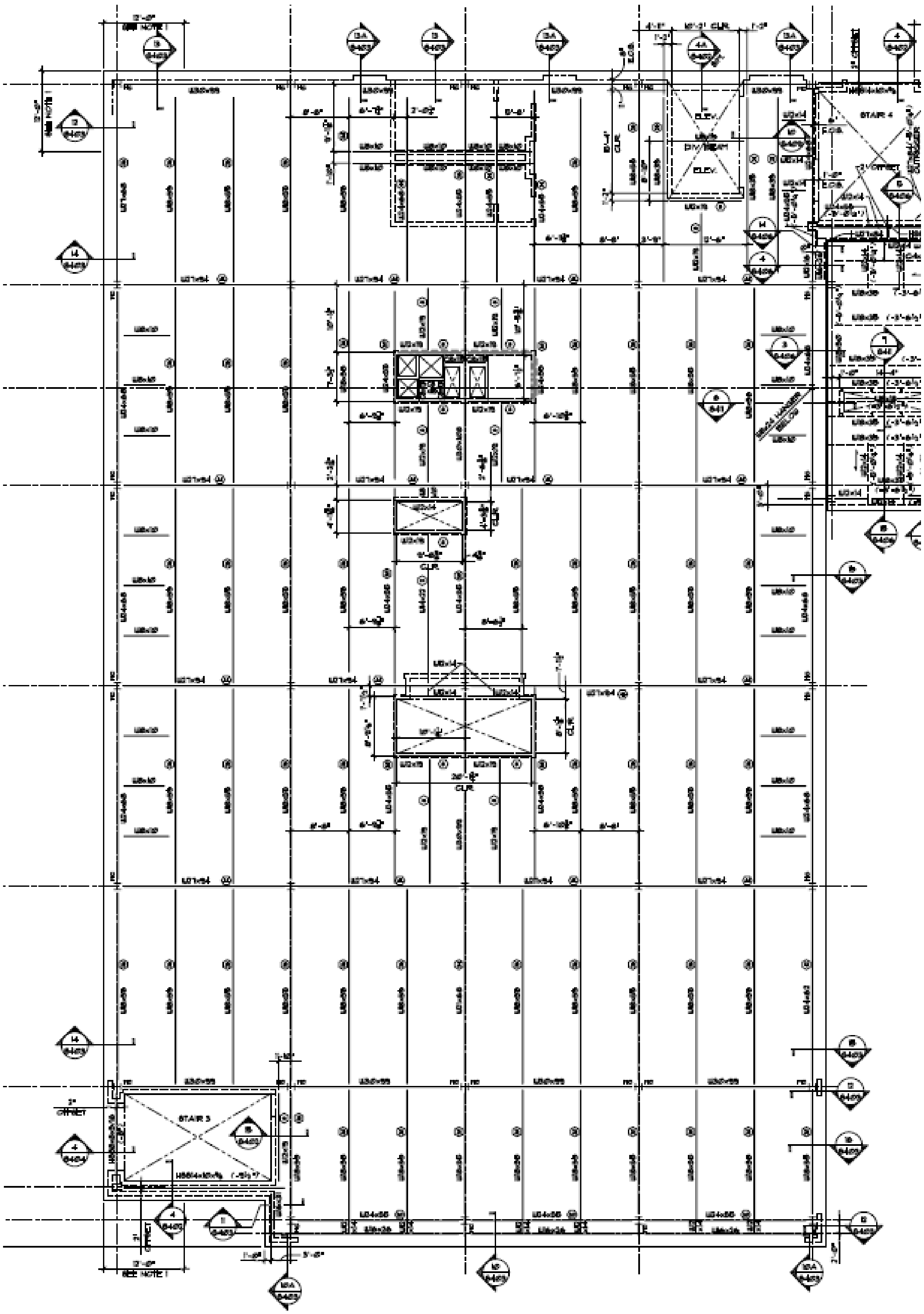


2nd Story frame, east wing (north), Courtesy of Highland Associates

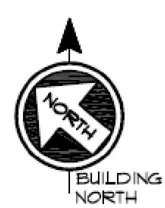


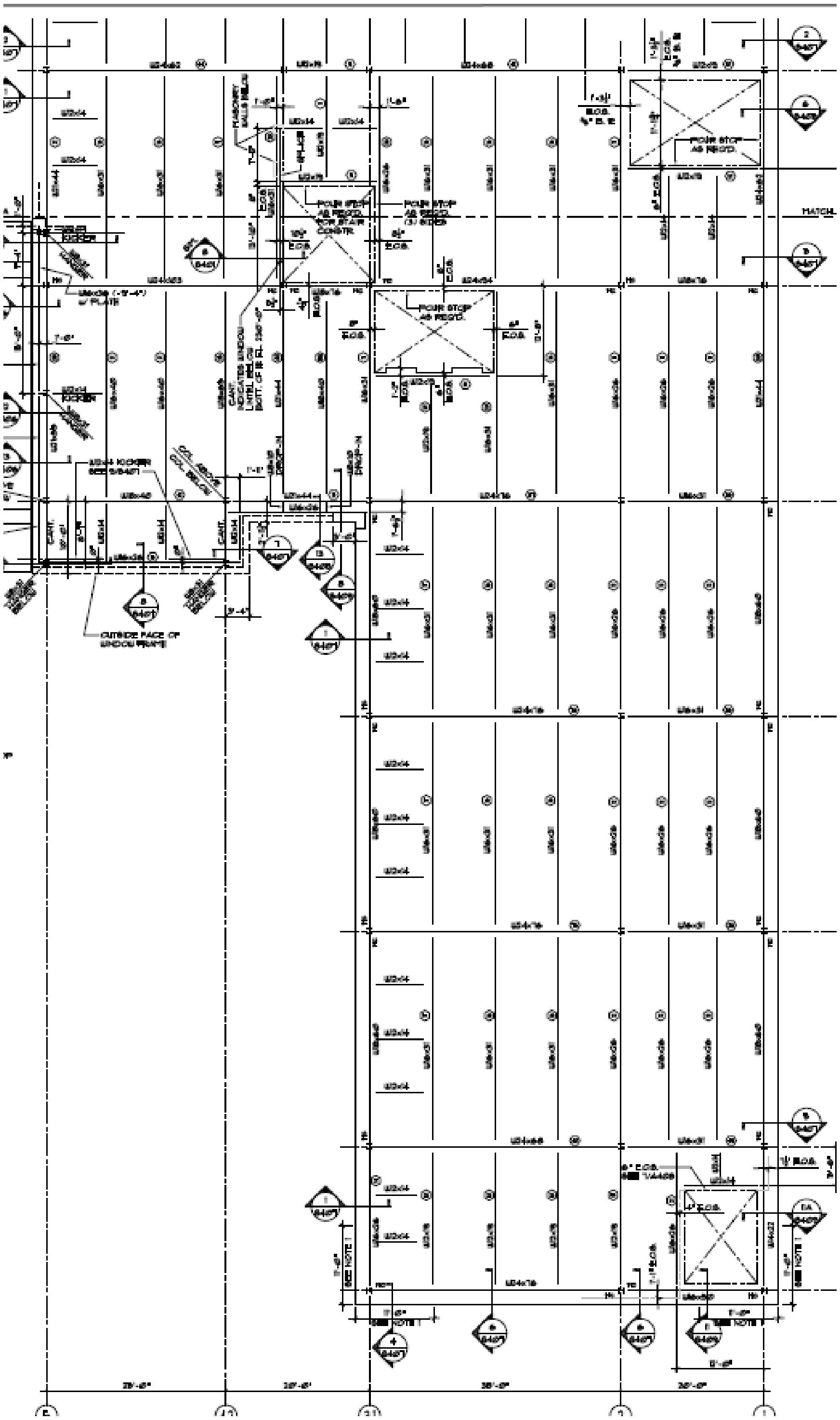


2nd Story frame, Link, Courtesy of Highland Associates

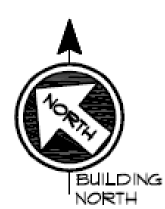


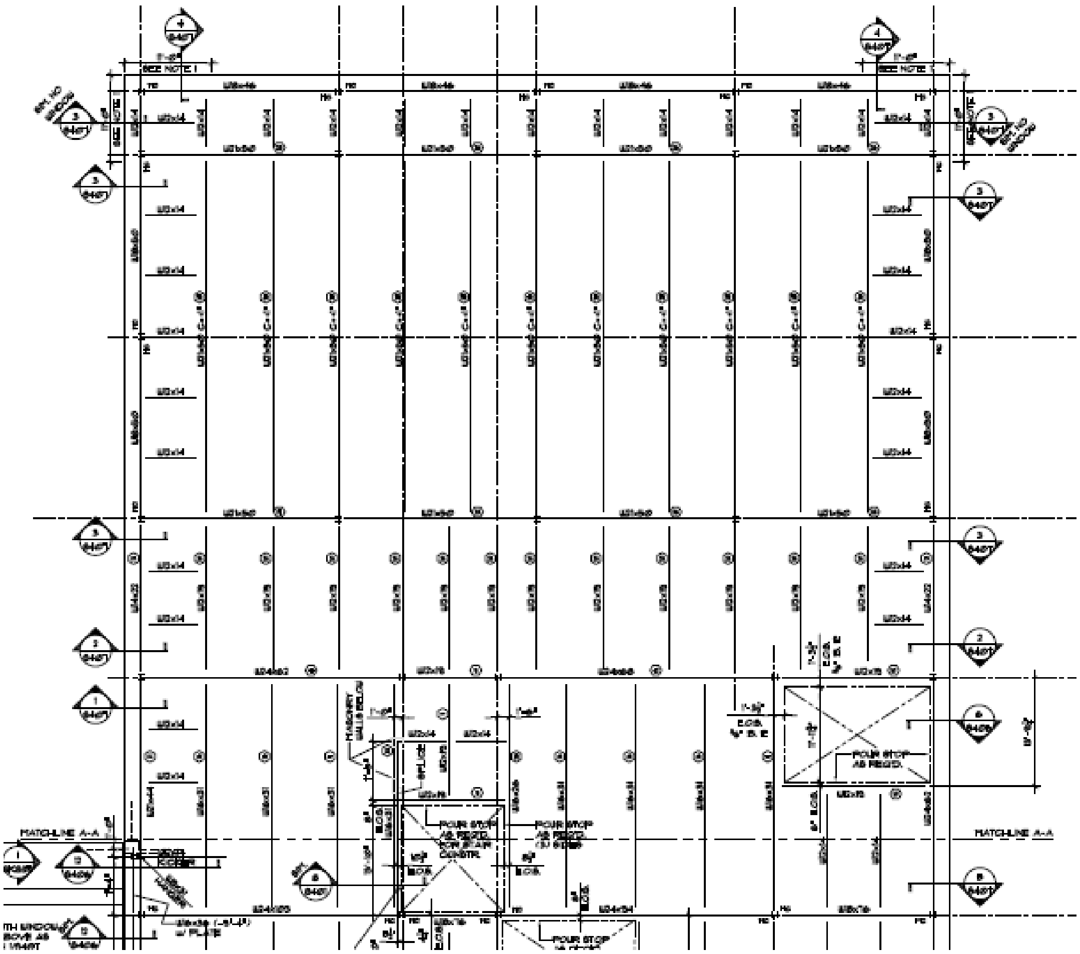
3rd Story frame, west wing, Courtesy of Highland Associates



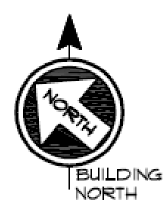


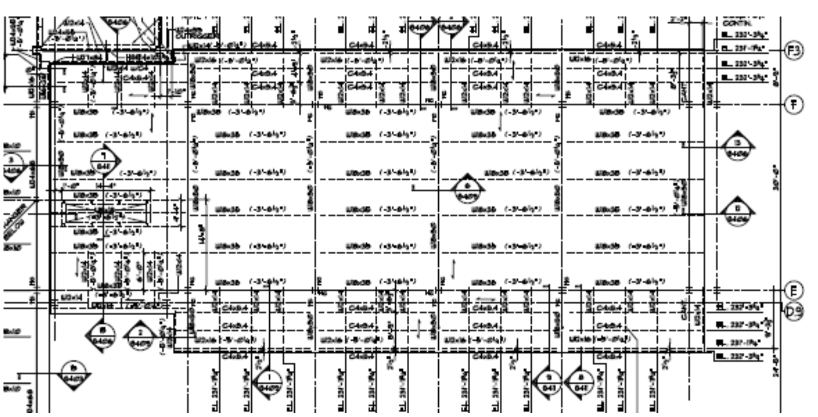
3rd Story frame, east wing (south), Courtesy of Highland Associates



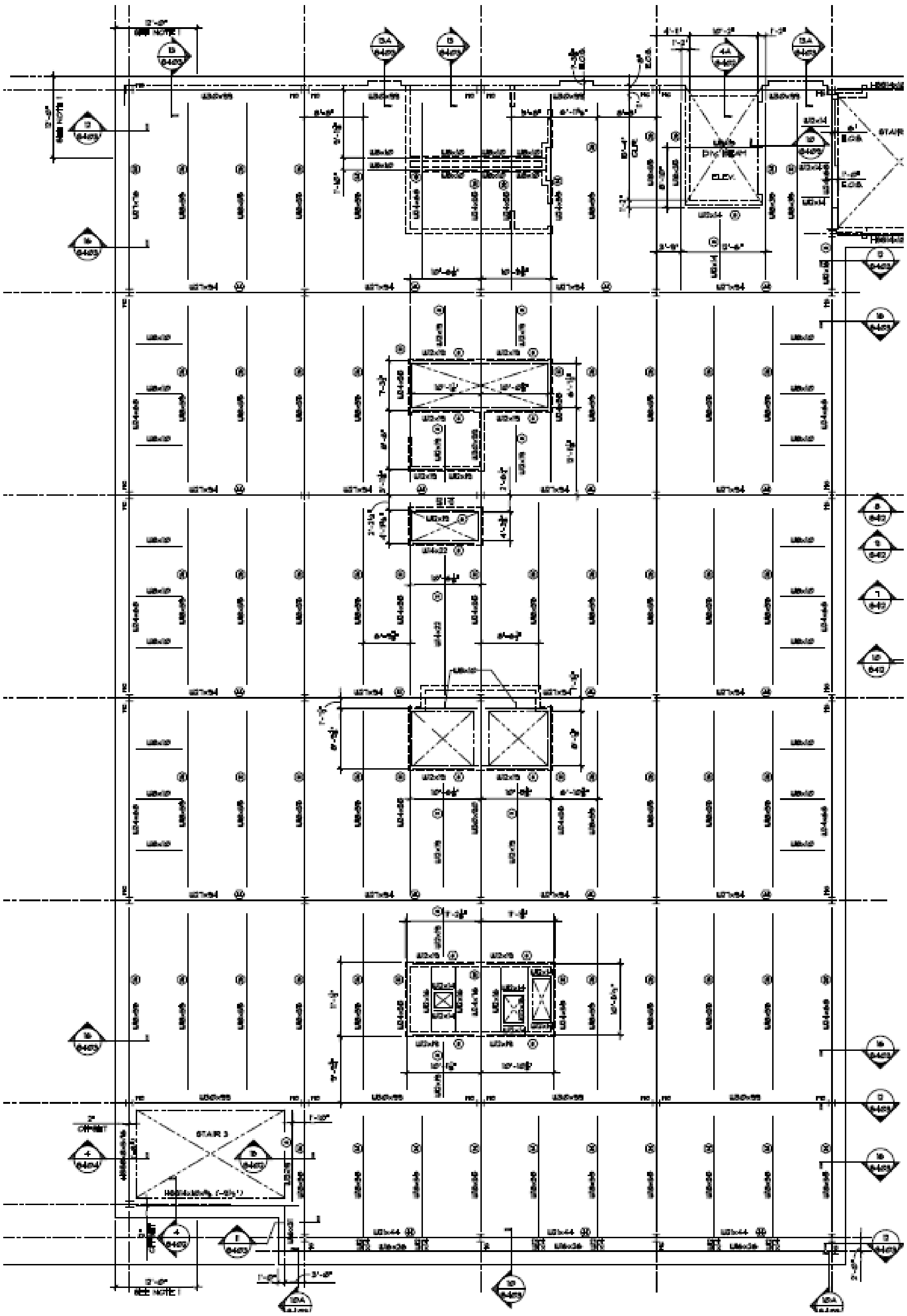


3rd Story frame, east wing (north), Courtesy of Highland Associates

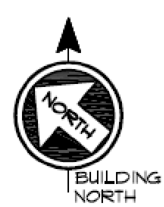


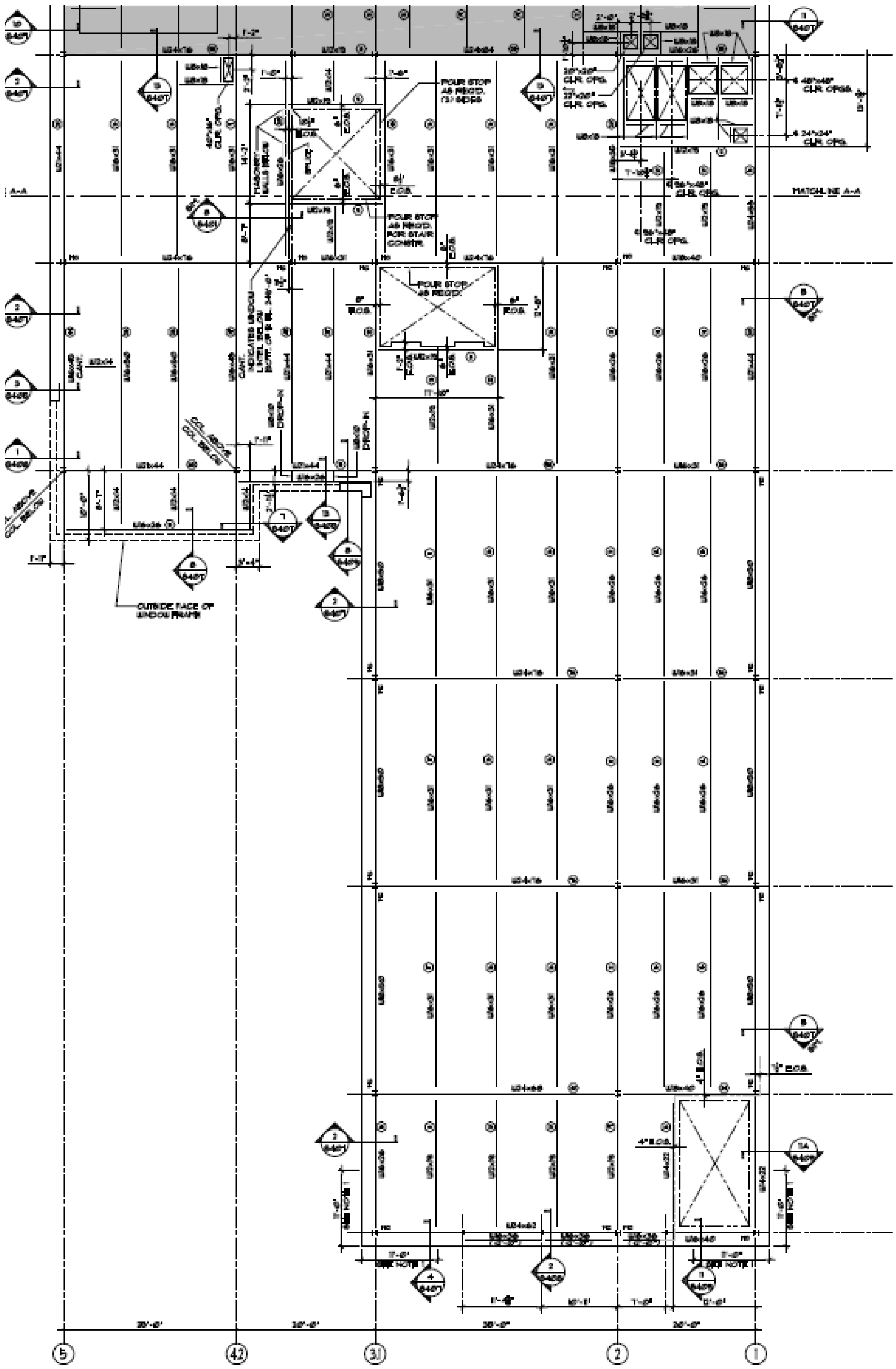


3rd Story frame, Link, Courtesy of Highland Associates

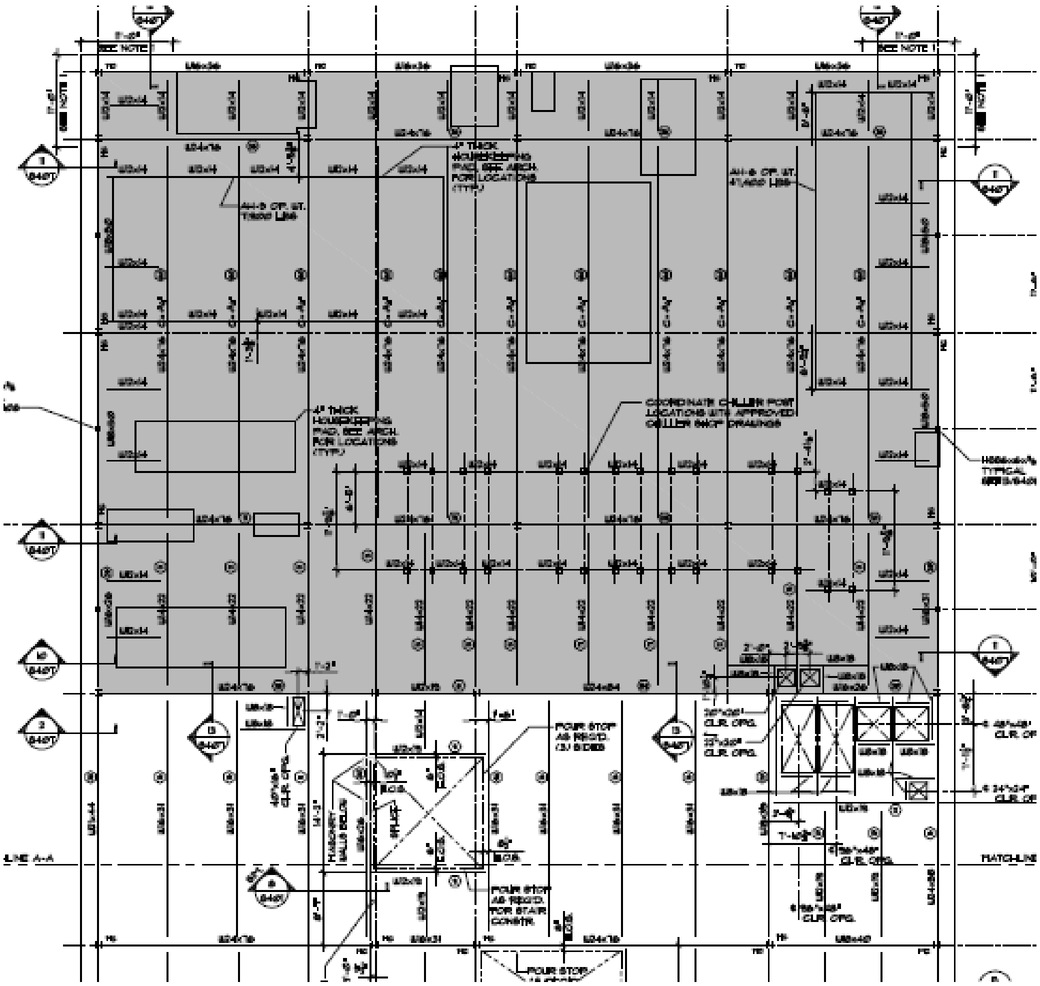


4th Story frame, west wing, Courtesy of Highland Associates

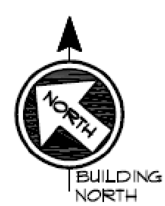


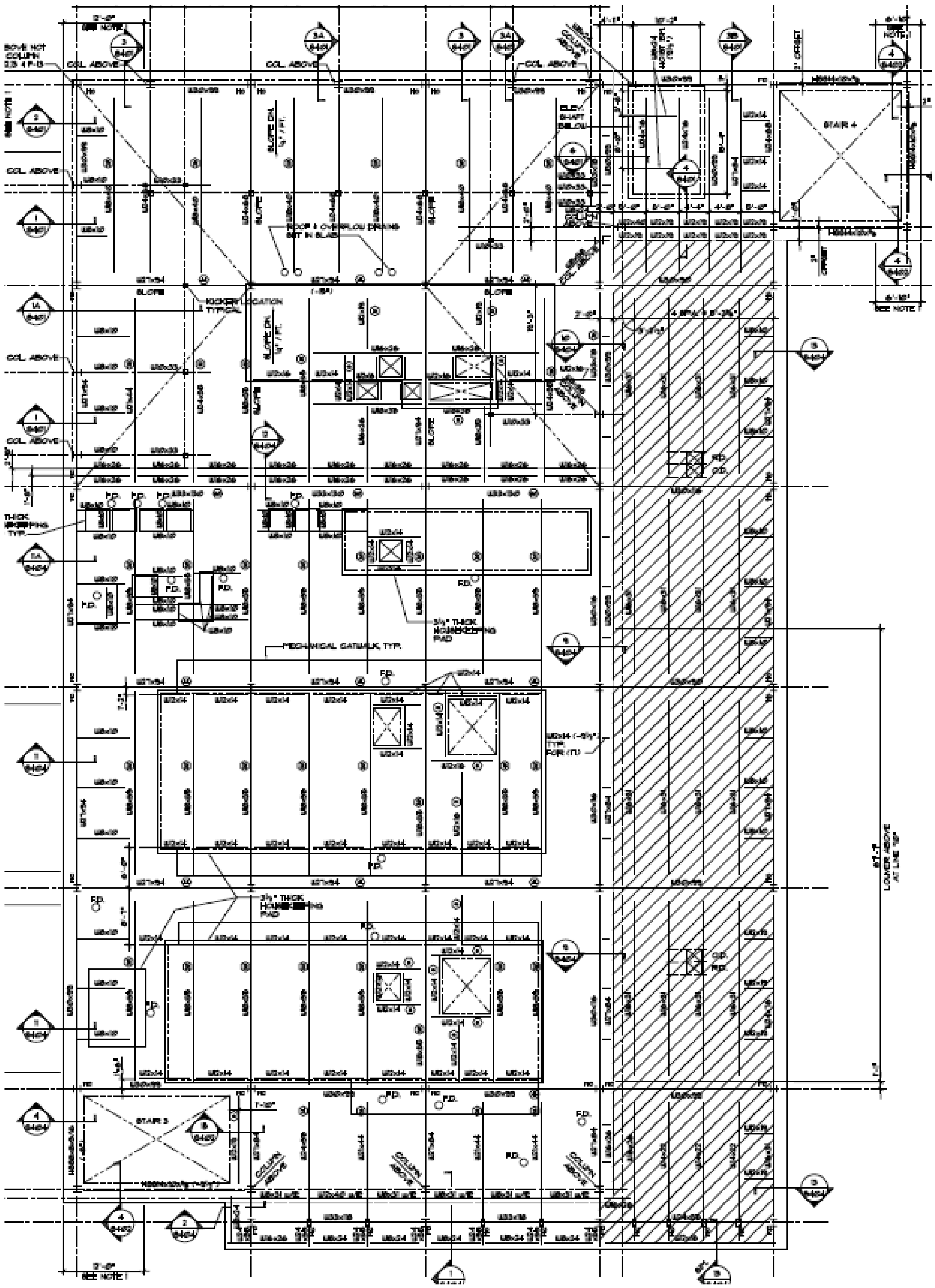


4th Story frame, east wing (south), Courtesy of Highland Associates

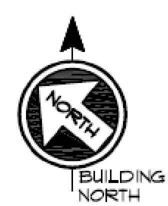


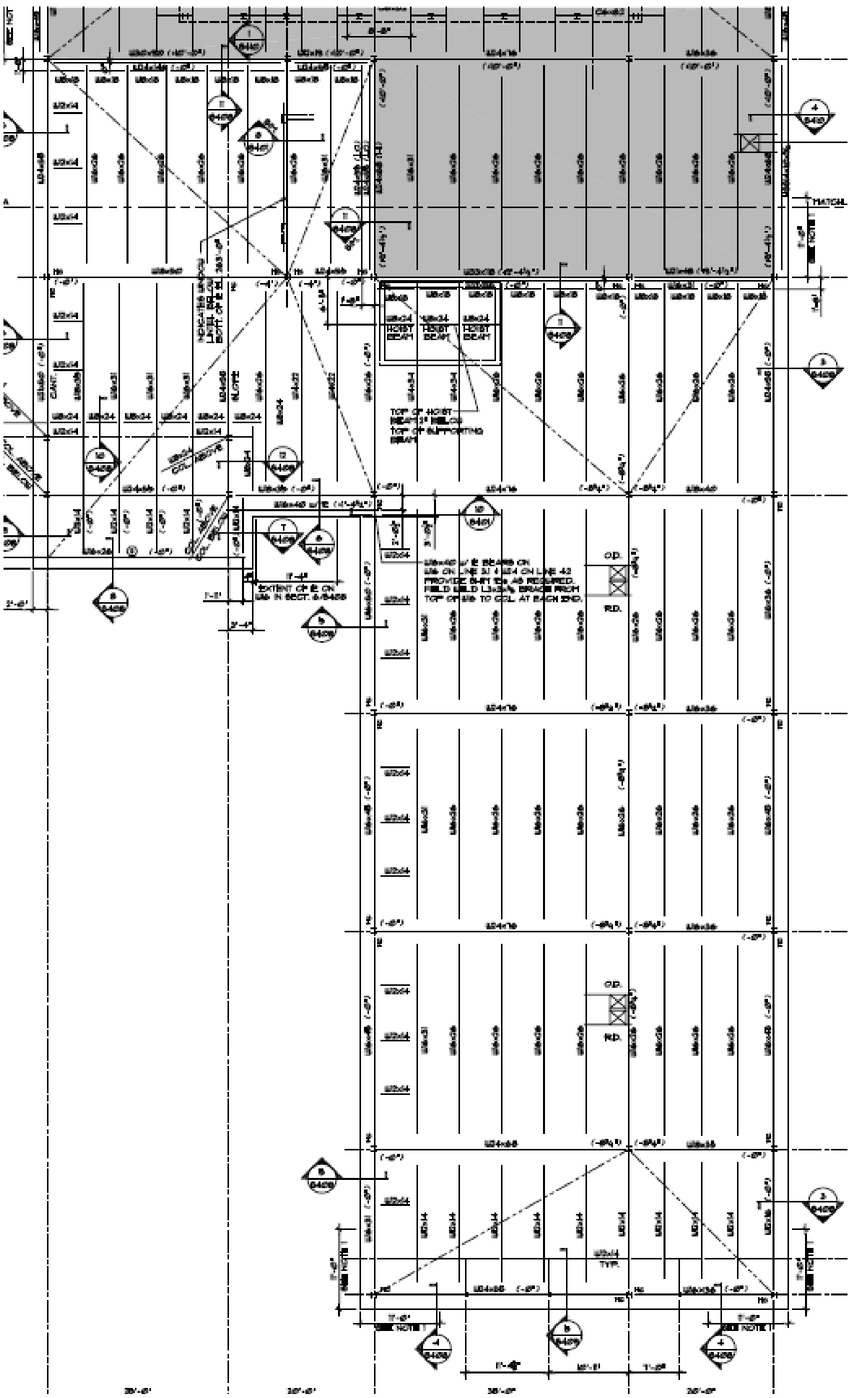
4th Story frame, east wing (north), Courtesy of Highland Associates



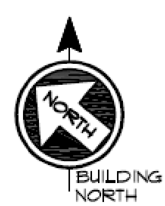


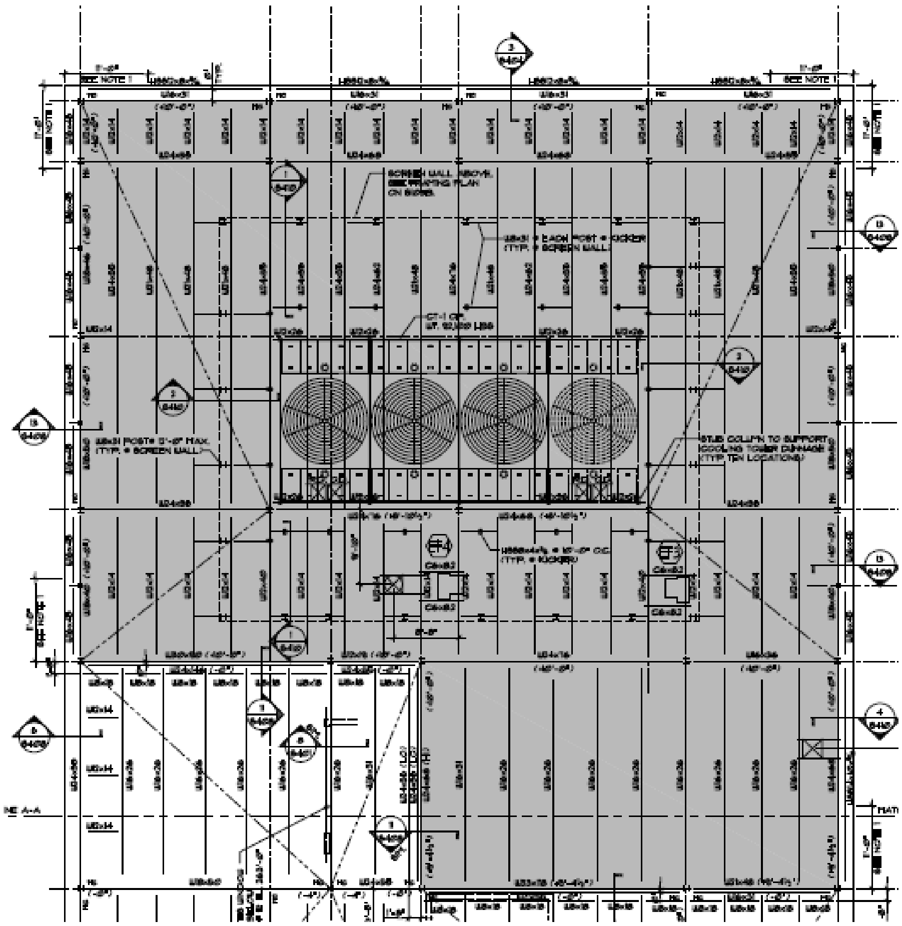
Main Roof Story frame, west wing, Courtesy of Highland Associates



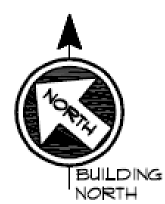


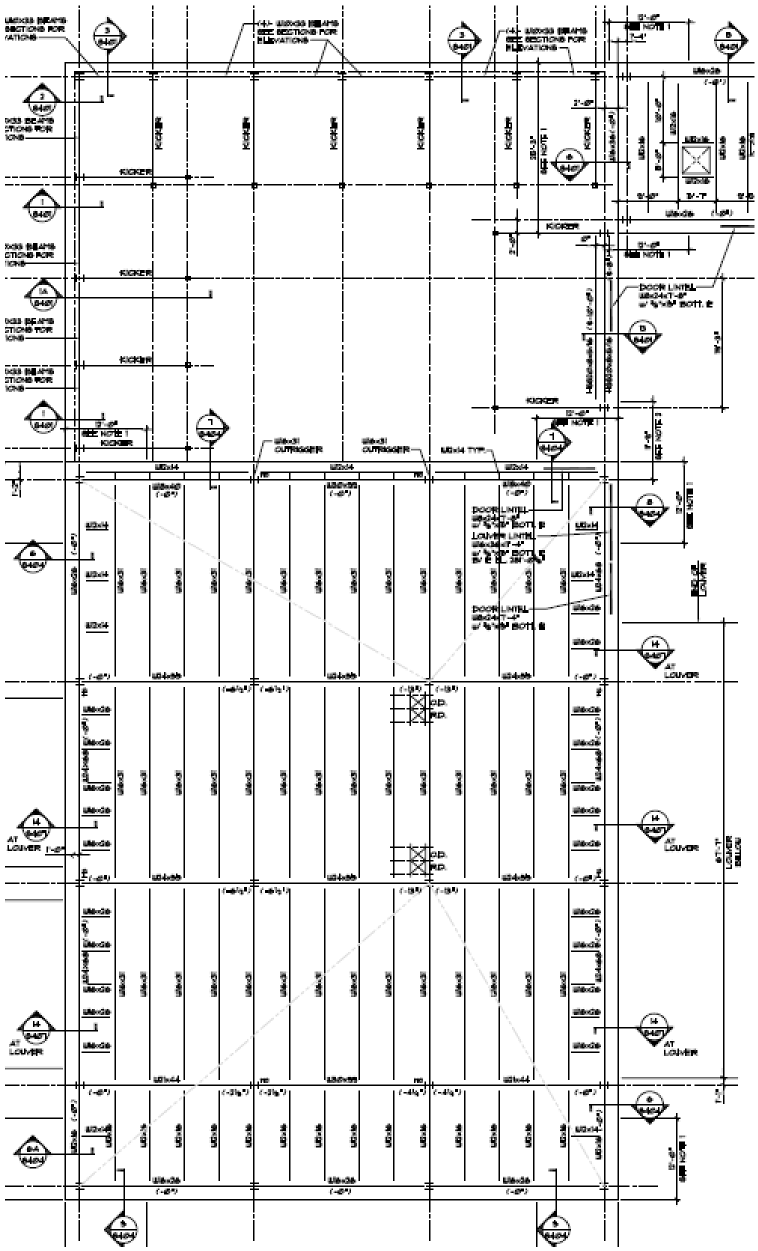
Main Roof Story frame, east wing (south), Courtesy of Highland Associates





Main Roof Story frame, east wing (north), Courtesy of Highland Associates



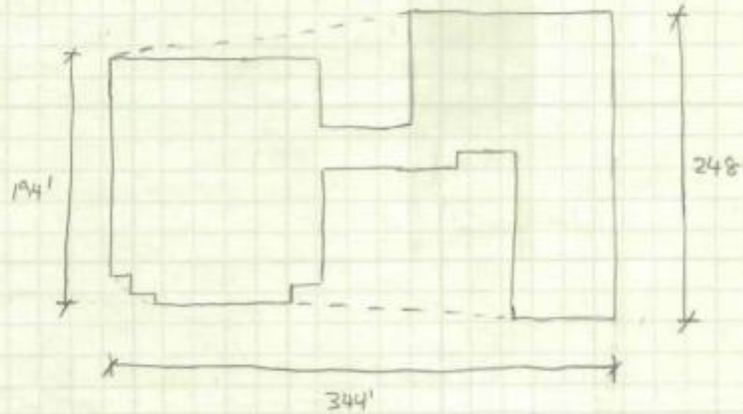


Penthouse Roof Story frame, west wing, Courtesy of Highland Associates

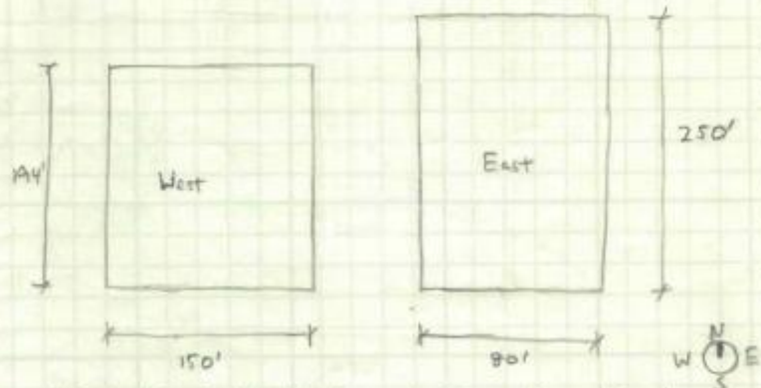
Appendix B: Miami, FL, Wind Load Calculations

Miami
Wind Design

Pg 1 of 7



Simplified Building

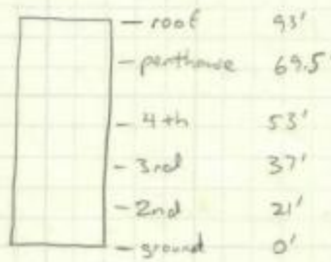


The building is changed to two rectangular buildings for easier calculation. Keeping their area relatively the same, the West Wing changed to 150' x 194' and the East Wing changed to 80' x 250' in the calculation.

* East Wing Controls Wind in the E-W Direction due to larger area.
* There are multiple roof heights with the TCMC but for this analysis, assume the highest roof is throughout the new rectangular building, which is 93'.

From design, $V_{3s} = 150$ MPH, Miami Florida
$I_w = 1.15$ = Buildings with a capacity > 500 for college
Exposure Category = B Urban surroundings
$K_d = 0.85$ for buildings main wind force resisting system.
$K_{zt} = 1.0$
K_z = varies depending on which story
$GC_{pi} = \pm 0.18$ Enclosed building; Fully

Wind Design



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

$= 0.00256(.99)(1.0)(.85)(150)^2(1.15)$

$q_{z_r} = 55.8$ psf for roof

$= 0.00256(.89)(1.0)(.85)(150)^2(1.15)$

$q_{z_p} = 50.2$ psf for penthouse floor

$= 0.00256(.83)(1.0)(.85)(150)^2(1.15)$

$q_{z_4} = 46.8$ psf for 4th story floor

$= 0.00256(.74)(1.0)(.85)(150)^2(1.15)$

$q_{z_3} = 41.7$ psf for 3th story floor

$= 0.00256(.70)(1.0)(.85)(150)^2(1.15)$

$q_{z_2} = 39.5$ psf for 2nd story floor

$= 0.00256(.70)(1.0)(.85)(150)^2(1.15)$

$q_{z_g} = 39.5$ psf for ground story floor

Finding Gust Effect Factor

$n_a = \frac{22.2}{h^{.8}} = \frac{22.2}{93^{(.8)}} = .59 < 1$ Hz so calculate in the event that building is flexible

$$G_f = 0.925\left(\frac{1 + 1.7 I_z \sqrt{g_Q^2 Q^2 + g_R^2 R^2}}{1 + 1.7 g_v I_z}\right)$$

g_Q and $g_v = 3.4$

$n_1 = \frac{100}{H} = \frac{100}{93} = 1.07$ average value C26.9-6 ASCE7-10

$n_1 = \frac{75}{H} = \frac{75}{93} = 0.81$ lower bound value C26.9-7 ASCE7-10

$g_R = \sqrt{2\ln(3{,}600)(1.07)} + \frac{0.577}{\sqrt{2\ln(3{,}600)(1.07)}} = 4.32$

$I_z = c\left(\frac{33}{\bar{z}}\right)^{1/6}$ $\bar{z} = \max \begin{cases} .6(93) = 55.8 \text{ ft} ✓ \\ 30 \text{ ft} \end{cases}$

$I_z = .30\left(\frac{33}{55.8}\right)^{1/6} = .275$ $c = 0.30$

Wind Design | | Page 3 of 7

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

$$R = \sqrt{\frac{1}{\beta} R_n R_h R_B (0.53 + 0.47 R_L)}$$ β assumed to be

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

$$N_1 = \frac{n_1 L_z}{V_z}$$ Constants are from table 26.9-1 (ASCE 7-10)

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

$$= 320 \left(\frac{55.8}{33}\right)^{1/3}$$

$$= 381.2$$

$$V_z = \bar{b}\left(\frac{\bar{z}}{33}\right)^{\bar{\alpha}}\left(\frac{88}{60}\right)V$$ $\bar{b} = .45$, $\bar{\alpha} = 1/7$

$$= .45\left(\frac{55.8}{33}\right)^{1/7}\left(\frac{88}{60}\right)90$$

$$= 64.0$$

$$N_1 = \frac{1.07(381.2)}{64} = 6.37$$

$$R_n = \frac{7.47(6.37)}{1 + 10.3(6.37)^{5/3}} = .044$$

Wind Design — Page 4 of 7

West Wing

N-S Direction

$h = 93$ ft
$L = 150$ ft
$B = 194$ ft

E-W Direction ← Is not required, does not control design

$h = 93$ ft
$L = 194$ ft
$B = 150$ ft

$\beta = 1\%$ recommended by ASCE 7-05 $= .01$

$$\eta_h = \frac{4.6 n_1 h}{\bar{V}_z} = \frac{4.6(1.07)(93)}{64} = 7.15 \qquad \eta_h = 7.15$$

$$\eta_B = \frac{4.6 n_1 B}{\bar{V}_z} = \frac{4.6(1.07)(194)}{64} = 14.9 \qquad \eta_B = \frac{4.6(1.07)(150)}{64} = 11.5$$

$$\eta_L = \frac{15.4 n_1 L}{\bar{V}_z} = \frac{15.4(1.07)(150)}{64} = 38.6 \qquad \eta_L = \frac{15.4(1.07)(194)}{64} = 49.9$$

$$R_\ell = \frac{1}{\eta} - \frac{1}{2\eta^2}\left(1 - e^{-2\eta}\right) \quad \text{for } \eta > 0$$

$$R_h = \frac{1}{7.15} - \frac{1}{2(7.15)^2}\left(1 - e^{-2(7.15)}\right) = .130 \qquad R_h = .130$$

$$R_B = \frac{1}{14.9} - \frac{1}{2(14.9)^2}\left(1 - e^{-2(14.9)}\right) = .064 \qquad R_B = \frac{1}{11.5} - \frac{1}{2(11.5)^2}\left(1 - e^{-2(11.5)}\right) = .083$$

$$R_L = \frac{1}{38.6} - \frac{1}{2(38.6)^2}\left(1 - e^{-2(38.6)}\right) = .026 \qquad R_L = \frac{1}{49.9} - \frac{1}{2(49.9)^2}\left(1 - e^{-2([illegible])}\right) = .020$$

$$R = \sqrt{\frac{1}{0.01}(.044)(.13)(.064)(0.53 + 0.47(.026))} = .14 \qquad R = \sqrt{\frac{1}{0.01}(0.044)(.13)(.083)(0.53 + 0.47(0.020))} = .16$$

$$Q = \sqrt{\frac{1}{1 + 0.63\left(\frac{194+93}{381.2}\right)^{0.63}}} = .81 \qquad Q = \sqrt{\frac{1}{1 + 0.63\left(\frac{150+93}{381.2}\right)^{0.63}}} = .82$$

$$G_f = 0.925\left(\frac{1 + 1.7(.275)\sqrt{(3.4)^2(.81)^2 + (4.32)^2(.140)^2}}{1 + 1.7(3.4)(.275)}\right) \qquad G_f = 0.925\left(\frac{1 + 1.7(.275)\sqrt{(3.4)^2(.82)^2 + (4.32)^2(.16)^2}}{1 + 1.7(3.4)(.275)}\right)$$

$G_f = .828$ $\qquad$ $G_f = .837$

Wind Design — Page 5 of 7

West Wing Pressures

$p = q G C_p - q_i (GC_{pi})$

Wall

	N-S	E-W
Windward	$C_p = 0.8$	$C_p = 0.8$
Sidewall	$C_p = -0.7$	$C_p = -0.7$
Leeward	$C_p = L/B = 150/194 = .77$	$C_p = L/B = 194/150 = 1.29$
	$C_p = -0.5$	$C_p = -0.45$ by interpolation

Roof (N-S)

$\theta = 0°$ $h/L = 93/150 = .62$

$C_p = -1.1$ for 0 to $h/2$ — by interpolation

$C_p = -0.6$ for $> h/2$

Roof (E-W)

$\theta = 0$ $h/L = 93/194 = .48$

$C_p = -0.9$ for 0 to h

$C_p = -0.5$ for h to $2h$

$C_p = -0.3$ for $> 2h$

$p = 55.8(.828)(0.8) - 55.8(\pm .18) =$

$= 37.0 \pm 10.1$

$= 47.1$ or 26.9 psf

at roof height, windward wall

* see excel for rest of calculations

Wind Design — Page 6 of 7

East Wing

N-S Direction

$h = 93$ ft
$L = 80$ ft
$B = 250$ ft

E-W Direction

$h = 93$ ft
$L = 250$ ft
$B = 80$ ft

$\beta = 1\%$ recommended by ASCE 7-05
$= .01$

N-S Direction:

$$\eta_h = \frac{4.6(1.07)(9.3)}{64} = 7.15$$

$$\eta_B = \frac{4.6(1.07)(250)}{64} = 19.2$$

$$\eta_L = \frac{15.4(1.07)(80)}{64} = 20.6$$

$R_h = .130$

$$R_B = \frac{1}{19.2} - \frac{1}{2(19.2)^2}\left(1 - e^{-2(19.2)}\right) = .050$$

$$R_L = \frac{1}{20.6} - \frac{1}{2(20.6)^2}\left(1 - e^{-2(20.6)}\right) = .047$$

$$R = \sqrt{\frac{1}{0.01}(.044)(.13)(.05)(.53 + .47(.047))} = .13$$

$$Q = \sqrt{\frac{1}{1 + 0.63\left(\frac{250+93}{381.2}\right)^{0.63}}} = .793$$

$$G_f = 0.925\left(\frac{1 + 1.7(.275)\sqrt{(3.4)^2(.793)^2 + (4.32)^2(.13)^2}}{1 + 1.7(3.4)(.275)}\right)$$

$G_f = .917$

E-W Direction:

$\eta_h = 7.15$

$$\eta_B = \frac{4.6(1.07)(80)}{64} = 6.15$$

$$\eta_L = \frac{15.4(1.07)(250)}{64} = 64.4$$

$R_h = .130$

$$R_B = \frac{1}{6.15} - \frac{1}{2(6.15)^2}\left(1 - e^{-2(6.15)}\right) = .150$$

$$R_L = \frac{1}{64.4} - \frac{1}{2(64.4)^2}\left(1 - e^{-2(6.15)}\right) = .015$$

$$R = \sqrt{\frac{1}{0.01}(0.044)(.13)(.15)(.53 + .47(.015))} = .21$$

$$Q = \sqrt{\frac{1}{1 + 0.63\left(\frac{80+93}{381.2}\right)^{0.63}}} = .850$$

$$G_f = 0.925\left(\frac{1 + 1.7(.275)\sqrt{(3.4)^2(.85)^2 + (4.32)^2(.21)^2}}{1 + 1.7(3.4)(.275)}\right)$$

$G_f = .863$

Wind Design Page 7 of 7

East Wing Pressures

$p = qGC_p - q_i(GC_{pi})$

Wall

	N-S.	E-W
Windward	$C_p = 0.8$	$C_p = 0.8$
Side Wall	$C_p = -0.7$	$C_p = -0.7$
Leeward	$C_p \Rightarrow L/B = 80/250 = .32$	$C_p = 250/80 = 3.125$
	$C_p = -0.5$	$C_p = -0.25$ by interpolation

Roof

$\theta = 0°$ $h/L = 93/80 = 1.162$

$\frac{h}{2} = \frac{93}{2} = 46.5$

$2h = 186$

Roof area >> 1000 sf R.F = .8

$C_p = -1.3$ for 0 to h/2

$C_p = -0.7$ for > h/2

$h/L = 93/250 = .372$

$C_p = -0.9$ for 0 to h

$C_p = -0.5$ for h to 2h

$C_p = -0.3$ for > 2h

$p = 55.8(.817)(0.8) - 55.8(\pm .18) = 9.51$

$= 36.5 \pm 10.1$

$= 46.6$ or 26.4 psf

at roof height, windward wall

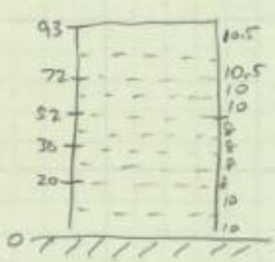
$p = 55.8(.863)(0.8) - 55.8(\pm .18)$

$= 38.6 \pm 10.1$

$= 48.7$ or 28.5 psf

* See Excel for rest of calculations

Wind Forces Breakdown



Appendix C: Miami, FL, Seismic Load Calculations

Seismic Analysis pg 1 of 1

For Miami Florida, Site Class D

$S_s = 0.050g$ $S_{ms} = 0.080g$ $S_{DS} = 0.053g$

$S_1 = 0.019g$ $S_{m1} = 0.047g$ $S_{D1} = 0.031g$

From Table 12.2-1

R = 3.5 for ordinary steel Moment Frames

$\Omega = 3$

Cd = 3

R = 3.25 for ordinary steel concentrically braced frames

$\Omega = 2$

Cd = 3.25

From Table 11.6-1 ASCE 7-05

$S_{DS} < 0.167$ Occupancy Category III ⇒

Seismic Category A.

Section 11.7 of code

V = .01(W) W ≈ 23,000 kips

V = .01(13,600) = 136 kips

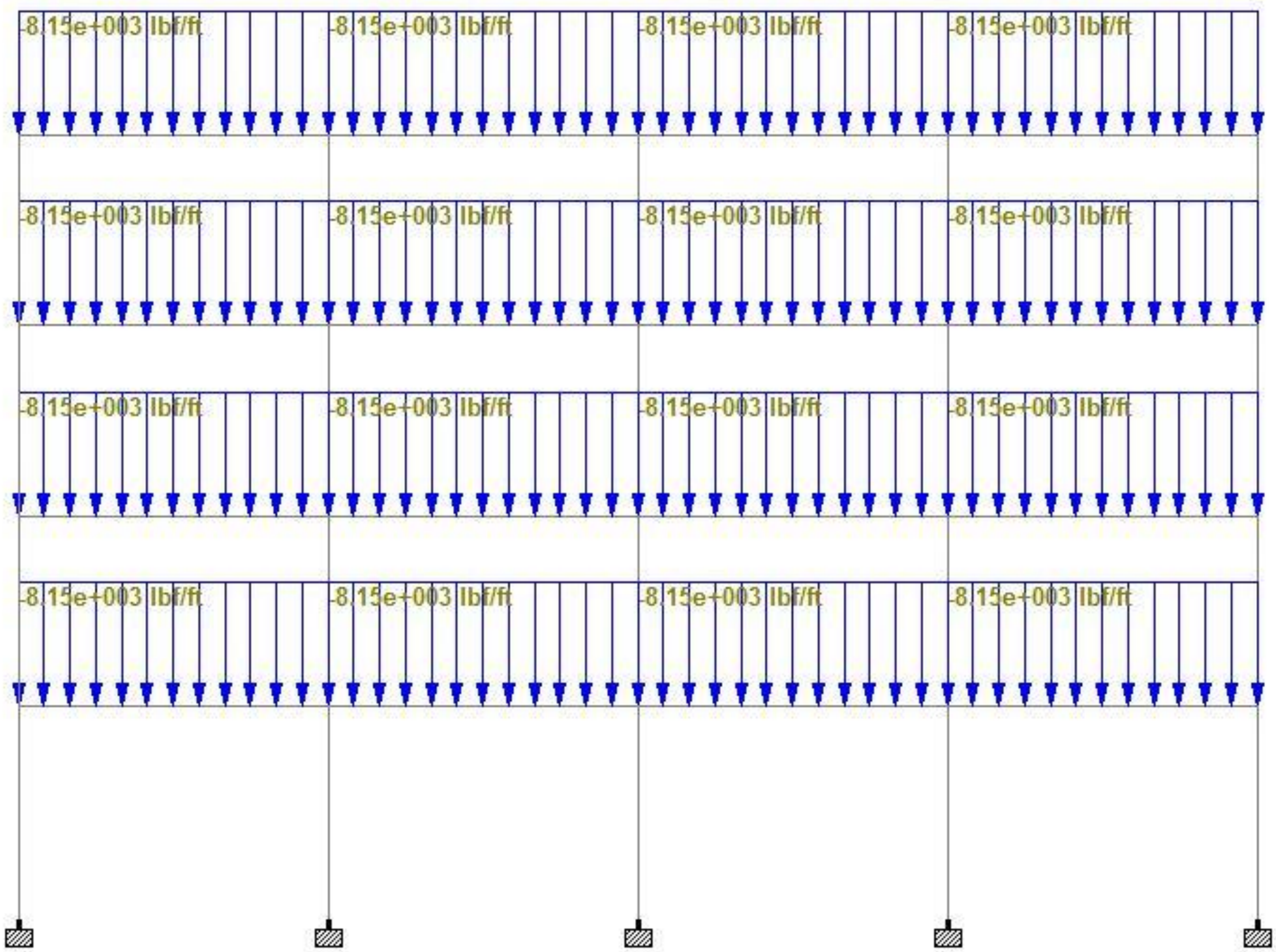
$F_x = 0.01 w_x$ = 130 kips at 1st for West Wing

See rest on excel

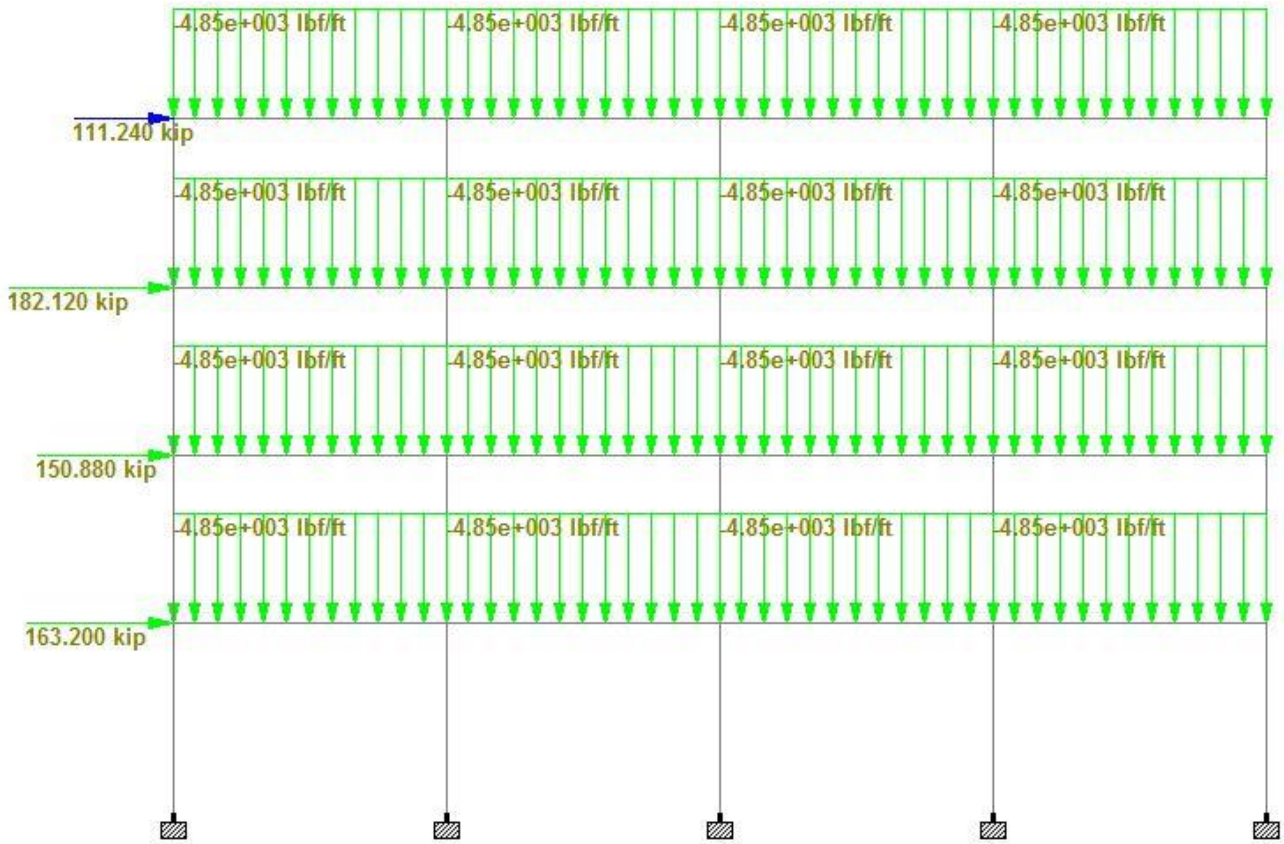
$F_x = 0.01(12,600) = 126$ kips at 1st for East Wing

See rest on excel

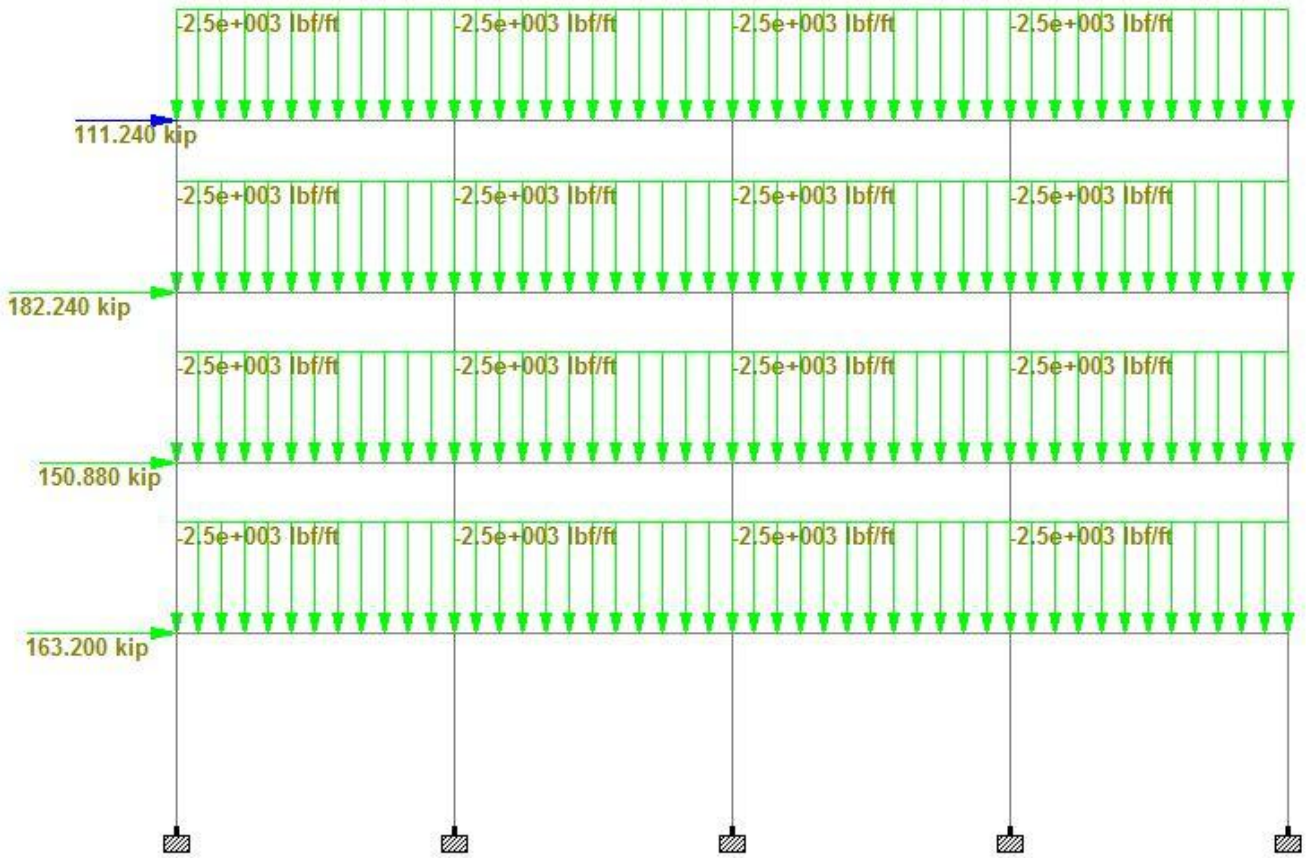
Appendix D: Moment Frame Design



1.2D+1.6L on Frame A



1.2D+1.6W+0.5L on Frame A



0.9D+1.6W on Frame A

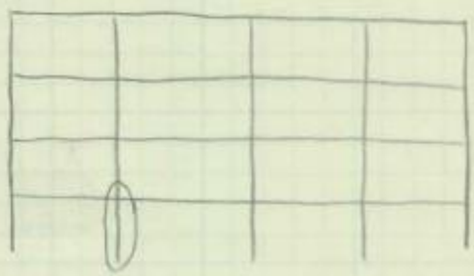
Moment Frame Design | Thesis | Page 1 of 3

Frame A will be used for this preliminary design

Check for dead + live load.

G12 = W14x257

Frame D



G12

Tributary area = 26' x 25' = 650 ft^2

Load = 3 Floors + 1 roof

$$LL_{red} = 0.25 + \frac{15}{\sqrt{4 \cdot 3(650)}} = .42$$

$P_L = 100(.42)(650) = 27,300$ 27,300(3) = 81,900

$P_D = 93(650) = 60450$ 60450(3) = 181350

$P_{LR} = 20(650) = 13,000$

$P_{DR} = 20(650) = 13,000$

$P_S = 30(650) = 19,500$

$P_u = 1.2(181350 + 13,000) + 1.6(81,900 + 13,000) + .5(19,500)$

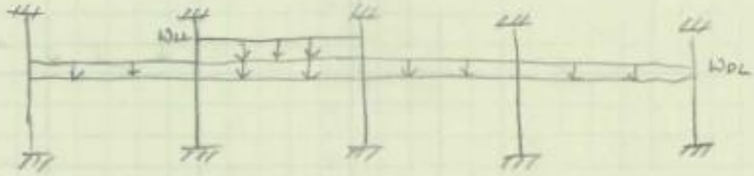
= 394.9 kips

The following loadings give the largest moments on beams.

$-0.121 w l^2$ = largest negative moment

+.0996 = largest positive moment

Columns continue



$w_u = 1.2(93)(25) + 1.6(100)(25)(.67) = 6.79$ klf

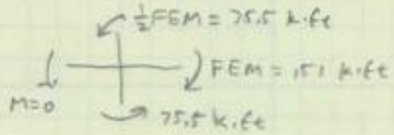
$LL_{red} = 0.25 + \frac{15}{\sqrt{2(25)(26)}} = .67$

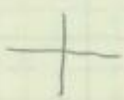
Dead load unbalanced moment ≈ 0

Live load unbalanced moment

$w_L = 1.6(100)(25)(.67) = 2.68$ klf

$FEM_u = \frac{2.68(26)^2}{12} = 151$ k·ft





$P_u = 394.9$ kips

$M_u = 75.5$ k·ft

$P_{eq} = 394.9 + \frac{25(75.5)}{14} = 530^k$

Use Column W14 x 90 $\phi P_n = 877^k$ @ 20ft

Beam sizes

$w_L = \frac{.65(100)(25)}{1000} = 1.625$ klf

$w_D = \frac{93(25)}{1000} = 2.325$ klf

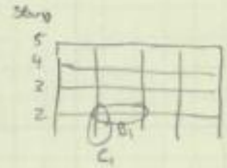
$w_u = 1.2(2.325) + 1.6(1.625) = 5.39$ klf

$\frac{w_u l^2}{12} = \frac{5.39(30)^2}{12} = 404.25$ k·ft

W18x97 with $\phi M_p = 495$ k·ft @ 30' unbraced

Moment Frame Design — pg 3 of 3

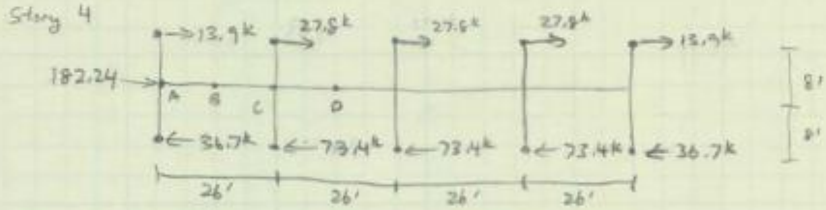
Portal Method Analysis

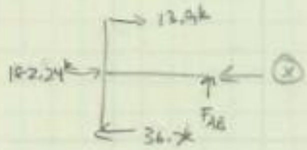


Frame A

1.6W load

Story 4





$\Sigma M_A = 13.9(8) + 36.7(8) - F_{AB}(13) = 0$

$F_{AB} = 31.1^k$

$M_{AC} = 31.1(13) = 404.3$ k-ft $\approx$ 380 STAAD model ✓ good.

Use load from STAAD model

Determining sizes

For C_1 ⇒ $P_r = 864$ kip

$M_r = 923$ k-ft

Try W 14x342 ⇒ $P_c = 3760$

$M_c = 1270$

$\frac{P_r}{P_c} = \frac{864}{3760} = .23 \geq 0.20 \qquad \frac{M_r}{M_c} = \frac{923}{1270} = .73$

$.23 + \frac{8}{9}(.73) = .88$ works

Try W 14x311 ⇒ $P_c = 3390$

$M_c = 1140$

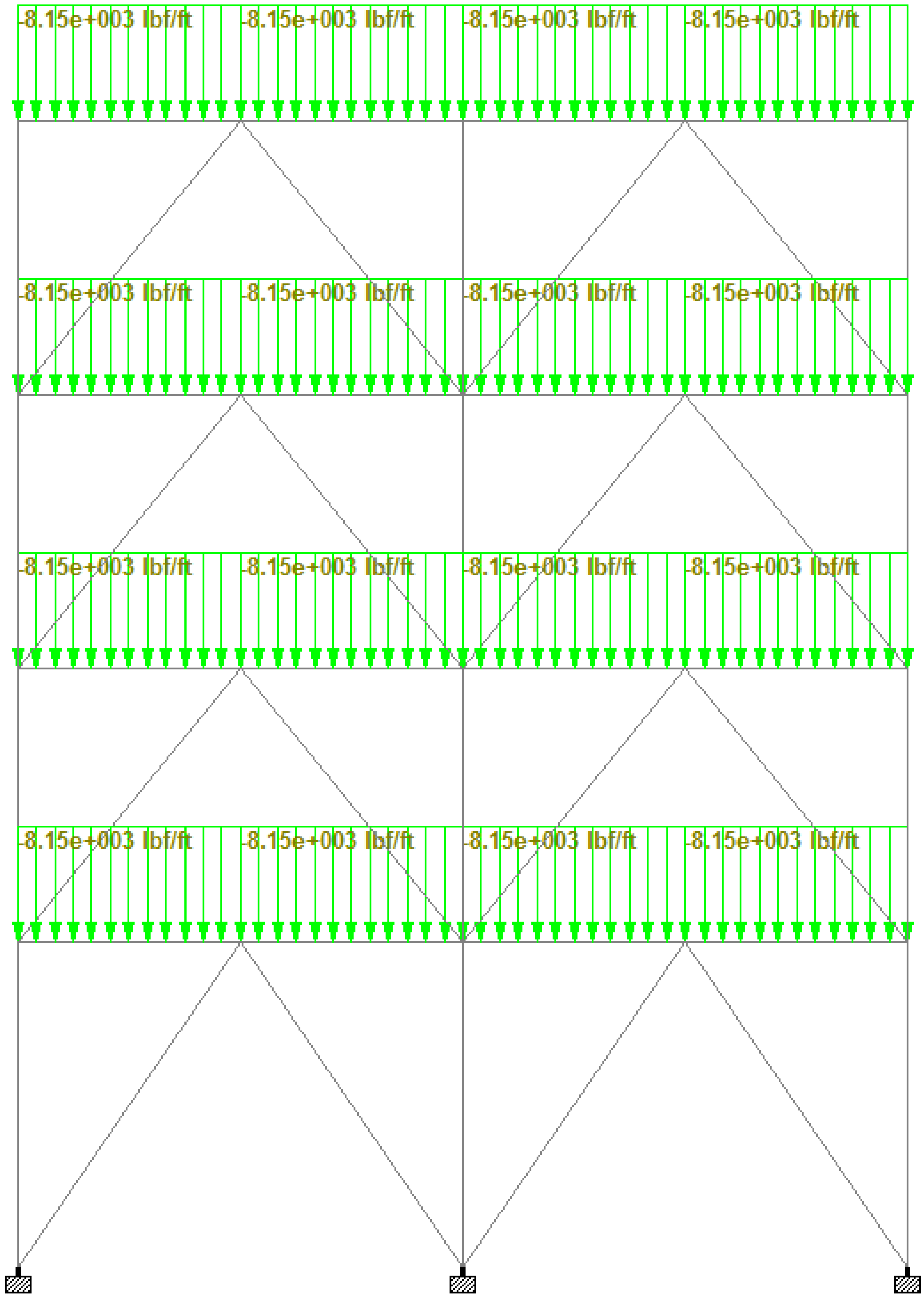
$\frac{P_r}{P_c} = \frac{864}{3390} = .254 \geq 0.20 \qquad \frac{M_r}{M_c} = \frac{923}{1140} = .81$

$.254 + \frac{8}{9}(.81) = .974$ works ✓

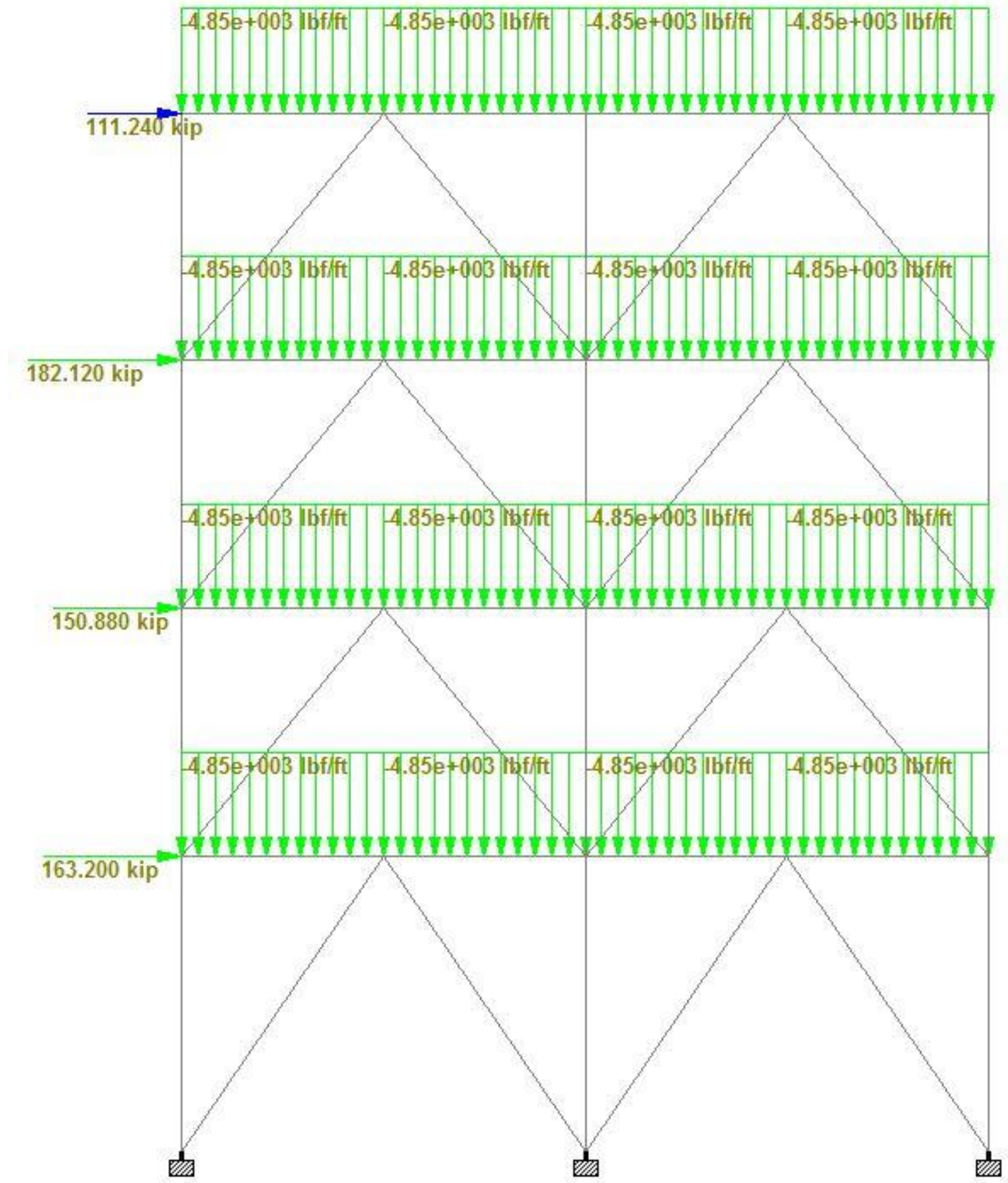
For B_1 ⇒ $M_u = 1189$ k-ft

Most economical = W 27 x 146 Table 3-10 Steel Manual.

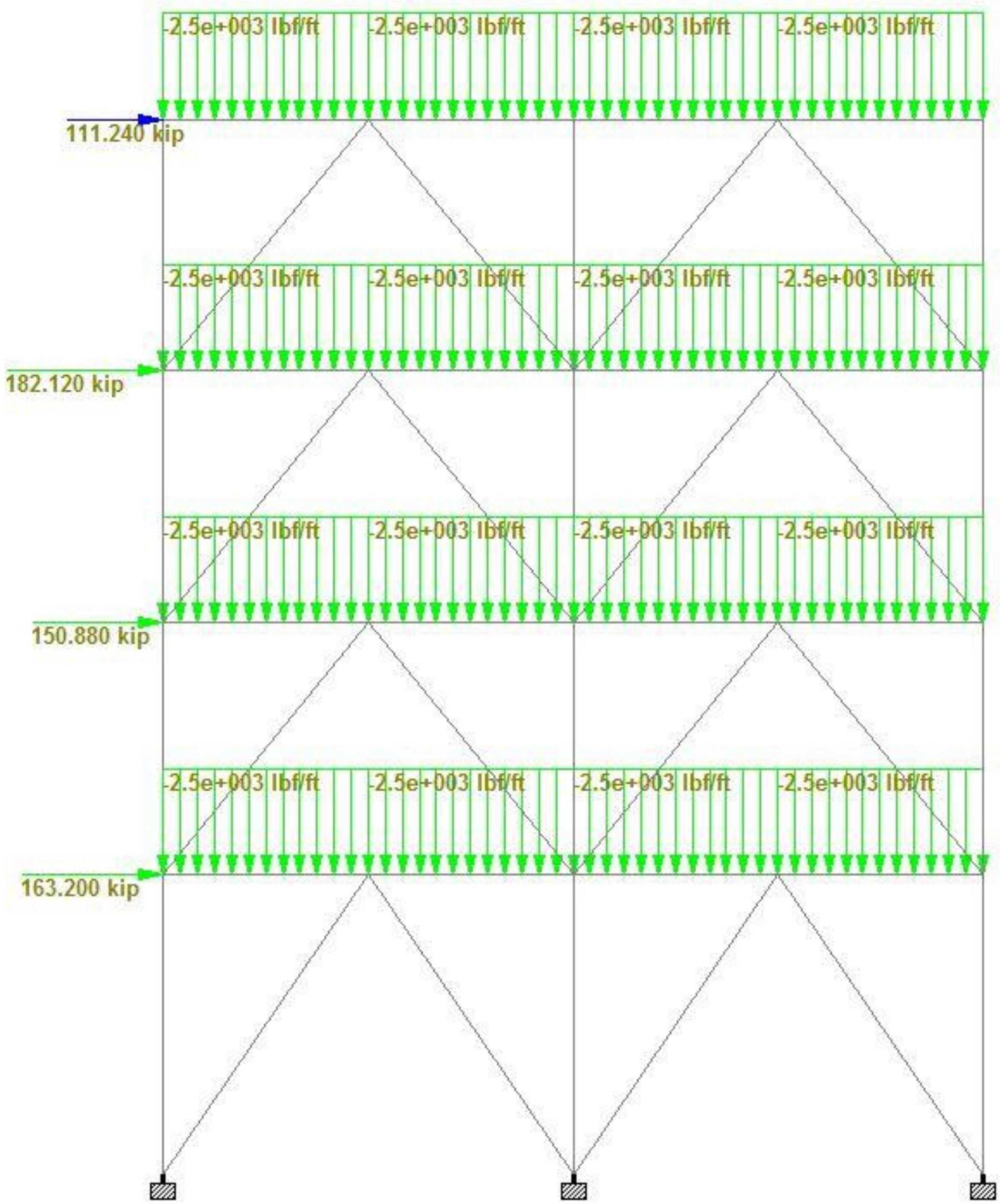
Appendix E: Chevron Braced Frame Design



1.2D+1.6L on Frame A



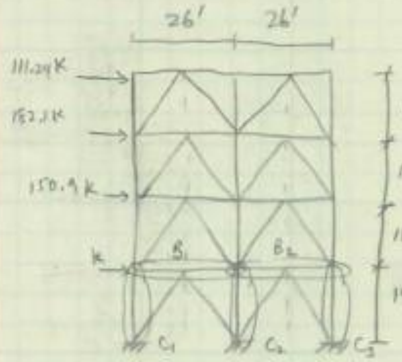
1.2D+1.6W+0.5L on Frame A



0.9D+1.6W on Frame A

Calculation Braced Frame | Thesis | Page 1 of 3

Preliminary Calculations for Braced Frame G in the West Wing



Frame A
West Wing

Select Trial Sizes
by strength design

- Columns
  the loads obtained from STAAD.

  Set of loads on columns. Columns will be the same size.
  So column size $C_1 = C_2 = C_3$

  Set of loads C_1 → $P_u = 417k$ $M_u = 12 k \cdot ft$ X won't control
  $P_u = 14k$ $M_u = 73 k \cdot ft$ → try

  C_2 → $P_u = 592k$ $M_u = 0$ → try
  $P_u = 354k$ $M_u = 55 k \cdot ft$ X won't control

  C_3 → $P_u = 508k$ $M_u = 57 k \cdot ft$ → try

  W14x109 is more than sufficient, based on inspection.
  $\phi P_n = 1130k$ $\phi M_n = 346 k \cdot ft$
  Can try smaller, depending on drift.

- Beams

  B_1 → $P_u = 250k$ $M_u = 47 k \cdot ft$
  $P_u = 68k$ $M_u = 190 k \cdot ft$
  $P_u = 230k$ $M_u = 102 k \cdot ft$
  B_2 → $P_u = 137k$ $M_u = 125 k \cdot ft$

  W24x62 is more than sufficient

Calculation Braced Frame | Page 2 of 3

- Bracings

P_u = 324 k on 1st Floor
P_u = 240 k on 2nd Floor
P_u = 181 k on 3rd Floor
P_u = 113 k on 4th Floor

} Controlling loads

Check for buckling.

$$F = \frac{\pi^2 E I}{(Kl)^2}$$

$$324 = \frac{\pi^2 (29{,}000)(I_{req})}{(23 \cdot 12)^2} \Rightarrow I_{req} = 86.3 \text{ in}^4$$

$$240 = \frac{\pi^2 (29{,}000)(I_{req})}{(21 \cdot 12)^2} \Rightarrow I_{req} = 53.3 \text{ in}^4$$

$$181 = \frac{\pi^2 (29{,}000)(I_{req})}{(21 \cdot 12)^2} \Rightarrow I_{req} = 40.2 \text{ in}^4$$

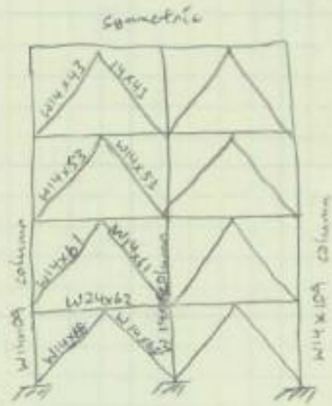
$$113 = \frac{\pi^2 (29{,}000)(I_{req})}{(21 \cdot 12)^2} \Rightarrow I_{req} = 25.1 \text{ in}^4$$

Buckling isn't much a problem.

1st Floor ⇒ W14x68 = ϕP_n = 330 k @ 24' unbraced length I = 722 in^4
2nd Floor ⇒ W14x61 = ϕP_n = 345 k @ 22' unbraced length I = 640 in^4
3rd Floor ⇒ W14x53 = ϕP_n = 156 k @ 22' unbraced length I = 541 in^4
4th Floor ⇒ W14x43 = ϕP_n = 146 k @ 22' unbraced length I = 428 in^4

Calculation Braced Frame | Thesis | Page 3 of 3

Preliminary sizes chosen for braced frame.



Final sizes will be chosen on ETAB design

Must be at least this size

Appendix F: Foundation Design

Mat Foundation | Thesis | Page 1 of 3

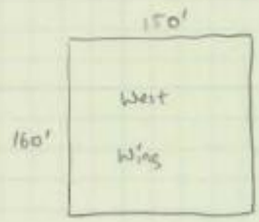
Designing a typical Mat Foundation

Simplified with assumptions due to lack of geotech report.

For west wing

Load Combos
D
D+L
D+W
D+.75W+.75L
0.6D+W

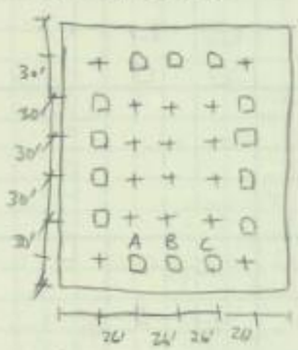
- Try $D_f = 10$ ft
- Assume soil has improvements to make $c_u = 2500\ lb/ft^2$
- Total dead + live load = 18000 k

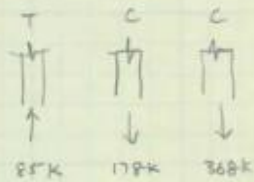


- We need to check for bearing and uplift in foundation design.
- 0.6D+W load combo controls foundation design because it causes an uplift on one side of the foundation.
- The other load combo may control for bearing.

Braced West Wing

□ = lateral load columns
+ = gravity columns





Column A needs to be designed for uplift

Column C needs to be designed for bearing capacity

Since it's a mat foundation, area its huge which lowers the stress on the soil.

Frame in the N-S direction does not control design.

$A = 150(160) = 24{,}000\ ft^2$

$I_x = \frac{1}{12}(150)(160)^3 = 51.2E^6\ ft^4$

Q = Axial load on Columns = 18,000 K

$I_y = \frac{1}{12}(160)(150)^3 = 45E^6\ ft^4$

$e_x = x' - \frac{B}{2} = .3$

$e_y = y' - \frac{L}{2} = .2$

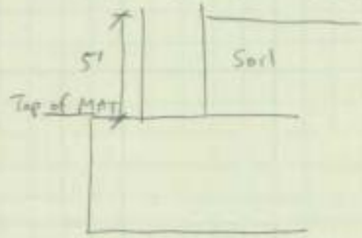
$$q = \frac{18{,}000}{24{,}000} \pm \frac{.3(18000)y}{45E^6} \pm \frac{.2(18000)x}{51.2E^6}$$

For $A = .75 - .09 - .06 = .6 = 600\ lbs/ft^2$

For $C = .75 + .09 + .06 = .9 = 900\ lbs/ft^2 < 2500\ lbs/ft^2$ ✓ $\frac{2500}{900} = F.S. = 2.8$

Mat Foundation | Thesis | Page 2 of 3

Amount of soil over column A to stop uplift.



Assume compact fill is $\gamma = 120\ lb/ft^2$

$4'(120)(30)(26) = 374\,k$ of soil keeping column A down, from uplift.

$F.S. = \frac{85}{374} = 4.4$

So bearing and uplift has been satisfied

Design foundation size and reinforcing

$q_{av} = \frac{900 + 600}{2} = 750\ lb/ft^2$

$q_{av}BL = 750(26)(160) = 312\ Kips$

Thickness of Mat Slab   * Assume load factor of 2.5

Critical Section is for diagonal tension shear at column A.

$b_o = \left(0.5 + \frac{d}{2}\right) + \left(0.5 + \frac{d}{2}\right) + \left(0.5 + d\right) = 1.5 + 2d$

$U = 2.5\left(\frac{365}{4}\right) = 230$

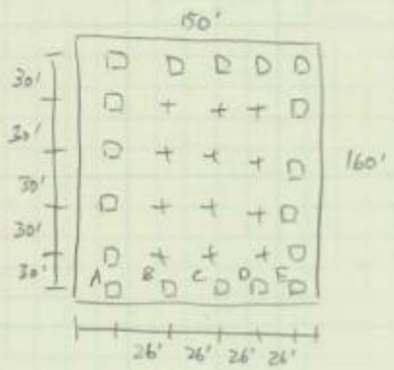
$230{,}000 = (1.5 + 2d)(d)\left[0.85\,(.34)\sqrt{4000}\right]$

$15724 = 1.5d + 2d^2$

$d = 87''$ ≈ 7.3 ft ≈ use $\boxed{7'\text{-}6''\,ft}$ ⇒ $D_f = 11'\text{-}6''$

Mat Foundation | Thesis | Page 3 of 3

For Moment West Wing



Bearing is less critical here since it is more spread out. So using a $D_f = 10'$ or 4' soil above MAT is sufficient

Thickness of MAT

Critical section at Column E with 284 k, Column D = 258 k

$U = (2.5)\left(\frac{284}{4}\right) = 162$

$162{,}000 = (1.5 + 2d)(d)\left[0.85(.34)\sqrt{4000}\right]$

$8100 = 1.5d + 2d^2$

$d = 67.2'' \approx 5.6\text{ ft} \approx$ use 6 ft $\Rightarrow D_f = 10'$

Reinforcing

Same as braced frame.

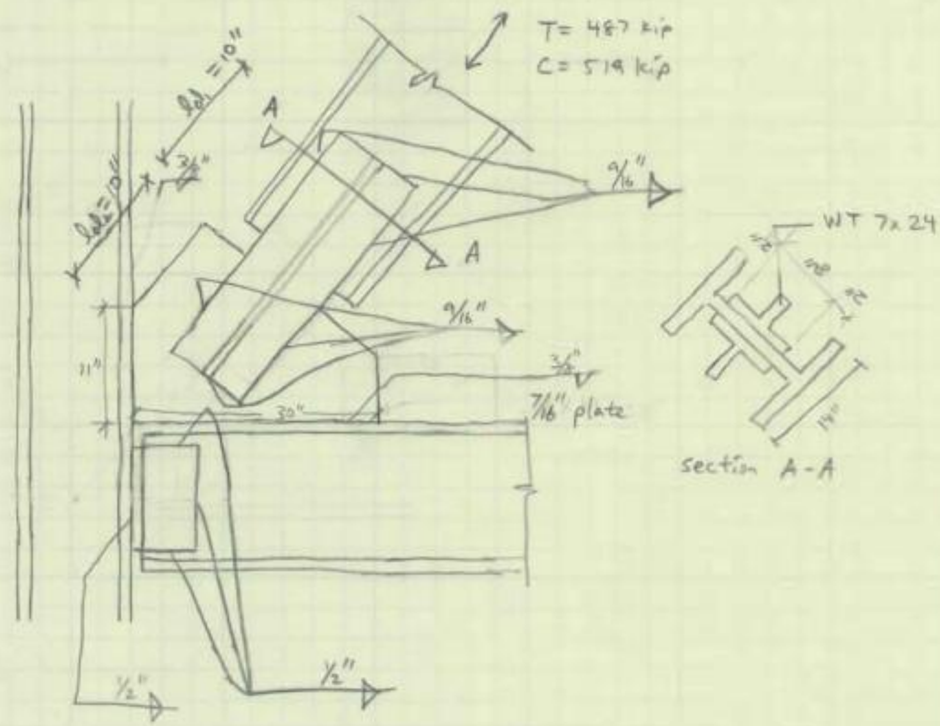
Summary

Typical Mat Foundation

	Braced	Moment	Current
F.S. for strength =	2.5	2.5	✓
F.S. for uplift =	4.4	not an issue	✓
F.S. for bearing =	2.8	2.8	✓
Depth into Earth =	11'-6"	10'	8'-8"
Thickness of Mat =	7'-6"	6'	4'

Appendix G: Welded Braced Connection Design

Connections | Thesis | Page 1 of 4



W14x74
A= 21.8
t_w = .45
t_f = .785

WT 7x24
A= 7.07
t_w = .34
t_f = .595
b_f = 8.03
d = 6.9

A: Limit States for Brace, W14x74

WT 7x37 $\bar{y}$ = 1.32

$U = 1 - \frac{1.32}{10} = .868$

Tension Yielding: $\phi R_n = 0.9(50)(21.8) = 981k$

Tension Rupture: $\phi R_n = 0.75(65)(.868)(21.8) = 922^k$

Weld Rupture: $\phi R_n = 0.75(0.6)(70)(.707)(1/16)[9)(20) + (9)(8)](2)$

$= 1.392[9(20) + 9(8)](2) = 701^k$

'or' take max

$= 1.392[0.85(9)(20) + 9(8)(1.5)](2) = 726^k$

both ok!

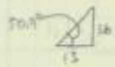
Base metal: $\phi R_n = 0.75(0.6)(65)(.45'')(28)(2) = 789^k$

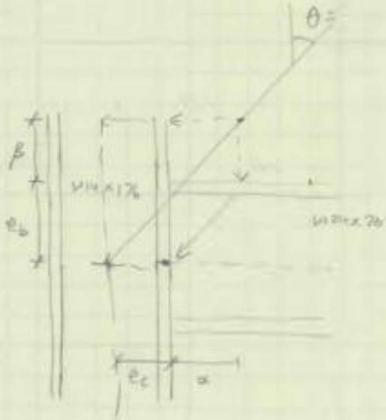
Block Shear: $\phi R_n = 0.75[(0.60)(65)(20) + 1.0(65)(8)](2) \le 0.75[(0.60)(50)(20) + (65)(8)](2)$

$= 1740^k \le 1344^k = 1344^k$ controls good!

Controlling $= 726^k > 519\ k$ ok

Page 2 of 4





$\alpha - \beta \tan\theta = e_b \tan\theta - e_c$

$\alpha = \frac{30}{2} = 15''$

$\beta = \frac{11}{2} = 5.5''$

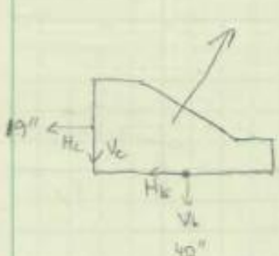
$e_b = 11.9''$

$e_c = 6.1\ in$

$\frac{e_c + \alpha}{e_b + \beta}$

$\frac{6.1 + 15}{11.9 + 5.5} = \tan\theta$

$\theta = 50.5 \approx 50.9$ ok



$r = \sqrt{(6.1+15)^2 + (11.9+5.5)^2}$

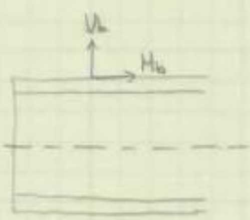
$r = 27.3$

$V_c = \frac{5.5}{27.3}(519) = 104.5^k$

$H_c = \frac{6.1}{27.3}(519) = 116^k$

$H_b = \frac{15}{27.3}(519) = 285^k$

$V_b = \frac{11.9}{27.3}(519) = 226^k$



B: Brace-to-Gusset WT:

Tension Yielding = $\phi R_n = 0.9(50)(7.07)(2) = 636^k$ ok

Tension Rupture = $\phi R_n = 0.75(65)(7.07)(2)(1) = 780^k$

Weld Rupture = "same" = $\phi R_n = 726^k$

Base Metal = $0.75(0.6)(65)(.65)(29)(2) = 1064^k$

Block Shear = Does not control by inspection.

Compression = $\phi R_n = 0.90(50)(7.07)(2) = 636^k$ $\frac{KL}{r} = \frac{20.5}{1.88} = 10.9 < 25$

Controlling = $636^k > 519^k$ ok

C: Gusset Plate

Gusset $A \approx 19.9 in^2$

Tension Yielding = $\phi R_n = 0.9(36)(19.9) = 645^k$

Tension Rupture = $\phi R_n = 0.75(58)(19.9) = 865^k$

Weld Rupture = "same" when WT is welded 10" on gusset plate.
$\phi R_n = 726^k$

Base Metal = $\phi R_n = 658^k$ "same thickness"

Block Shear = $\phi R_n = 1344^k$

Compression = $\phi R_n = 0.90(36)(19.9) = 645^k$

Controlling = $645^k > 519^k$ ok

D: Gusset to Beam Connection (look at pg 2 for forces)

W 24x76
A=22.4
d=23.9
t_w=.44
t_f=.68

Weld Rupture: $\phi R_n = 1.392((2)(6)(30)(1.5)) = 751^k > 226^k = V_b$ ✓

: $\phi R_n = 1.392((2)(6)(30)(1.0)) = 501^k > 285^k = H_b$ ✓

Beam web yielding

$\phi R_n = 1.0(5(1.18) + (30))(50)(.44) = 789.8^k$ ok

Beam web crippling

$$\phi R_n = 0.75(0.80)(.44)^2 \left[1 + 3\left(\frac{30}{23.9}\right)\left(\frac{.44}{.68}\right)^{1.5}\right]\sqrt{\frac{29{,}000(50)(.68)}{.44}}$$

$= 521^k$ ok

E: Gusset to Column Connection

W14x176
A=51.8
k_{des}=1.91
t_w=.83
t_f=1.31
d=15.2

Weld Rupture: $\phi R_n = 1.392((2)(6)(11)(1.5)) = 275^k > 116^k$ ✓

: $\phi R_n = 1.392((2)(6)(11)) = 183^k > 105^k$ ✓

F: Beam to Column Connection (Double Angle 2L 4x4x½x16).

Weld Rupture due to eccentricity shear

$C = 2.65$, $C_1 = 1.0$, $D = 7/16"$

$\phi R_n = .75(1.0)(2.65)(7)(16)(2) = 445.2^k > 251^k$ ok.

$l = 16"$
$k = \frac{3.5}{16} = .22$
$x = .033$
$xl = .53"$
$a = \frac{4-.53}{16} = .216$

Page 4 of 4

F: continue

Beam Web Strength at Weld

$$\phi V_n = \frac{0.75(.16)(65)(.44)(1.0)}{1,392(7)(1.0)}(445.2) = 588^k > 68^k$$

Angle: Tension Yield $\phi R_n = 0.9(36)(16)(1/2)(2) = 518.4^k$

Tension Rupture $\phi R_n = .75(58)(16)(1/2)(2) = 696^k$

Column Weld Rupture Strength.

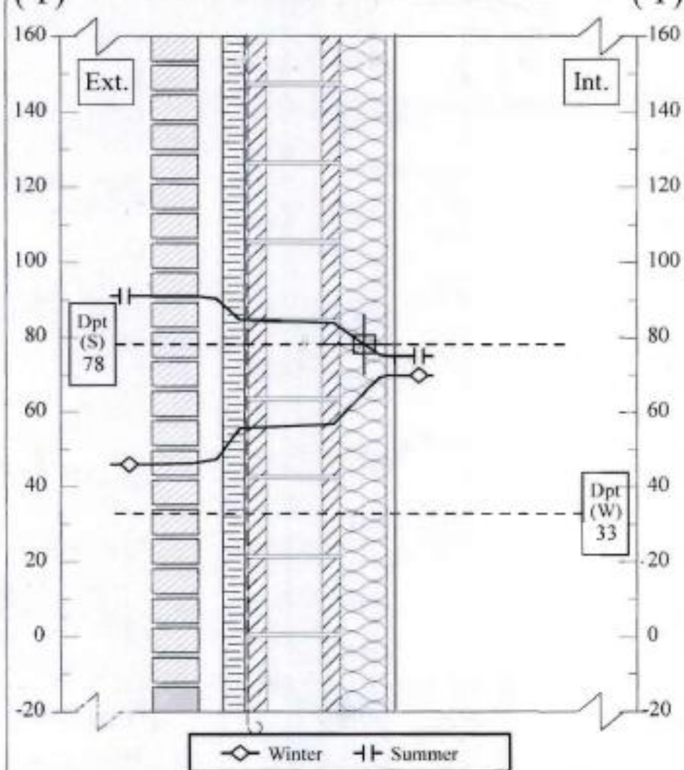
$$\phi V_n = \frac{2(16)^2(1.392)(8)}{\sqrt{(16)^2 + 12.96(4.42)^2}} = 252^k > 68^k \quad e = 4 + \frac{.83}{2} = 4.42$$

Appendix H: Façade Breadth

R VALUE ANALYSIS

The Heat, Air and Moisture Building Science Toolbox - V.1B-E/U (11)

WALL SECTION AND TEMPERATURE GRADIENTS



PROJECT

Name: TCMC Wall Analysis

Number:

City: Miami, FL

Date: 3/20/2013

Analysis by: Xiao Ye Zheng

Wall Type: Option:

CLIMATIC CONDITIONS

	Winter		Summer	
	Int.	Ext.	Int.	Ex
Temp (°F)	70	46	75	91
RH (%)	25	60	50	64
DPT (°F)	33	33	56	78

PENNSYLVANIA STATE UNIVERSITY

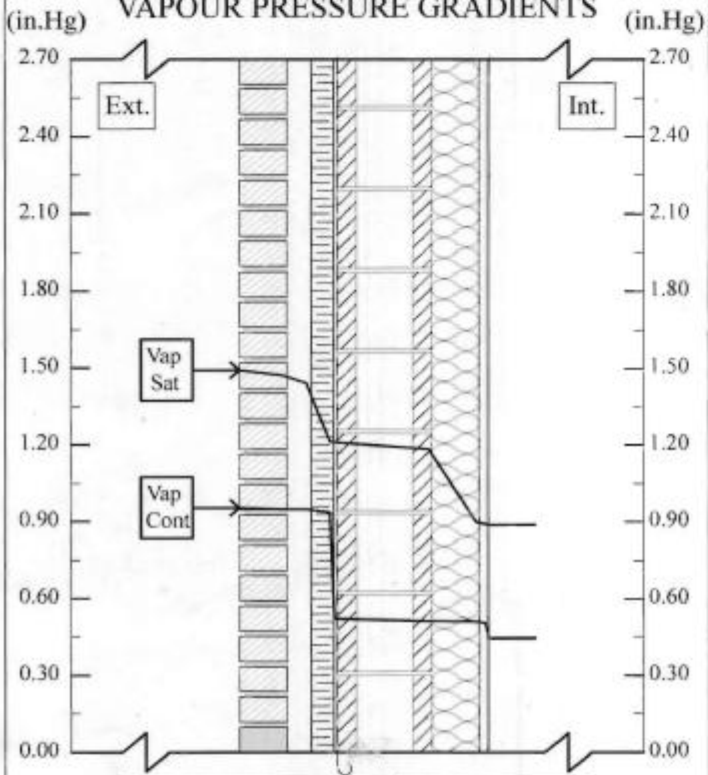
104 ENGINEERING, UNIT A
UNIVERSITY PARK, PA, USA, 1680

	Generic Material	Manufacturer	Model No.	Thick (in.)	RVal (R)	W.Temp. (°F)	S.Tem (°F)
1	brick, (vented), 4 in.	No Recor...	Generic...	3.50	0.64	46.3	91.0
2	cavity, 2 in.	No Recor...	Generic...	2.00	0.98	47.4	90.3
3	rigid ins.,(expand.), 2 in.	No Recor...	Generic...	2.00	7.90	55.6	84.7
4	poly film, (6mil)	No Recor...	Generic...	0.01	0.12	55.7	84.7
5	block, 8 in.	No Recor...	Generic...	8.03	1.03	56.8	83.9
6	batt ins., 4 in.	No Recor...	Generic...	4.00	12.19	69.4	75.4
7	gypsum bd., 5/8 in., (#1)	No Recor...	Generic...	0.63	0.46	69.9	75.1
8	paint (#1), (12mil)	No Recor...	Generic...	0.01	0.12	70.0	75.0
	Total or (Layer 0)			20.18	23.44	(45.7)	(91.4

CONDENSATION ANALYSIS

The Heat, Air and Moisture Building Science Toolbox - V.1B-E/U (11a)

WALL SECTION AND VAPOUR PRESSURE GRADIENTS



** NO CONDENSATION **

PROJECT

Name	
Number	
City	Miami, FL
Date	
Analysis by:	
Wall Type	Option

CLIMATIC CONDITIONS

	Winter		Summer	
	Int.	Ext.	Int.	Ext
Temp (°F)	—	—	75	91
RH (%)	—	—	50	64
DPT (°F)	—	—	56	78

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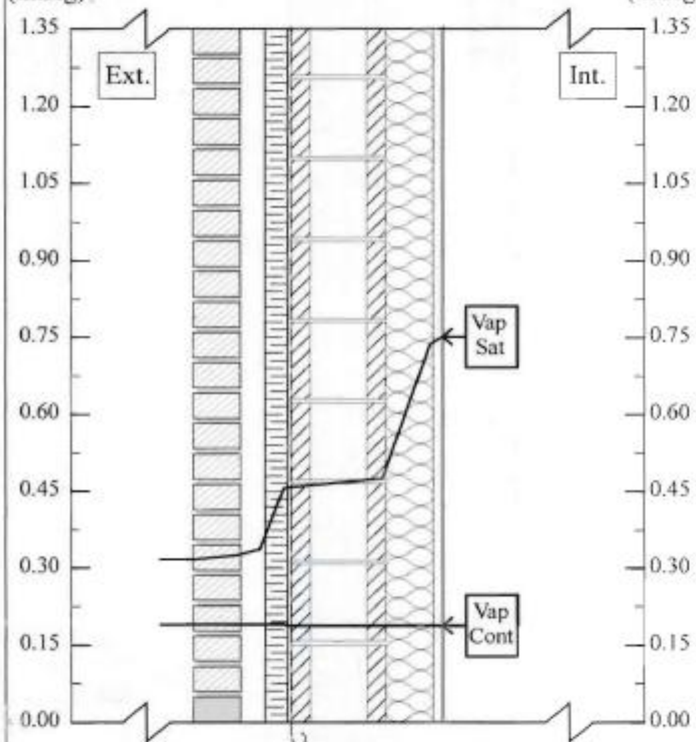
	Material	Manufacturer	Model No.	Rvap (1/M)	Temp (°F)	VapSat (in.Hg)	VapCo (in.Hg
1	brick, (vented), 4 in.	No Recor...	Generic...	0.191	90.6	1.449	0.935
2	cavity, 2 in.	No Recor...	Generic...	0.016	89.9	1.419	0.935
3	rigid ins.,(expand.), 2 in.	No Recor...	Generic...	0.515	84.5	1.195	0.922
4	poly film, (6mil)	No Recor...	Generic...	16.827	84.4	1.192	0.515
5	block, 8 in.	No Recor...	Generic...	0.418	83.7	1.166	0.505
6	batt ins., 4 in.	No Recor...	Generic...	0.040	75.4	0.887	0.504
7	gypsum bd., 5/8 in., (#1)	No Recor...	Generic...	0.229	75.1	0.878	0.498
8	paint (#1), (12mil)	No Recor...	Generic...	2.488	75.0	0.876	0.438
9							
10							
11							
12							
	TOTAL or (Layer 0)			20.810	(91.0)	(1.469)	(0.940

CONDENSATION ANALYSIS

The Heat, Air and Moisture Building Science Toolbox - V.1B-E/U (11a)

WALL SECTION AND VAPOUR PRESSURE GRADIENTS



** NO CONDENSATION **

PROJECT

Name

Number

City Miami, FL

Date

Analysis by:

Wall Type Option

CLIMATIC CONDITIONS

	Winter		Summer	
	Int.	Ext.	Int.	Ex
Temp (°F)	70	46	-	-
RH (%)	25	60	-	-
DPT (°F)	33	33	-	-

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	Material	Manufacturer	Model No.	Rvap (1/M)	Temp (°F)	VapSat (in.Hg)	VapCo (in.Hg
1	brick, (vented), 4 in.	No Recor...	Generic...	0.191	46.7	0.320	0.187
2	cavity, 2 in.	No Recor...	Generic...	0.016	47.7	0.332	0.187
3	rigid ins.,(expand.), 2 in.	No Recor...	Generic...	0.515	55.7	0.448	0.187
4	poly film, (6mil)	No Recor...	Generic...	16.827	55.9	0.450	0.185
5	block, 8 in.	No Recor...	Generic...	0.418	56.9	0.468	0.185
6	batt ins., 4 in.	No Recor...	Generic...	0.040	69.4	0.725	0.185
7	gypsum bd., 5/8 in., (#1)	No Recor...	Generic...	0.229	69.9	0.737	0.185
8	paint (#1), (12mil)	No Recor...	Generic...	2.488	70.0	0.740	0.185
9							
10							
11							
12							
	TOTAL or (Layer 0)			20.810	(46.0)	(0.312)	(0.187

Appendix I: Solar Panel Breadth

Panasonic
ideas for life

HIT® Photovoltaic Module

HIT® Power 220A

VBHN220AA01

HIT Delivers More Real World Performance

19.8 % cell conversion efficiency

Hybrid cell produces the highest output on cloudy days

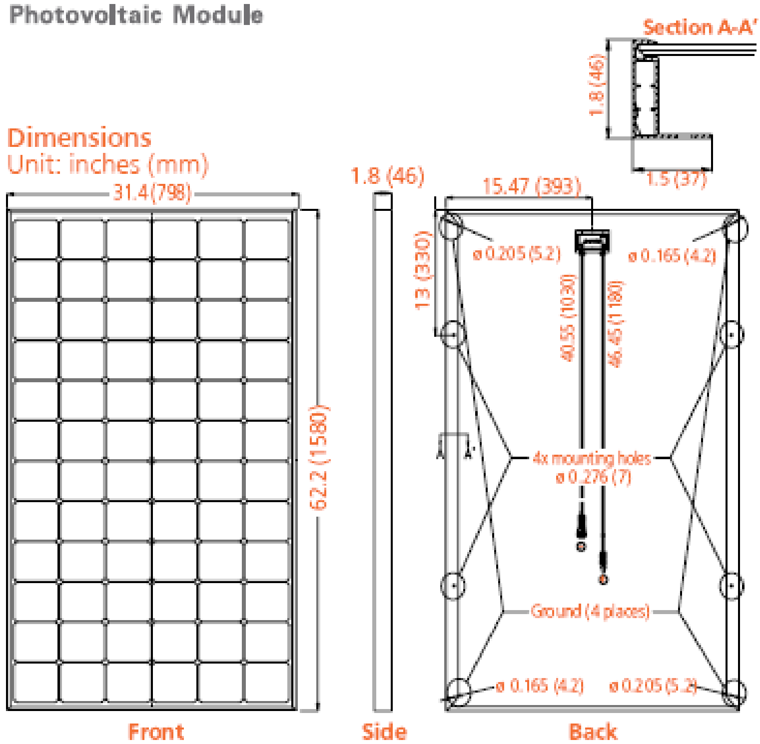
Highest warranted tolerance: -0/+10 %

Most PTC Watts: 204.4

Lowest temperature coefficient: -0.33%

Highest PTC/STC Ratio: 93%+

HIT® Power
Photovoltaic Module



High Efficiency

HIT® Power solar panels are leaders in sunlight conversion efficiency. Obtain maximum power within a fixed amount of space. Save money using fewer system attachments and racking materials, and reduce costs by spending less time installing per Watt.

Power Guarantee

The power ratings for HIT Power panels guarantee customers receive 100% of the nameplate rated power (or more) at the time of purchase, enabling owners to generate more kWh per rated Watt, quicken investments returns, and help realize complete customer satisfaction.

Temperature Performance

As temperatures rise, HIT Power solar panels produce 10% or more electricity (kWh) than conventional crystalline silicon solar panels at the same temperature.

Valuable Features

The packing density of the panels reduces transportation, fuel, and storage costs per installed watt.

American Made Quality

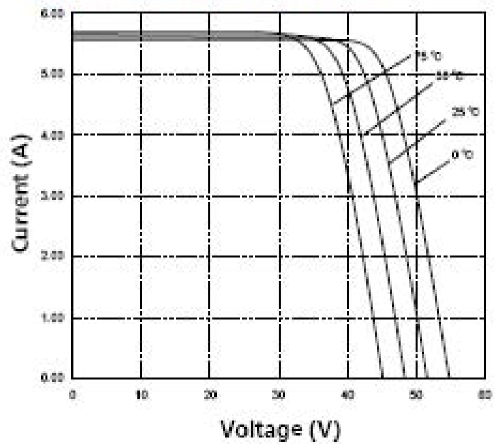
Our silicon wafers located inside HIT solar panels are made in Oregon, and the panels are assembled in an ISO 9001 (quality), 14001 (environment), and 18001 (safety) certified factory. Unique eco-packing minimizes cardboard waste at the job site. The panels have a Limited 20-Year Power Output and 10-Year Product Workmanship Warranty.

HIT® Power 220A

Electrical Specifications

Model	HIT Power 220A or VBHN220AA01
Rated Power (Pmax)[1]	220 W
Maximum Power Voltage (Vpm)	42.7 V
Maximum Power Current (Ipm)	5.17 A
Open Circuit Voltage (Voc)	52.3 V
Short Circuit Current (Isc)	5.65 A
Temperature Coefficient (Pmax)	-0.336%/ °C
Temperature Coefficient (Voc)	-0.145 V/ °C
Temperature Coefficient (Isc)	1.98 mA/ °C
NOCT	114.8°F (46°C)
CEC PTC Rating	204.4 W
Cell Efficiency	19.8%
Module Efficiency	17.4%
Watts per Ft.[2]	16.22 W
Maximum System Voltage	600 V
Series Fuse Rating	15 A
Warranted Tolerance (-/+)	-0% / +10%

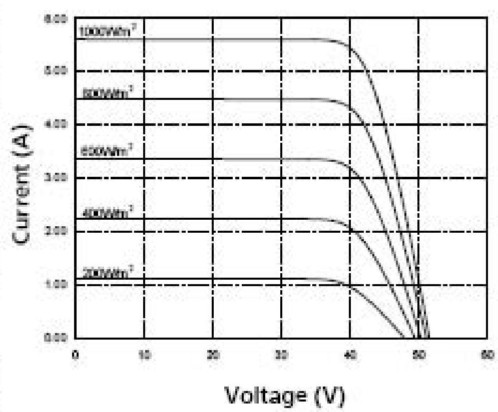
Dependence on Temperature



Mechanical Specifications

Internal Bypass Diodes	3 Bypass Diodes
Module Area	13.56 Ft² (1.26m²)
Weight	35.3 Lbs. (16kg)
Dimensions LxWxH	62.2x31.4x1.8 in. (1580x798x46 mm)
Cable Length +Male/-Female	46.45/40.55 in. (1180/1030 mm)
Cable Size / Type	No. 12 AWG / PV Cable
Connector Type[3]	Multi-Contact® Type IV (MC4™)
Static Wind / Snow Load	60PSF (2880Pa) / 39PSF (1867Pa)
Pallet Dimensions LxWxH	63.2x32x72.8 in. (1607x815x1850 mm)
Quantity per Pallet / Pallet Weight	35 pcs./1322.7 Lbs (600 kg)
Quantity per 53' Trailer	980 pcs.

Dependence on Irradiance



Operating Conditions & Safety Ratings

Ambient Operating Temperature[2]	-4°F to 115°F (-20°C to 46°C)
Hail Safety Impact Velocity	1" hailstone (25mm) at 52 mph (23m/s)
Fire Safety Classification	Class C
Safety & Rating Certifications	UL 1703, cUL, CEC
Limited Warranty	10 Years Workmanship, 20 Years Power Output

[1] STC: Cell temp. 25°C, AM1.5, 1000W/m²
[2] Monthly average low and high of the installation site.
Note: Specifications and information above may change without notice.
[3] Safety locking clip (PV-SSH4) is not supplied with the module.

"HIT" is a registered trademark of Panasonic Group. The name "HIT" comes from "Heterojunction with intrinsic Thin-layer" which is an original technology of Panasonic Group.

⚠ **CAUTION!** Please read the installation manual carefully before using the products.

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Cupertino, CA 95014
Phone 408-861-8424
Fax 408-861-3990
http://www.panasonic.com/solar

Panasonic®

SB 3300 / 3800 / 3800/V

Powerful

- Efficiency up to 95.6 %
- OptiCool active temperature management
- The best tracking efficiency with OptiTrac MPP tracking

Safe

- Galvanic isolation
- Integrated ESS DC load-disconnecting unit
- Rated nominal power at temperatures up to 45 °C

Flexible

- For indoor and outdoor installation
- Suitable for generator grounding

SUNNY BOY 3300 / 3800

The generalist

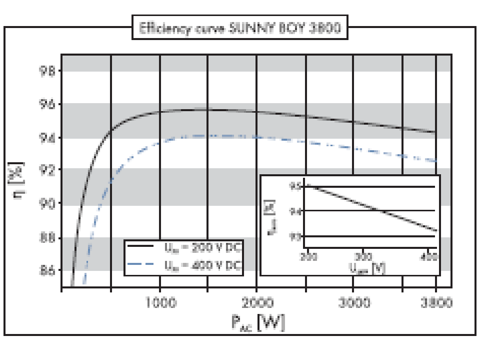
It is robust, easy-to-handle, and, thanks to its galvanic isolation, used in all kinds of AC grids: the Sunny Boy 3300 / 3800. Due to its suitability for generator grounding, it can be combined with all module types. The generously-proportioned die-cast aluminum housing together with the OptiCool active cooling system guarantee the highest yields and a long service life, even under extreme conditions.

Technical Data
SUNNY BOY 3300 / 3800 / 3800/V

	SB 3300	SB 3800	SB 3800/V*
Input (DC)			
Max. DC power	3820 W	4040 W	4040 W
Max. DC voltage	500 V	500 V	500 V
PV-voltage range, MPPT	200 V – 400 V	200 V – 400 V	200 V – 400 V
Max. input current	20 A	20 A	20 A
Number of MPP trackers	1	1	1
Max. number of strings (parallel)	3	3	3
Output (AC)			
Nominal AC ouput	3300 W	3800 W	3680 W
Max. AC power	3600 W	3800 W	3680 W
Max. output current	18 A	18 A	16 A
Nominal AC voltage / range	220 V – 240 V / 180 V – 260 V	220 V – 240 V / 180 V – 260 V	220 V – 240 V / 180 V – 260 V
AC grid frequency (self-adjusting) / range	50 Hz / 60 Hz / ±4.5 Hz	50 Hz / 60 Hz / ± 4.5 Hz	50 Hz / 60 Hz / ± 4.5 Hz
Phase shift (cos φ)	1	1	1
AC connection	single-phase	single-phase	single-phase
Efficiency			
Max. efficiency / Euro-Eta	95.2 % / 94.4 %	95.6 % / 94.7 %	95.6 % / 94.7 %
Protection devices			
DC reverse polarity protection	●	●	●
ESS DC load-disconnecting switch	●	●	●
AC short-circuit protection	●	●	●
Ground fault monitoring	●	●	●
Grid monitoring (SMA Grid Guard)	●	●	●
Galvanically isolated	●	●	●
General Data			
Dimensions (W / H / D) in mm	450 / 352 / 236	450 / 352 / 236	450 / 352 / 236
Weight	38 kg	38 kg	38 kg
Operating temperature range	-25 °C ... +60 °C	-25 °C ... +60 °C	-25 °C ... +60 °C
Noise emission (typical)	≤ 40 dB(A)	≤ 42 dB(A)	≤ 42 dB(A)
Consumption: operating (standby) / night	< 7 W / 0.1 W	< 7 W / 0.1 W	< 7 W / 0.1 W
Topology	LF transformer	LF transformer	LF transformer
Cooling concept	OptiCool	OptiCool	OptiCool
Mounting location: indoors / outdoors (IP65)	● / ●	● / ●	● / ●
Features			
DC connection: MC3 / MC4 / Tyco	● / ○ / ○	● / ○ / ○	● / ○ / ○
AC connection: plug connector	●	●	●
LCD	●	●	●
Interfaces: Bluetooth / RS485	○ / ○	○ / ○	○ / ○
Warranty: 5 years / 10 years	● / ○	● / ○	● / ○
Certificates and approvals	www.SMA.de	www.SMA.de	www.SMA.de
Certificate number (please include when ordering)	–	–	V0153

● Standard ○ Optional

Data at nominal conditions – Last update: March 2009
*Version for country requirements in accordance with EN 50438 with I_{AC} = 16 A



Accessories


RS485 interface of type 485PB-NR


Bluetooth Piggy-Back


Grounding-Kit "Positive" ESHV-P-NR


Grounding-Kit "Negative" ESHV-N-NR