Structural Calculations for New McDonald's Restaurant
Winchester & Malco Way
Memphis, TN

Region: Raleigh
Site ID: 041-1135
Type: 45114 – MS

John Beaumont, P.E.
TN Professional Engineer #112616

Prepared By:
Core States Group
201 S. Maple Ave. Suite 300, Ambler, PA 19002

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PROJECT DESIGN CRITERIA

BUILDING CODE / YEAR:	2012 International Building Code
FOUNDATION DESIGN:	
Soil Report Prepared By:	PSI
Soil Report Number:	0502841
Soil Report Dated:	6-28-2013
Type of Foundation:	Masonry
Soil Bearing Capacity:	2500 psf cols 2000 psf footings
Minimum Footing Depth:	18 inches
Minimum Footing Width:	18 in (wall), 30 in (column)
Special Ordinances:	4-6 feet of overexcavation reqd.
LOAD CRITERIA:	
A. Dead Load:	
Roof:	20 psf
B. Live Load:	
Floor Load:	100 psf
Minimum Roof Load:	20 psf
Ground Snow Load:	10 psf
Special Ordinances:	
C. Wind Load:	
Wind Velocity:	115 mph-Ultimate 3S Gust
Wind Exposure:	B
Wind Importance Factor:	1.0
Special Ordinances:	
D. Seismic Load:	
Ss/S1:	79.7% / 28.3%
Fa/Fv:	1.181 / 1.834
Occupancy Category:	II
Seismic Importance Factor:	1.0
Seismic Design Category:	D
Site Class:	D
Structural System:	Inter. Reinf. Masonry Shearwalls/OSCBF
R:	3.5/3.25
Special Ordinances:	
SERVICEABILITY:	
Dead Load + Live Load:	L/180
Live Load:	L/240
Wind Load / Seismic:	L/240
Secondary Wall Members:	L/90

ADDITIONAL ORDINANCES OR AMENDMENTS:

Conversion Factors:

LOAD ANALYSIS:

$k := 1000 lbf$ $\quad plf := \frac{lbf}{ft}$ $\quad psf := \frac{lbf}{ft^2}$ $\quad pcf := \frac{lbf}{ft^3}$ $\quad ksi := \frac{k}{in^2}$

Building Dimensions: $Lu_t := 45ft$ $\quad Lu_L := 115.33ft$ $\quad S_j := 6.0ft$ $\quad H_b := 18.67ft$

1. Roof Dead Load:

Roof $\quad DLr := 20psf$

2. Roof Live Load:

$Lo := 20psf$

$At := Lu_t \cdot S_j$ $\quad At = 270\,ft^2$

$$R1 := \begin{cases} 1.0 & \text{if } At \le 200ft^2 \\ \left(1.2 - 0.001 \cdot \frac{At}{ft^2}\right) & \text{if } 200ft^2 < At < 600ft^2 \\ 0.6 & \text{if } At \ge 600ft^2 \end{cases}$$

$R1 = 0.93$

$F := \frac{3}{8}$ slope of roof, number of inches of rise per foot

$$R2 := \begin{cases} 1.0 & \text{if } F \le 4 \\ (1.2 - 0.05F) & \text{if } 4 < F < 12 \\ 0.6 & \text{if } F \ge 12 \end{cases}$$

$R2 = 1$

$LLr := Lo \cdot R1 \cdot R2$ $\quad LLr = 18.6 \cdot psf$

3. Wind Load:

Basic Wind Velocity of 115 mph, Vfm Exposure B

According to ASCE7-10, Directional Simplified Procedure Chapter 27:

Main WIndforce Resisting System: $a := \min(0.10 \cdot Lu_t, 0.10 \cdot Lu_L, 0.4 \cdot H_b)$ $\quad a = 4.5ft$

Horizontal Pressures Table 27.6-1

	Longitudinal Direction		Transverse Direction	
Lower Wall	$P_{WL} := 24.5 \cdot psf$	$P_{WL} = 24.5 \cdot psf$	$P_{WT} := 21.2 \cdot psf$	$P_{WT} = 21.2 \cdot psf$
Parapet	$P_{PL} := P_{WL} \cdot 2.25$	$P_{PL} = 55.125 \cdot psf$	$P_{PT} := P_{WT} \cdot 2.25$	$P_{PT} = 47.7 \cdot psf$

Vertical Pressures Table 27.6-2

$\lambda := 0.692$ Exposure Adjustment Factor

Windward Roof $P_{R3} := -33.1 \cdot psf \cdot \lambda$ $P_{R3} = -22.905 \cdot psf$

Leeward Roof $P_{R4} := -29.5 \cdot psf \cdot \lambda$ $P_{R4} = -20.414 \cdot psf$

$P_{R5} := -24.2 \cdot psf \cdot \lambda$ $P_{R5} = -16.746 \cdot psf$

$Pw_{vu} := \min(P_{R3}, P_{R4}, P_{R5}, -16psf)$ $Pw_{vu} = -22.905 \cdot psf$ Wind Load - Vertical

$Pw_{vd} := 16psf$ Wind Down

$P_{wu} := 19.3psf$ $P_{wu} = 19.3 \cdot psf$ Wind Load - Uplift

$h_w := 13.33ft$ Joist Bearing height $H_w := 9.33ft$ height of window $H_s := 2ft$ Height of sill

$T_h := \frac{h_w}{2} + (H_b - h_w)$ $T_h = 12.005 ft$ Tributary Height

$h_p := (H_b - h_w)$ $h_p = 5.34ft$

$VW_{nu} := P_{PL} \cdot h_p \cdot Lu_L + P_{WL} \cdot \frac{h_w}{2} \cdot Lu_L$ $VW_{nu} = 52.782 \cdot k$ $VW_{bu} := P_{PT} \cdot h_p \cdot Lu_t + P_{WT} \cdot \frac{h_w}{2} \cdot Lu_t = 17.821 \cdot k$ $VW_{bu} = 17.821 \cdot k$

<u>Components and Cladding:</u> Chapter 30

$EWF := 0.9$ Table 30.7-2

$P_{wr} := 77.4psf \cdot \lambda \cdot EWF$ Zone 2 $P_{wr} = 48.205 \cdot psf$ Wind Load - Vertical

$P_w := 33.7psf \cdot \lambda \cdot EWF$ Zone 4 $P_w = 20.988 \cdot psf$ Wind Load - Horizontal Wall

$P_{wu} := P_{wr} + P_w$ $P_{wu} = 69.193 \cdot psf$ Wind Load - Uplift on Overhang

4. <u>Snow Load</u>: Ground

$P_g := 10psf$ $h_r := 4.0ft$

$C_e := 1.0$ $I_s := 1.0$ $C_t := 1.0$

$Pf := 0.7 \cdot C_e \cdot C_t I_s \cdot P_g$ $Pf = 7 \cdot psf$ ASCE 7-10

$$Pf_{min} := \begin{cases} (I_s \cdot P_g) & \text{if } P_g \le 20psf \\ (20psf \cdot I_s) & \text{if } P_g > 20psf \end{cases}$$ $Pf_{min} = 10 \cdot psf$

$P_f := \max(Pf_{min}, Pf)$ $P_f = 10 \cdot psf$

$\gamma_a := \frac{0.13}{ft} \cdot P_g + 14pcf$ $\quad\gamma_a = 15.3 \cdot pcf$

$\gamma := \min(\gamma_a, 30pcf)$ $\quad\gamma = 15.3 \cdot pcf$ snow density

$h_b := \frac{P_f}{\gamma}$ $\quad h_b = 0.654 ft$ height of snow for flat roof snow load

$h_c := h_r - h_b$ $\quad h_c = 3.346 ft$ height of parapet minus hb

check := if$\left(\frac{h_c}{h_b} < 0.2, \text{"Drift Load not required to be applied"}, \text{"Drift load needs to be applied"}\right)$

check = "Drift load needs to be applied"

Drift from parapet:

Drift in Transverse direction:

$h_{dta} := \left[\left(0.43 ft \cdot \sqrt[3]{\frac{Lu_t}{ft}} \cdot \sqrt[4]{\frac{P_g}{psf} + 10}\right) - 1.5 ft\right] \cdot 0.75$ $\quad h_{dta} = 1.301 ft$

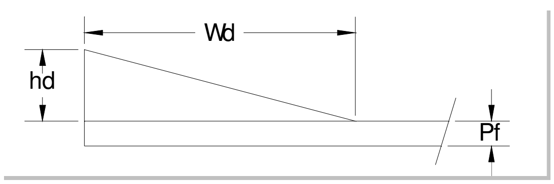
$h_{dt} := \text{if}(h_{dta} \le h_c, h_{dta}, h_c)$ $\quad h_{dt} = 1.301 ft$ Height of Drift:

$W_{dta} := \text{if}\left(h_{dta} \le h_c, 4 \cdot h_{dta}, 4 \cdot \frac{h_{dta}^2}{h_c}\right)$ $\quad W_{dta} = 5.203 ft$

$W_{dt} := \min(W_{dta}, 8 \cdot h_c)$ $\quad W_{dt} = 5.203 ft$ Width of drift

$P_{dt} := \gamma \cdot h_{dt}$ $\quad P_{dt} = 19.903 \cdot psf$ Drift surcharge load

$P_m := (h_{dt} + h_b) \cdot \gamma$ $\quad P_m = 29.903 \cdot psf$ Maximum intensity of snow load at parapet



Drift in Longitudinal direction:

$h_{dLa} := \left[\left(0.43 ft \cdot \sqrt[3]{\frac{Lu_L}{ft}} \cdot \sqrt[4]{\frac{P_g}{psf} + 10}\right) - 1.5 ft\right] \cdot 0.75$ $\quad h_{dLa} = 2.195 ft$

$h_{dL} := \text{if}(h_{dLa} \le h_c, h_{dLa}, h_c)$ $\quad h_{dL} = 2.195 ft$ Height of Drift:

$W_{dLa} := \text{if}\left(h_{dLa} \le h_c, 4 \cdot h_{dLa}, 4 \cdot \frac{h_{dLa}^2}{h_c}\right)$ $\quad W_{dLa} = 8.779 ft$ Width of drift

$W_{dL} := \min(W_{dLa}, 8 \cdot h_c)$ $\quad W_{dL} = 8.779 ft$

$P_{dL} := \gamma \cdot h_{dL}$ $\quad P_{dL} = 33.579 \cdot psf$ Drift surcharge load

$P_m := (h_{dL} + h_b) \cdot \gamma$ $\quad P_m = 43.579 \cdot psf$ Maximum intensity of snow load at parapet

5. Seismic Load:

$Lu_L = 115.33\,ft$ $\quad Lu_t = 45\,ft$ $\quad I_E := 1.0$

$Ww_{48} := 45\,psf$ Weight of wall, 8" masonry block w/ reinforcement and grouted solid at 48" o.c.-32" o.c.

$Ww_{24} := 57\,psf$ Weight of wall, 8" masonry block w/ reinforcement and grouted solid at 24" o.c.- 16" o.c.

$Ww_8 := 81\,psf$ Weight of wall, 8" masonry block w/ reinforcement and grouted solid at 8" o.c.

$w_{st} := 10\,psf$ Weight of metal studs w/ EIFS finish

$w_m := Ww_{48}$ $\quad w_m = 45 \cdot psf$

$h_w := 13.33\,ft$ Joist Bearing height $\quad H_w := 9.33\,ft$ height of window $\quad H_s := 2.0\,ft$ Height of sill

$T_h := \frac{h_w}{2} + (H_b - h_w)$ $\quad T_h = 12.005\,ft$ Tributary Height

Seismic Base Shear: Vs

$S_s := 79.7\%$ $\quad F_a := 1.181$ $\quad T_L := 12$ $\quad C_t := 0.02$ $\quad x := 0.75$

$S_1 := 28.3\%$ $\quad F_v := 1.834$

$S_{ms} := F_a \cdot S_s$ $\quad S_{ms} = 0.941$ $\quad S_{ds} := \frac{2}{3} \cdot S_{ms}$ $\quad S_{ds} = 0.628$

$S_{m1} := F_v \cdot S_1$ $\quad S_{m1} = 0.519$ $\quad S_{d1} := \frac{2}{3} \cdot S_{m1}$ $\quad S_{d1} = 0.346$ $\quad C_u := 1.7$

$T_a := C_t \cdot \left(\frac{h_w}{ft}\right)^x$ $\quad T_a = 0.14$

$T := C_u \cdot T_a$ $\quad T = 0.237$

$$SDC_s := \begin{cases} \text{"A"} & \text{if } S_{ds} < 0.167 \\ \text{"B"} & \text{if } 0.167 \le S_{ds} < 0.33 \\ \text{"C"} & \text{if } 0.33 \le S_{ds} < 0.50 \\ \text{"D"} & \text{if } 0.5 \le S_{ds} \end{cases} \qquad SDC_s = \text{"D"}$$

$$SDC_1 := \begin{cases} \text{"A"} & \text{if } S_{d1} < 0.067 \\ \text{"B"} & \text{if } 0.067 \le S_{d1} < 0.133 \\ \text{"C"} & \text{if } 0.133 \le S_{d1} < 0.20 \\ \text{"D"} & \text{if } 0.2 \le S_{d1} \end{cases} \qquad SDC_1 = \text{"D"} \qquad SDC := \max(SDC_s, SDC_1)$$

$Result := if(S_1 \ge 75\%, \text{"E"}, SDC)$ $\quad Result = \text{"D"}$ Seismic Design Category D

$R_1 := 3.5$ $\quad$ A – 8 $\quad \Omega_{o1} := 2.25$ $\quad C_{d1} := 2.25$

$R_2 := 3.25$ $\quad$ B - 4 $\quad \Omega_{o2} := 2$ $\quad C_{d2} := 3.25$

$\rho := 1.3$ Redundancy For Seismic Design Category D

$Cs_1 := \frac{S_{ds}}{\frac{R_1}{I_E}}$ $Cs_1 = 0.179$

$Cs_2 := \frac{S_{ds}}{\frac{R_2}{I_E}}$ $Cs_2 = 0.193$

$Cs_{max1} := \begin{cases} \frac{S_{d1}}{T \cdot \left(\frac{R_1}{I_E}\right)} & \text{if } T \le T_L \\ \frac{S_{d1} \cdot T_L}{T^2 \cdot \left(\frac{R_1}{I_E}\right)} & \text{if } T > T_L \end{cases}$ $Cs_{max1} = 0.417$

$Cs_{max2} := \begin{cases} \frac{S_{d1}}{T \cdot \left(\frac{R_2}{I_E}\right)} & \text{if } T \le T_L \\ \frac{S_{d1} \cdot T_L}{T^2 \cdot \left(\frac{R_2}{I_E}\right)} & \text{if } T > T_L \end{cases}$ $Cs_{max2} = 0.449$

$Cs_{min1} := \begin{cases} 0.01 & \text{if } S_1 < 60\% \\ \frac{0.5 \cdot S_1}{\left(\frac{R_1}{I_E}\right)} & \text{if } S_1 \ge 60\% \end{cases}$ $Cs_{min1} = 0.01$

$Cs_{min2} := \begin{cases} 0.01 & \text{if } S_1 < 60\% \\ \frac{0.5 \cdot S_1}{\left(\frac{R_2}{I_E}\right)} & \text{if } S_1 \ge 60\% \end{cases}$ $Cs_{min2} = 0.01$

$Cs_1 := \begin{cases} Cs_1 & \text{if } Cs_{min1} < Cs_1 < Cs_{max1} \\ Cs_{min1} & \text{if } Cs_1 < Cs_{min1} \\ Cs_{max1} & \text{if } Cs_{max1} \le Cs_1 \end{cases}$ $Cs_1 = 0.179$

$Cs_2 := \begin{cases} Cs_2 & \text{if } Cs_{min2} < Cs_2 < Cs_{max2} \\ Cs_{min2} & \text{if } Cs_2 < Cs_{min2} \\ Cs_{max2} & \text{if } Cs_{max2} \le Cs_2 \end{cases}$ $Cs_2 = 0.193$

$W_{dlt} := w_m \cdot \left[\left(2 \cdot Lu_L\right) \cdot \left(T_h\right)\right]$ $W_{dlt} = 124.608 \cdot k$

$W_{dlL} := w_m \cdot \left[\left(2 \cdot Lu_t\right) \cdot \left(T_h\right)\right]$ $W_{dlL} = 48.62 \cdot k$

$W_{roof} := DLr \cdot \left(Lu_L \cdot Lu_t\right)$ $W_{roof} = 103.797 \cdot k$

$W_{mech} := 925lbf + 800lbf + 3000lbf \cdot 2 + 150lbf \cdot 3 + 100lbf \cdot 2 + 260lbf \cdot 3$ $W_{mech} = 9.155 \cdot k$

$W_m := \begin{cases} W_{mech} & \text{if } P_f \le 30psf \\ W_{mech} + \left(0.2 \cdot P_f \cdot Lu_L \cdot Lu_t\right) & \text{if } P_f > 30psf \end{cases}$ $W_m = 9.155 \cdot k$

$W_t := W_{roof} + W_{dlt} + W_m$	$W_t = 237.56 \cdot k$	$W_L := W_{roof} + W_{dlL} + W_m$	$W_L = 161.572 \cdot k$
$Q_{Et} := Cs_2 \cdot W_t$	$Q_{Et} = 45.868 \cdot k$	$Q_{EL} := Cs_1 \cdot W_L$	$Q_{EL} = 28.968 \cdot k$
$E_{ht} := Q_{Et} \cdot \rho$	$E_{ht} = 59.628 \cdot k$	$E_{hL} := Q_{EL} \cdot \rho$	$E_{hL} = 37.658 \cdot k$
$E_{vt} := 0.2 \cdot S_{ds} \cdot W_t$	$E_{vt} = 29.814 \cdot k$	$E_{vL} := 0.2 \cdot S_{ds} \cdot W_L$	$E_{vL} = 20.277 \cdot k$
$E_{5t} := E_{ht} + E_{vt}$	$E_{5t} = 89.442 \cdot k$	$E_{5L} := E_{hL} + E_{vL}$	$E_{5L} = 57.936 \cdot k$
$E_{7t} := E_{ht} - E_{vt}$	$E_{7t} = 29.814 \cdot k$	$E_{7L} := E_{hL} - E_{vL}$	$E_{7L} = 17.381 \cdot k$
$V_{st} := .7E_{ht}$	$V_{st} = 41.74 \cdot k$	$V_{sL} := .7E_{hL}$	$V_{sL} = 26.361 \cdot k$ ASD Factored

$V_{Wn} := .6V_{Wnu}$ $V_{Wn} = 31.669 \cdot k$ $V_{Wb} := .6V_{Wbu}$ $V_{Wb} = 10.692 \cdot k$ ASD Factored

$V_{Lut} := \max(V_{st}, V_{Wn})$ $V_{Lut} = 41.74 \cdot k$ $V_{LuL} := \max(V_{sL}, V_{Wb})$ $V_{LuL} = 26.361 \cdot k$

Load Combinations (Strength Design):

$LC1 := 1.4DLr$ $LC1 = 28 \cdot psf$

$LC2 := 1.2 \cdot DLr + 0.5P_f$ $LC2 = 29 \cdot psf$

$LC2a := 1.2 \cdot DLr + 0.5 \cdot LLr$ $LC2a = 33.3 \cdot psf$

$LC3 := 1.2 \cdot DLr + 1.6 \cdot LLr + 0.5Pw_{vd}$ $LC3 = 61.76 \cdot psf$

$LC3a := 1.2 \cdot DLr + 1.6 \cdot P_f + 0.5 \cdot Pw_{vd}$ $LC3a = 48 \cdot psf$ Governs

$LC4 := 1.2 \cdot DLr + 1.0 \cdot Pw_{vd} + 0.5 \cdot P_f$ $LC4 = 45 \cdot psf$

$LC4a := 1.2 \cdot DLr + 1.0 \cdot Pw_{vd} + 0.5 \cdot LLr$ $LC4a = 49.3 \cdot psf$

$LC5 := 1.2 \cdot DLr + 1.0 \cdot \frac{E_{5t}}{Lu_t \cdot Lu_L} + 0.2 \cdot P_f$ $LC5 = 43.234 \cdot psf$

$LC5a := 1.2 \cdot DLr + 1.0 \cdot \frac{E_{5L}}{Lu_t \cdot Lu_L} + 0.2 \cdot P_f$ $LC5a = 37.163 \cdot psf$

$LC6 := 0.9 \cdot DLr + 1.0 \cdot Pw_{vu}$ $LC6 = -4.905 \cdot psf$

$LC7 := 0.9 \cdot DLr + 1.0 \cdot \frac{E_{7t}}{Lu_t \cdot Lu_L}$ $LC7 = 23.745 \cdot psf$

$LC7a := 0.9 \cdot DLr + 1.0 \cdot \frac{E_{7L}}{Lu_t \cdot Lu_L}$ $LC7a = 21.349 \cdot psf$

$TL := \max(LC1, LC2, LC2a, LC3, LC3a, LC4, LC4a, LC5, LC5a, LC6, LC7, LC7a)$ $TL = 61.76 \cdot psf$

$TL_{serv} := DLr + \max(P_f, LLr) + 0.6Pw_{vd}$ $TL_{serv} = 48.2 \cdot psf$

Roof Joist Design:

Design of typical joist (J1):

$L_j := Lu_t - 1.33ft$ $DLr = 20 \cdot psf$ $LLr = 18.6 \cdot psf$ $L_j = 43.67ft$ $a_d := \frac{W_{dt}}{3}$ $a_d = 1.734ft$ $S_j = 6ft$

$W_u := TL \cdot S_j$ $W_u = 370.56 \cdot plf$

$$Rj_1 := \frac{W_u \cdot L_j}{2} + \frac{\frac{P_{dt} \cdot W_{dt} \cdot S_j}{2} \cdot (L_j - a_d)}{L_j}$$ $Rj_1 = 8.39 \cdot k$

$$Rj_2 := \frac{W_u \cdot L_j}{2} + \frac{\frac{P_{dt} \cdot W_{dt} \cdot S_j}{2} \cdot a_d}{L_j}$$ $Rj_2 = 8.104 \cdot k$

$$M_{jcent} := \frac{W_u \cdot L_j^2}{8} + \frac{\frac{P_{dt} \cdot W_{dt} \cdot S_j}{2} \cdot (L_j - a_d) \cdot \frac{L_j}{2}}{L_j} \qquad M_{jcent} = 94.85 \, ft \cdot k$$

$$M_{jpoint} := \frac{W_u \cdot \frac{L_j}{2}}{2} \cdot \left(L_j - \frac{L_j}{2}\right) + \frac{\frac{P_{dt} \cdot W_{dt} \cdot S_j}{2} \cdot (a_d) \cdot (L_j - a_d)}{L_j} \qquad M_{jpoint} = 88.853 \, ft \cdot k$$

Using the Manufacturer's Design Properties: For LH Series 28LH06, Lj = 44 ft, Depth @ ends = 28

$W_{allow} := 592 plf$ $\quad R_{allow} := \frac{W_{allow} \cdot L_j}{2}$ $\quad R_{allow} = 12.926 \cdot k$ $\quad M_{allow} := \frac{W_{allow} \cdot L_j^2}{8}$ $\quad M_{allow} = 141.123 \cdot k \cdot ft$

$R_j := \max(R_{j1}, R_{j2})$ $\quad R_j = 8.39 \cdot k$

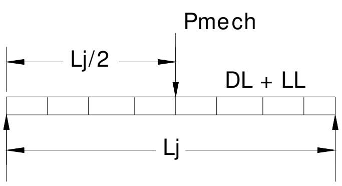
check := if($R_{allow} \ge R_j$, "OK" , "Not OK") $\quad$ check = "OK"

$M_j := \max(M_{jcent}, M_{jpoint})$ $\quad M_j = 94.85 \cdot k \cdot ft$

check := if($M_{allow} \ge M_j$, "OK" , "Not OK") $\quad$ check = "OK"

Use 28LH06 for Roof Steel Joist for TL

Design of joist at Mechanical Load (RTU-1 and RTU-2):



$L_j = 43.67 ft$ $\quad M_j = 94.85 \cdot k \cdot ft$ $\quad R_j = 8.39 \cdot k$ $\quad Trib_L := 6.0 ft$

$P_{mech} := \frac{3300 lbf}{8}$ $\quad P_{mech} = 412.5 \cdot lbf$ $\quad a := 9 ft$ $\quad c := 8 ft$ $\quad b := L_j - a - c$ $\quad b = 26.67 ft$

$P_{mech2} := \frac{1000 lbf}{4}$ $\quad P_{mech2} = 250 \cdot lbf$ $\quad b_2 := 9.5 ft$ $\quad c_2 := 3.5 ft$ $\quad a_2 := L_j - b_2 - c_2$ $\quad a_2 = 30.67 ft$

$W_{umech} := TL \cdot Trib_L$ $\qquad W_{umech} = 370.56 \cdot plf$

$$R_{j3} := \frac{W_{umech} \cdot L_j}{2} + \frac{\frac{1.6 P_{dt} \cdot W_{dt} \cdot Trib_L}{2} \cdot (L_j - a_d)}{L_j} + \frac{1.2 \cdot P_{mech}}{L_j} \cdot (L_j - a + b) + \frac{1.2 P_{mech2}}{L_j} \cdot (L_j - a_2 + b_2)$$

$$R_{j4} := \frac{W_{umech} \cdot L_j}{2} + \frac{\frac{1.6 P_{dt} \cdot W_{dt} \cdot Trib_L}{2} \cdot a_d}{L_j} + \frac{1.2 \cdot P_{mech}}{L_j} \cdot (L_j - b + a) + \frac{1.2 P_{mech2}}{L_j} \cdot (L_j - b_2 + a_2)$$

$R_{jmax} := \max(R_{j3}, R_{j4})$ $\quad R_{jmax} = 9.418 \cdot k$

$$M_{jcent2} := \frac{W_{umech} \cdot L_j^2}{8} + \frac{\frac{1.6P_{dt} \cdot W_{dt} \cdot Trib_L}{2} \cdot (L_j - a_d) \cdot \frac{L_j}{2}}{L_j} + \frac{1.2 \cdot P_{mech}}{L_j} \cdot (L_j - a + b) \cdot a + \frac{1.2P_{mech2}}{L_j} \cdot (L_j - a_2 + b_2) \cdot a_2$$

$$M_{jpoint2} := \frac{W_{umech} \cdot \frac{L_j}{2}}{2} \cdot \left(L_j - \frac{L_j}{2}\right) + \frac{\frac{1.6P_{dt} \cdot W_{dt} \cdot Trib_L}{2} \cdot a_d \cdot (L_j - a_d)}{L_j} + \frac{1.2 \cdot P_{mech}}{L_j} \cdot (L_j - b + a) \cdot b + \frac{1.2P_{mech2}}{L_j} \cdot (L_j - b_2 + a_2) \cdot b_2$$

$M_{j2} := \max(M_{jcent2}, M_{jpoint2})$ $\qquad M_{j2} = 109.756 \cdot k \cdot ft$

Using the Manufacturer's Design Properties For LH Series 28LH06, Lj = 44 ft, Depth @ ends = 28

check := if($R_{allow} \geq R_{jmax}$, "OK" , "Not OK") $\qquad$ check = "OK"

check := if($M_{allow} \geq M_{j2}$, "OK" , "Not OK") $\qquad$ check = "OK"

Use 28LH06 for Roof Steel Joist for TL

Design of joist at Mechanical Load (RTU-1 and MAC):

$L_j = 43.67 ft$ $\qquad M_j = 94.85 \cdot k \cdot ft$ $\qquad R_j = 8.39 \cdot k$ $\qquad Trib_L := 6.0 ft$

$P_{mech} := \frac{3300 lbf}{8}$ $\qquad P_{mech} = 412.5 \cdot lbf$ $\qquad a := 6.5 ft$ $\qquad c := 6.67 ft$ $\qquad b := L_j - a - c$ $\qquad b = 30.5 ft$

$P_{mech2} := \frac{925 lbf}{6}$ $\qquad P_{mech2} = 154.167 \cdot lbf$ $\qquad b_2 := 10.33 ft$ $\qquad c_2 := 4.33 ft$ $\qquad a_2 := L_j - b_2 - c_2$ $\qquad a_2 = 29.01 ft$

$W_{umech} := TL \cdot Trib_L$ $\qquad W_{umech} = 370.56 \cdot plf$

$$R_{j5} := \frac{W_{umech} \cdot L_j}{2} + \frac{\frac{1.6P_{dt} \cdot W_{dt} \cdot Trib_L}{2} \cdot (L_j - a_d)}{L_j} + \frac{1.2 \cdot P_{mech}}{L_j} \cdot (L_j - a + b) + \frac{1.2P_{mech2}}{L_j} \cdot (L_j - a_2 + b_2)$$

$$R_{j6} := \frac{W_{umech} \cdot L_j}{2} + \frac{\frac{1.6P_{dt} \cdot W_{dt} \cdot Trib_L}{2} \cdot a_d}{L_j} + \frac{1.2 \cdot P_{mech}}{L_j} \cdot (L_j - b + a) + \frac{1.2P_{mech2}}{L_j} \cdot (L_j - b_2 + a_2)$$

$R_{jmax} := \max(R_{j5}, R_{j6})$ $\qquad R_{jmax} = 9.441 \cdot k$

$$M_{jcent3} := \frac{W_{umech} \cdot L_j^2}{8} + \frac{\frac{1.6P_{dt} \cdot W_{dt} \cdot Trib_L}{2} \cdot (L_j - a_d) \cdot \frac{L_j}{2}}{L_j} + \frac{1.2 \cdot P_{mech}}{L_j} \cdot (L_j - a + b) \cdot a + \frac{1.2P_{mech2}}{L_j} \cdot (L_j - a_2 + b_2) \cdot a_2$$

$$M_{jpoint3} := \frac{W_{umech} \cdot \frac{L_j}{2}}{2} \cdot \left(L_j - \frac{L_j}{2}\right) + \frac{\frac{1.6P_{dt} \cdot W_{dt} \cdot Trib_L}{2} \cdot a_d \cdot (L_j - a_d)}{L_j} + \frac{1.2 \cdot P_{mech}}{L_j} \cdot (L_j - b + a) \cdot b + \frac{1.2P_{mech2}}{L_j} \cdot (L_j - b_2 + a_2) \cdot b_2$$

$M_{j3} := \max(M_{jcent3}, M_{jpoint3})$ $\qquad M_{j3} = 106.815 \cdot k \cdot ft$

Using the Manufacturer's Design Properties : For LH Series 28LH06, Lj = 44 ft, Depth @ ends = 28

$check := if(R_{allow} \geq Rj_{max}, \text{"OK"}, \text{"Not OK"})$ $check = \text{"OK"}$

$check := if(M_{allow} \geq Mj3, \text{"OK"}, \text{"Not OK"})$ $check = \text{"OK"}$

Use 28LH06 for Roof Steel Joist for TL

Design of joist at Mechanical Load (RTU-3 and Condensers):

$L_j = 43.67 ft$ $Mj = 94.85 \cdot k \cdot ft$ $Rj = 8.39 \cdot k$ $Trib_L := 6.0 ft$

$P_{mech} := \frac{3300 lbf}{8}$ $P_{mech} = 412.5 \cdot lbf$ $a := 8.33 ft$ $c := 8 ft$ $b := L_j - a - c$ $b = 27.34 ft$

$P_{mech2} := \frac{260 lbf \cdot 3}{10}$ $P_{mech2} = 78 \cdot lbf$ $b_2 := 12.75 ft$ $c_2 := 5.67 ft$ $a_2 := L_j - b_2 - c_2$ $a_2 = 25.25 ft$

$W_{umech} := TL \cdot Trib_L$ $W_{umech} = 370.56 \cdot plf$

$$Rj_7 := \frac{W_{umech} \cdot L_j}{2} + \frac{\frac{1.6 P_{dt} \cdot W_{dt} \cdot Trib_L}{2} \cdot (L_j - a_d)}{L_j} + \frac{1.2 \cdot P_{mech}}{L_j} \cdot (L_j - a + b) + \frac{1.2 P_{mech2}}{L_j} \cdot (L_j - a_2 + b_2)$$

$$Rj_8 := \frac{W_{umech} \cdot L_j}{2} + \frac{\frac{1.6 P_{dt} \cdot W_{dt} \cdot Trib_L}{2} \cdot a_d}{L_j} + \frac{1.2 \cdot P_{mech}}{L_j} \cdot (L_j - b + a) + \frac{1.2 P_{mech2}}{L_j} \cdot (L_j - b_2 + a_2)$$

$Rj_{max} := \max(Rj_7, Rj_8)$ $Rj_{max} = 9.346 \cdot k$

$$Mj_{cent4} := \frac{W_{umech} \cdot L_j^2}{8} + \frac{\frac{1.6 P_{dt} \cdot W_{dt} \cdot Trib_L}{2} \cdot (L_j - a_d) \cdot \frac{L_j}{2}}{L_j} + \frac{1.2 \cdot P_{mech}}{L_j} \cdot (L_j - a + b) \cdot a + \frac{1.2 P_{mech2}}{L_j} \cdot (L_j - a_2 + b_2) \cdot a_2$$

$$Mj_{point4} := \frac{W_{umech} \cdot \frac{L_j}{2}}{2} \cdot \left(L_j - \frac{L_j}{2}\right) + \frac{\frac{1.6 P_{dt} \cdot W_{dt} \cdot Trib_L}{2} \cdot a_d \cdot (L_j - a_d)}{L_j} + \frac{1.2 \cdot P_{mech}}{L_j} \cdot (L_j - b + a) \cdot b + \frac{1.2 P_{mech2}}{L_j} \cdot (L_j - b_2 + a_2) \cdot b_2$$

$Mj4 := \max(Mj_{cent4}, Mj_{point4})$ $Mj4 = 106.363 \cdot k \cdot ft$

Using the Manufacturer's Design Properties For LH Series 28LH06, Lj = 44 ft, Depth @ ends = 28

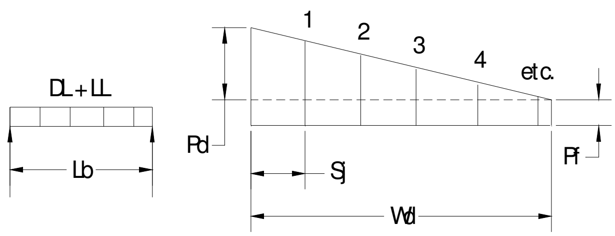
$check := if(R_{allow} \geq Rj_{max}, \text{"OK"}, \text{"Not OK"})$ $check = \text{"OK"}$

$check := if(M_{allow} \geq Mj4, \text{"OK"}, \text{"Not OK"})$ $check = \text{"OK"}$

Use 28LH06 for Roof Steel Joist for TL

Design of joist @ Ends of Bldg:

$L_j = 43.67 ft$ $S_j = 6 ft$ $W_{dL} = 8.779 ft$ $P_{dL} = 33.579 \cdot psf$



@ Location 1

$S_{j1} := 3.0ft$ $S_{j2} := 6.0ft$ $S_{j3} := 6.0ft$

$L_1 := W_{dL} - S_{j1}$ $L_1 = 69.347 \cdot in$

$Wu_1 := \left[1.6\left(\frac{P_{dL} \cdot L_1}{W_{dL}}\right) + TL\right] \cdot \left(\frac{S_{j1} + S_{j2}}{2}\right)$ $Wu_1 = 437.07 \cdot plf$

$Rj_{15a} := \frac{Wu_1 \cdot L_j}{2}$ $Rj_{15a} = 9.543 \cdot k$

$M_{8a} := \frac{Wu_1 \cdot L_j^2}{8}$ $M_{8a} = 104.19 \cdot k \cdot ft$

check := if($R_{allow} \geq Rj_{15a}$, "OK" , "Not OK") check = "OK"

check := if($M_{allow} \geq M_{8a}$, "OK" , "Not OK") check = "OK"

@ Location 2

$L_2 := L_1 - S_{j2}$ $L_2 = -2.653 \cdot in$

$Wu_2 := \left[1.6\left(\frac{P_{dL} \cdot L_2}{W_{dL}}\right) + TL\right] \cdot \left(\frac{S_{j2} + S_{j3}}{2}\right)$ $Wu_2 = 362.44 \cdot plf$

$Rj_{15b} := \frac{Wu_2 \cdot L_j}{2}$ $Rj_{15b} = 7.914 \cdot k$

$M_{8b} := \frac{Wu_2 \cdot L_j^2}{8}$ $M_{8b} = 86.4 \cdot k \cdot ft$

check := if($R_{allow} \geq Rj_{15b}$, "OK" , "Not OK") check = "OK"

check := if($M_{allow} \geq M_{8b}$, "OK" , "Not OK") check = "OK"

Use 28LH06 for Roof Steel Joist for TL

Roof Deck Check:

Use 1 1/2" B 22 gauge metal deck, 3 spans $w_{allow} := 87psf$

check := if($w_{allow} \geq TL$, "OK" , "Not OK") check = "OK"

$dt := 0.0295in$ $I := 0.169in^4$ $Sp := 0.186in^3$ $Sn := 0.192in^3$ $Fy := 33ksi$

Use 5/8" puddle welds @ 6" o.c. at perimeter supports and at 12" o.c. at intermediate supports

Roof Joist Bearing Plate:

$F_{exx} := 70ksi$ $E_s := 29000ksi$

$Rjmax := max(Rj_{15a}, Rj_{max})$ $Rjmax = 9.543 \cdot k$ $fy := 36ksi$

Use allowable stress on masonry below bearing plate: $\rho := 250psi$

$Areqd := \frac{Rjmax}{\rho}$ $Areqd = 38.174 \cdot in^2$

Use bearing plate 5"x12" $l := 5in$ $w := 12in$

$Aact := l \cdot w$ $Aact = 60 \cdot in^2$

check := if(Aact ≥ Areqd, "OK" , "Not OK") check = "OK"

$Fb := 0.75 \cdot fy$ $Fb = 27 \cdot ksi$

$fb := \frac{Rjmax}{l \cdot w}$ $fb = 0.159 \cdot ksi$

check := if(Fb > fb, "OK" , "Not OK") check = "OK"

$n := \frac{l}{2}$ $n = 2.5 \cdot in$

$t := \sqrt{\frac{3 \cdot fb \cdot n^2}{Fb}}$ $t = 0.332 \cdot in$

Use Bearing Plate 3/8"x5"x12" w/ 2-1/2"ϕx6" Headed Studs

$Vmax := Rjmax$ $Vmax = 9.543 \cdot k$

$Fnw := 0.6 \cdot F_{exx}$ $Fnw = 42 \cdot ksi$ nominal Shear stress at fillet weld

$A := 0.177in \cdot 2in \cdot 2$ $A = 0.708 \cdot in^2$ Weld Throat Area for 1/4" fillet weld 2 1/2" long

$\phi Rn := 0.45 \cdot Fnw \cdot A$ $\phi Rn = 13.381 \cdot k$ Design Shear Strength

$Weld := \frac{Vmax}{\phi Rn}$ $Weld = 0.713$

check := if(Weld ≤ 1.0, "OK" , "Not OK") check = "OK"

Joist welded to bearing plate 1/4" fillet weld, 2" long both sides of joist, minimum

Lintel Design:

Lintel L1 over service doors and DT windows:

$L1 := 4.67ft$ $w_m = 45 \cdot psf$ $h_m := 11.33ft$ $F_y := 36ksi$ $\phi_b := 0.9$

$w1 := TL \cdot \left(\frac{Lu_t}{2}\right) + 1.2 \cdot w_m \cdot h_m$ $w1 = 2001.42 \cdot plf$

$w1_{serv} := TL_{serv} \cdot \left(\frac{Lu_t}{2}\right) + w_m \cdot h_m$ $w1_{serv} = 1594.35 \cdot plf$

$R1 := \frac{w1 \cdot L1}{2}$ $\quad R1 = 4.673 \cdot k$

$M1 := \frac{w1 \cdot L1^2}{8}$ $\quad M1 = 5.456 \cdot ft \cdot k$

Try 2-L5x3 1/2x5/16 $\quad F_y = 36 \cdot ksi$ $\quad F_u := 58ksi$ $\quad A_g := 5.12in^2$ $\quad A_e := 3.84in^2$ $\quad Z_x := 3.45in^3$

$\phi tPn_y := 113k$ $\quad \phi tPn_r := 137k$ $\quad J := 0.0883in^4$ $\quad G := 11200ksi$ $\quad I_y := 2.69in^4$ $\quad d := 5in$

Allowable Bending: $\quad b_f := 3.5in$ $\quad t_f := 0.313in$ $\quad S_x := 3.87in^3$ $\quad I_x := 13.2in^4$

$M_p := F_y \cdot Z_x$ $\quad M_p = 10.35 \cdot ft \cdot k$

$B := 2.3 \cdot \frac{d}{L1} \cdot \sqrt{\frac{I_y}{J}}$ $\quad B = 1.133$

$M_{cr} := \frac{\pi \cdot \sqrt{E_s \cdot I_y \cdot G \cdot J}}{L1} \cdot \left(B + \sqrt{1 + B^2}\right)$ $\quad M_{cr} = 108.474 \cdot ft \cdot k$

$\lambda_c := \frac{b_f}{t_f}$ $\quad \lambda_c = 11.182$ $\quad \lambda_r := 0.45 \cdot \sqrt{\frac{E_s}{F_y}}$ $\quad \lambda_r = 12.772$

check := | "Section is Compact" if $\lambda_c \le \lambda_r$
"Section is slender" if $\lambda_c > \lambda_r$

check = "Section is Compact"

$M_{nx} := \min(M_p, M_{cr})$ $\quad M_{nx} = 10.35 \cdot ft \cdot k$

check := if($M_{nx} \ge M1$, "OK" , "Not OK") $\quad$ check = "OK"

$$Q_s := \begin{cases} 1.0 & \text{if } \lambda_c \le 0.75 \cdot \sqrt{\frac{E_s}{F_y}} \\ 1.908 - 1.22 \cdot \lambda_c \cdot \sqrt{\frac{F_y}{E_s}} & \text{if } 0.75 \cdot \sqrt{\frac{E_s}{F_y}} < \lambda_c \le 1.03 \cdot \sqrt{\frac{E_s}{F_y}} \\ \frac{0.69 \cdot E_s}{F_y \cdot \lambda_c^2} & \text{if } \lambda_c > 1.03 \cdot \sqrt{\frac{E_s}{F_y}} \end{cases}$$

$Q_s = 1$

$F_b := 0.6 \cdot Q_s \cdot F_y$ $\quad F_b = 21.6 \cdot ksi$

$f_b := \frac{\phi_b \cdot M1}{S_x}$ $\quad f_b = 15.226 \cdot ksi$

Result := if($F_b \ge f_b$, "OK" , "Not OK") $\quad$ Result = "OK"

$\Delta := \frac{5 \cdot w1_{serv} \cdot L1^4}{384 \cdot E_s \cdot I_x}$ $\quad \Delta = 0.045 \cdot in$

$\Delta allow := \frac{L1}{600}$ $\Delta allow = 0.093 \cdot in$ $\Delta_{max} := 0.3in$

$\Delta_{allow} := if(\Delta allow < \Delta_{max}, \Delta allow, \Delta_{max})$ $\Delta_{allow} = 0.093 \cdot in$

check := if($\Delta < \Delta_{allow}$, "OK", "Not OK") check = "OK"

Use 2-L5x3 1/2x5/16 LLV

Lintel bearing on masonry check: $b_w := 7in$ bearing := 6in

$\rho := 250psi$ $\rho_{act} := \frac{R1}{b_w \cdot bearing}$ $\rho_{act} = 111.269 \cdot psi$

check := if($\rho \geq \rho_{act}$, "OK", "Not OK") check = "OK"

Lintel L1 over rear crew window:

$L2 := 3.33ft$ $w_m = 45 \cdot psf$ $h_m := 10.67ft$ $F_y = 36 \cdot ksi$

$w2 := TL \cdot \left(\frac{S_j}{2}\right) + 1.2 \cdot w_m \cdot h_m$ $w2 = 761.46 \cdot plf$

$w2_{serv} := TL_{serv} \cdot \left(\frac{S_j}{2}\right) + w_m \cdot h_m$ $w2_{serv} = 624.75 \cdot plf$

$R2 := \frac{w2 \cdot L2}{2}$ $R2 = 1.268 \cdot k$

$M2 := \frac{w2 \cdot L2^2}{8}$ $M2 = 1.055 \cdot ft \cdot k$

Try 2-L5x3 1/2x5/16 $F_y = 36 \cdot ksi$ $F_u := 58ksi$ $A_g := 5.12in^2$ $A_e := 3.84in^2$ $Z_x := 3.45in^3$

$\phi tPn_y := 117k$ $\phi tPn_r := 145k$ $J := 0.0883in^4$ $G := 11200ksi$ $I_y := 2.69in^4$ $d := 5in$

Allowable Bending: $b_f := 3.5in$ $t_f := 0.313in$ $S_x := 3.87in^3$ $I_x := 13.2in^4$

$M_p := F_y \cdot Z_x$ $M_p = 10.35 \cdot ft \cdot k$

$B := 2.3 \cdot \frac{d}{L1} \cdot \sqrt{\frac{I_y}{J}}$ $B = 1.133$

$M_{cr} := \frac{\pi \cdot \sqrt{E_s \cdot I_y \cdot G \cdot J}}{L2} \cdot \left(B + \sqrt{1 + B^2}\right)$ $M_{cr} = 152.125 \cdot ft \cdot k$

$\lambda_c := \frac{b_f}{t_f}$ $\lambda_c = 11.182$ $\lambda_r := 0.45 \cdot \sqrt{\frac{E_s}{F_y}}$ $\lambda_r = 12.772$

check := | "Section is Compact" if $\lambda_c \leq \lambda_r$
| "Section is slender" if $\lambda_c > \lambda_r$

check = "Section is Compact"

$M_{nx} := \min(M_p, M_{cr})$ $M_{nx} = 10.35 \cdot ft \cdot k$

check := if($M_{nx} \geq M2$, "OK" , "Not OK") check = "OK"

$$Q_s := \begin{cases} 1.0 & \text{if } \lambda_c \leq 0.75 \cdot \sqrt{\frac{E_s}{F_y}} \\ 1.908 - 1.22 \cdot \lambda_c \cdot \sqrt{\frac{F_y}{E_s}} & \text{if } 0.75 \cdot \sqrt{\frac{E_s}{F_y}} < \lambda_c \leq 1.03 \cdot \sqrt{\frac{E_s}{F_y}} \\ \frac{0.69 \cdot E_s}{F_y \cdot \lambda_c^2} & \text{if } \lambda_c > 1.03 \cdot \sqrt{\frac{E_s}{F_y}} \end{cases}$$

$Q_s = 1$

$Fb := 0.6 \cdot Q_s \cdot F_y$ $Fb = 21.6 \cdot ksi$

$fb := \frac{\phi_b \cdot M2}{S_x}$ $fb = 2.945 \cdot ksi$

Result := if($Fb \geq fb$, "OK" , "Not OK") Result = "OK"

$\Delta := \frac{5 \cdot w2_{serv} \cdot L2^4}{384 \cdot E_s \cdot I_x}$ $\Delta = 0.005 \cdot in$

$\Delta allow := \frac{L2}{600}$ $\Delta allow = 0.067 \cdot in$ $\Delta_{max} := 0.3in$ $\Delta_{allow} := \text{if}(\Delta allow < \Delta_{max}, \Delta allow, \Delta_{max})$ $\Delta_{allow} = 0.067 \cdot in$

check := if($\Delta < \Delta_{allow}$, "OK" , "Not OK") check = "OK"

Use 2-L5x3 1/2x5/16 LLV

Lintel bearing on masonry check: $b_w := 7in$ bearing := 6in $\rho := 250psi$

$\rho_{act} := \frac{R2}{b_w \cdot bearing}$ $\rho_{act} = 30.186 \cdot psi$ check := if($\rho \geq \rho_{act}$, "OK" , "Not OK") check = "OK"

STEEL HEADER DESIGN:

Header "H1" over front arcade openings:

$F_{yy} := 46ksi$ $w_m = 45 \cdot psf$ $\phi_b = 0.9$ $w_{st} = 10 \cdot psf$

$L_{h1} := 14ft$ $TL = 61.76 \cdot psf$ $h_{st} := 6ft$ $w_b := 22.39plf$

$w_{h1} := TL \cdot \left(\frac{16in}{2} + 3ft\right) + 1.2 \cdot w_{st} \cdot h_{st} + 1.2 \cdot w_b$ $w_{h1} = 325.321 \cdot plf$

$w_{h1serv} := TL_{serv} \cdot \left(\frac{16in}{2} + 3ft\right) + w_{st} \cdot h_{st} + w_b$ $w_{h1serv} = 259.123 \cdot plf$

$V_{h1serv} := \frac{w_{h1serv} \cdot L_{h1}}{2}$ $V_{h1serv} = 1.814 \cdot k$

$V_{h1} := \frac{w_{h1} \cdot L_{h1}}{2}$ $V_{h1} = 2.277 \cdot k$

$M_{h1} := \frac{w_{h1} \cdot L_{h1}^2}{8}$ $\qquad$ $M_{h1} = 7.97 \cdot ft \cdot k$

$P_{wu} = 69.193 \cdot psf$ $\qquad$ $P_f = 10 \cdot psf$ $\qquad$ $P_{max} := max(P_{wu} - .9DLr, 1.6 \cdot P_f)$ $\qquad$ $P_{max} = 51.193 \cdot psf$

$V_{h1y} := \frac{P_{max} \cdot 3ft \cdot L_{h1}}{2}$ $\qquad$ $V_{h1y} = 1.075 \cdot k$

$M_{h1y} := \frac{(P_{max} \cdot 3ft \cdot L_{h1}) \cdot L_{h1}}{4}$ $\qquad$ $M_{h1y} = 7.525 \cdot k \cdot ft$

$\begin{pmatrix} I_x \\ d \\ t_w \\ t_f \\ b_f \\ A_g \\ w_b \\ r_y \\ r_{ts} \\ Z_x \\ Z_y \\ C_w \\ S_x \\ S_y \\ I_y \\ J \\ b_T \\ h_T \\ c \end{pmatrix} :=$

Beam Section

Section :	HSS8X6X1/4		*Chosen from dropdown of AISC Shapes*
I =	56.6	in^4	*lookup from AISC table1-1*
d =	8.0	in	*lookup from AISC table1-1*
t_w =	0.233	in	*lookup from AISC table1-1*
tf =	0.233	in	*lookup from AISC table1-1*
bf =	6.000	in	*lookup from AISC table1-2*
Ag =	6.170	in^2	*lookup from AISC table1-2*
Wb	22.389	plf	*lookup from AISC table1-3*
r_y =	2.43	in	
r_{ts} =	0.46	in	*Table 1, eq. 9.6.7*
Zx Provided =	16.9		*from AISC table 3-2 lookup, change to small*
Zy Provided =	13.9		
C_w =	0.25	in^6	
S_x =	14.20	in^3	
Sy =	12.10	in^3	
I_y =	36.40	in^4	
J =	70.30	in^4	
b/t=	22.80		
h/t	31.30		
c	20.8	in^3	

c =	20.8	in^3	
E =	29000	ksi	*Steel Modulus*
F_y =	46	ksi	*AISC 14th ed. HSS Sections*

$I_x := I_x \cdot in^4$ $I_x = 56.6 \cdot in^4$ $r_y := r_y \cdot in$ $r_y = 2.43 \cdot in$ $S_y := S_y \cdot in^3$ $S_y = 12.1 \cdot in^3$

$d := d \cdot in$ $d = 8 \cdot in$ $r_{ts} := r_{ts} \cdot in$ $r_{ts} = 0.461 \cdot in$ $I_y := I_y \cdot in^4$ $I_y = 36.4 \cdot in^4$

$t_w := t_w \cdot in$ $t_w = 0.233 \cdot in$ $Z_x := Z_x \cdot in^3$ $Z_x = 16.9 \cdot in^3$ $J := J \cdot in^4$ $J = 70.3 \cdot in^4$

$t_f := t_f \cdot in$ $t_f = 0.233 \cdot in$ $Z_y := Z_y \cdot in^3$ $Z_y = 13.9 \cdot in^3$

$b_f := b_f \cdot in$ $b_f = 6 \cdot in$ $C_w := C_w \cdot in^6$ $C_w = 0.25 \cdot in^6$ $c = 20.8$

$A_g := A_g \cdot in^2$ $A_g = 0.043 ft^2$ $S_x := S_x \cdot in^3$ $S_x = 14.2 \cdot in^3$ $F_y := 46 ksi$

$Zx := \frac{M_{h1}}{\phi_b \cdot F_{yy}}$ $Zx = 2.31 \cdot in^3$ Required Zx

check := if$(Zx \le Z_x, \text{"OK"}, \text{"Not OK"})$ check = "OK"

$Zy := \frac{M_{h1y}}{F_{yy}}$ $Zy = 1.963 \cdot in^3$ Required Zy

check := if$(Zy \le Z_y, \text{"OK"}, \text{"Not OK"})$ check = "OK"

$\lambda p := 1.12 \cdot \sqrt{\frac{E_s}{F_{yy}}}$ $\lambda p = 28.121$ $\lambda r := 1.40 \cdot \sqrt{\frac{E_s}{F_{yy}}}$ $\lambda r = 35.152$ $\lambda_{steel} := \frac{b_f}{t_f}$ $\lambda_{steel} = 25.751$

check := | "Section is Compact" if $\lambda_{steel} \le \lambda p$
| "Section is non campact" if $\lambda_{steel} > \lambda p$
| "Section is slender" if $\lambda_{steel} > \lambda r$

check = "Section is Compact"

$$Sx := \begin{cases} \frac{M_{h1}}{0.66 \cdot F_{yy}} & \text{if } \lambda_{steel} \le \lambda p \\ \frac{M_{h1}}{F_{yy}} & \text{if } \lambda_{steel} \end{cases}$$

$Sx = 2.079 \cdot in^3$

check := if$(Sx \le S_x, \text{"OK"}, \text{"Not OK"})$ check = "OK"

Check Torsional Capacity:

$$F_{cr} := \begin{cases} (0.6 \cdot F_{yy}) & \text{if } \frac{d}{t_f} \le 2.45 \cdot \sqrt{\frac{E_s}{F_{yy}}} \\ \frac{0.6 \cdot F_{yy} \cdot \left(2.45 \cdot \sqrt{\frac{E_s}{F_{yy}}}\right)}{\frac{d}{t_f}} & \text{if } 2.45 \cdot \sqrt{\frac{E_s}{F_{yy}}} < \frac{d}{t_f} \le 3.07 \cdot \sqrt{\frac{E_s}{F_{yy}}} \\ \frac{0.458 \cdot \pi^2 \cdot E_s}{\left(\frac{d}{t_f}\right)^2} & \text{if } 3.07 \cdot \sqrt{\frac{E_s}{F_{yy}}} < \frac{d}{t_f} \le 260 \end{cases}$$

$F_{cr} = 27.6 \cdot ksi$

$M_{nx} := Z_x \cdot F_{yy}$ $\quad M_{nx} = 64.783 \cdot k \cdot ft$ $\quad M_p := M_{nx}$

$$M_{nlt} := \begin{cases} \text{"Lateral Torsional buckling does not apply"} & \text{if } \lambda_{steel} \le \lambda p \\ \left[M_p - (M_p - F_{yy} \cdot S_x) \cdot \left(3.57 \cdot \frac{b_f}{t_f} \cdot \sqrt{\frac{F_{yy}}{E_s}} - 4.0\right)\right] & \text{if } \lambda_{steel} > \lambda p \\ (F_{cr} \cdot S_x) & \text{if } \lambda_{steel} > \lambda r \end{cases}$$

$M_{nlt} =$ "Lateral Torsional buckling does not apply"

$M_{nx} := \min(M_{nx})$ $\quad M_{nx} = 64.783 \cdot k \cdot ft$

$M_{cx} := \phi_b \cdot M_{nx}$ $\quad M_{cx} = 58.305 \cdot k \cdot ft$

check := if($M_{cx} \ge M_{h1}$, "OK" , "Not OK") $\quad$ check = "OK"

$M_{ny} := Z_y \cdot F_{yy}$ $\quad M_{ny} = 53.283 \cdot k \cdot ft$

$M_{cy} := \phi_b \cdot M_{ny}$ $\quad M_{cy} = 47.955 \cdot k \cdot ft$

check := if($M_{cy} \ge M_{h1y}$, "OK" , "Not OK") $\quad$ check = "OK"

Check combined compression and bending capacity:

$P_n := F_{yy} \cdot A_g$ $\quad P_n = 283.82 \cdot k$ $\quad \phi_t := 0.9$ $\quad P_c := \phi_t \cdot P_n$ $\quad P_c = 255.438 \cdot k$ $\quad P_r := 0k$

$A_w := 2 \cdot (d - 3 \cdot t_f) \cdot t_f$ $\quad A_w = 3.402 \cdot in^2$ $\quad C_v := 1.0$ $\quad \phi_v := 1.0$

$V_n := 0.6 \cdot F_{yy} \cdot A_w \cdot C_v$ $\quad V_n = 93.903 \cdot k$ $\quad V_c := \phi_v \cdot V_n$ $\quad V_c = 93.903 \cdot k$

$$SF := \left(\frac{M_{h1}}{M_{cx}} + \frac{M_{h1y}}{M_{cy}}\right)$$

$SF = 0.294$ $\quad$ eq: H1

check := if($SF \le 1.0$, "OK" , "Not OK") $\quad$ check = "OK"

Check deflection:

$$\Delta_{h1} := \frac{5 \cdot w_{h1serv} \cdot L_{h1}^4}{384 \cdot E_s \cdot I_x}$$

$\Delta_{h1} = 0.136 \cdot in$

$\Delta allow := \frac{L_{h1}}{600}$ $\Delta allow = 0.28 \cdot in$ $\Delta_{max} := 0.3in$ $\Delta_{allow} := if(\Delta allow < \Delta_{max}, \Delta allow, \Delta_{max})$ $\Delta_{allow} = 0.28 \cdot in$

$check := if(\Delta_{h1} < \Delta_{allow}, "OK", "Not OK")$ check = "OK"

Use HSS8x6x1/4 LLV, Header H1

HSS Welded Connection to HSS Beam:

$F_{exx} = 70 \cdot ksi$ $fillet := \frac{3}{16} in$ Table J2.4 $D := fillet$ $\phi_w := 0.75$ $L_{ev} := 7in \cdot 2$ $L_{eh} := 5in \cdot 2$

$R_{nv} := 0.6 \cdot F_{exx} \cdot \frac{\sqrt{2}}{2} \cdot D \cdot L_{ev}$ $R_{nv} = 77.959 \cdot k$ $\phi Rnv := \phi_w \cdot R_{nv}$ $\phi Rnv = 58.469 \cdot k$ Vert. Design Shear Strength

$R_{nh} := 0.6 \cdot F_{exx} \cdot \frac{\sqrt{2}}{2} \cdot D \cdot L_{eh}$ $R_{nh} = 55.685 \cdot k$ $\phi Rnh := \phi_w \cdot R_{nh}$ $\phi Rnh = 41.763 \cdot k$ Horiz. Design Shear Strength

$check := if(V_{h1} \le \phi Rnv, "OK", "not OK")$ check = "OK"

$check := if(V_{h1y} \le \phi Rnh, "OK", "not OK")$ check = "OK"

Use 3/16" fillet weld all around HSS beam to plate

Metal Stud Bearing:

$F_y := 33ksi$ $h_{st} := 15.33ft$ $a := 9.5ft$ $b := h_{st} - a$ $b = 5.83ft$ $V_{h1} = 2.277 \cdot k$ $V_{h1y} = 1075.055lbf$

$P_w = 20.988 \cdot psf$ $TL_{serv} = 48.2 \cdot psf$

using CSJ 6" 18 GA. metal studs spaced @ 16" o.c.:

$I_x := 2.316in^4$ $S_x := 0.772in^3$ $A := 0.447in^2$ $M_{allow} := 16764in \cdot (lbf)$

$P_{ax} := \frac{w_{h1} \cdot L_{h1}}{2}$ $P_{ax} = 2.277 \cdot k$

$P_{allow} := 1.615k \cdot 2$ $P_{allow} = 3.23 \cdot k$ allowable axial load for 2 studs @ 20psf cladding load, per dietrich

$check := if(P_{allow} > P_{ax}, "OK", "NOT OK")$ check = "OK"

$M_{stud} := \frac{V_{h1y} \cdot a \cdot b}{h_{st}}$ $M_{stud} = 46.608 \cdot k \cdot in$

$check := if(M_{allow} \cdot 2 > M_{stud}, "OK", "NOT OK")$ check = "NOT OK"

Header "H2" over side arcade openings:

$F_{yy} := 46ksi$ $w_m = 45 \cdot psf$ $\phi_b = 0.9$ $w_{st} = 10 \cdot psf$

$L_{h2} := 8ft$ $TL = 61.76 \cdot psf$ $h_{st} := 6ft$ $w_b := 22.39plf$

$w_{h2} := TL \cdot \left(\frac{16in}{2} + 3ft\right) + 1.2 \cdot w_{st} \cdot h_{st} + 1.2 \cdot w_b$ $w_{h2} = 325.321 \cdot plf$

$w_{h2serv} := TL_{serv} \cdot \left(\frac{16in}{2} + 3ft \right) + w_{st} \cdot h_{st} + w_b$ $\quad w_{h2serv} = 259.123 \cdot plf$

$V_{h2} := \frac{w_{h2} \cdot L_{h2}}{2}$ $\quad V_{h2} = 1.301 \cdot k$

$V_{h2serv} := \frac{w_{h2serv} \cdot L_{h2}}{2}$ $\quad V_{h2serv} = 1.036 \cdot k$

$M_{h2} := \frac{w_{h2} \cdot L_{h2}^2}{8}$ $\quad M_{h2} = 2.603 \cdot ft \cdot k$

$P_{max} := \max(P_{wu} - .9DLr, 1.6 \cdot P_f)$ $\quad P_{max} = 51.193 \cdot psf$

$V_{h2y} := \frac{P_{max} \cdot 3ft \cdot L_{h2}}{2}$ $\quad V_{h2y} = 0.614 \cdot k$

$M_{h2y} := \frac{(P_{max} \cdot 3ft \cdot L_{h2}) \cdot L_{h2}}{4}$ $\quad M_{h2y} = 2.457 \cdot k \cdot ft$

$\begin{pmatrix} I_x \\ d \\ t_w \\ t_f \\ b_f \\ A_g \\ w_b \\ r_y \\ r_{ts} \\ Z_x \\ Z_y \\ C_w \\ S_x \\ S_y \\ I_y \\ J \\ b_T \\ h_T \\ c \end{pmatrix} :=$

Beam Section

Section :	HSS8X6X1/4		*Chosen from dropdown of AISC Shapes*
I =	56.6	in^4	*lookup from AISC table1-1*
d =	8.0	in	*lookup from AISC table1-1*
t_w =	0.233	in	*lookup from AISC table1-1*
tf =	0.233	in	*lookup from AISC table1-1*
bf =	6.000	in	*lookup from AISC table1-2*
Ag =	6.170	in^2	*lookup from AISC table1-2*
Wb	22.389	plf	*lookup from AISC table1-3*
r_y =	2.43	in	
r_{ts} =	0.46	in	*Table 1, eq. 9.6.7*
Zx Provided =	16.9		*from AISC table 3-2 lookup, change to small*
Zy Provided =	13.9		
C_w =	0.25	in^6	
S_x =	14.20	in^3	
Sy =	12.10	in^3	
I_y =	36.40	in^4	
J =	70.30	in^4	
b/t=	22.80		
h/t	31.30		
c =	20.8	in^3	
E =	29000	ksi	*Steel Modulus*
F_y =	46	ksi	*AISC 14th ed. HSS Sections*

$I_x := I_x \cdot in^4$ $\quad I_x = 56.6 \cdot in^4$

$d := d \cdot in$ $\quad d = 8 \cdot in$

$t_w := t_w \cdot in$ $\quad t_w = 0.233 \cdot in$

$t_f := t_f \cdot in$ $\quad t_f = 0.233 \cdot in$

$b_f := b_f \cdot in$ $\quad b_f = 6 \cdot in$

$A_g := A_g \cdot in^2$ $\quad A_g = 0.043 ft^2$

$r_y := r_y \cdot in$ $\quad r_y = 2.43 \cdot in$

$r_{ts} := r_{ts} \cdot in$ $\quad r_{ts} = 0.461 \cdot in$

$Z_x := Z_x \cdot in^3$ $\quad Z_x = 16.9 \cdot in^3$

$Z_y := Z_y \cdot in^3$ $\quad Z_y = 13.9 \cdot in^3$

$C_w := C_w \cdot in^6$ $\quad C_w = 0.25 \cdot in^6$

$S_x := S_x \cdot in^3$ $\quad S_x = 14.2 \cdot in^3$

$S_y := S_y \cdot in^3$ $\quad S_y = 12.1 \cdot in^3$

$I_y := I_y \cdot in^4$ $\quad I_y = 36.4 \cdot in^4$

$J := J \cdot in^4$ $\quad J = 70.3 \cdot in^4$

$c = 20.8$

$F_y := 46 ksi$

$Zx := \frac{M_{h2}}{\phi_b \cdot F_{yy}}$ $\quad Zx = 0.754 \cdot in^3$ Required Zx

check := if$(Zx \le Z_x$,"OK" ,"Not OK"$)$ $\quad$ check = "OK"

$Zy := \frac{M_{h2y}}{F_{yy}}$ $\quad Zy = 0.641 \cdot in^3$ Required Zy

check := if$(Zy \le Z_y$,"OK" ,"Not OK"$)$ $\quad$ check = "OK"

$\lambda p := 1.12 \cdot \sqrt{\frac{E_s}{F_{yy}}}$ $\quad \lambda p = 28.121$

$\lambda r := 1.40 \cdot \sqrt{\frac{E_s}{F_{yy}}}$ $\quad \lambda r = 35.152$

$\lambda_{steel} := \frac{b_f}{t_f}$ $\quad \lambda_{steel} = 25.751$

check := | "Section is Compact" if $\lambda_{steel} \le \lambda p$
| "Section is non campact" if $\lambda_{steel} > \lambda p$
| "Section is slender" if $\lambda_{steel} > \lambda r$

check = "Section is Compact"

$Sx := \begin{cases} \frac{M_{h2}}{0.66 \cdot F_{yy}} & \text{if } \lambda_{steel} \le \lambda p \\ \frac{M_{h2}}{F_{yy}} & \text{if } \lambda_{steel} \end{cases}$ $\quad Sx = 0.679 \cdot in^3$

check := if$(Sx \le S_x$,"OK" ,"Not OK"$)$ $\quad$ check = "OK"

Check Torsional Capacity:

$$F_{cr} := \begin{cases} (0.6 \cdot F_{yy}) & \text{if } \frac{d}{t_f} \le 2.45 \cdot \sqrt{\frac{E_s}{F_{yy}}} \\ \dfrac{0.6 \cdot F_{yy} \cdot \left(2.45 \cdot \sqrt{\frac{E_s}{F_{yy}}}\right)}{\frac{d}{t_f}} & \text{if } 2.45 \cdot \sqrt{\frac{E_s}{F_{yy}}} < \frac{d}{t_f} \le 3.07 \cdot \sqrt{\frac{E_s}{F_{yy}}} \\ \dfrac{0.458 \cdot \pi^2 \cdot E_s}{\left(\frac{d}{t_f}\right)^2} & \text{if } 3.07 \cdot \sqrt{\frac{E_s}{F_{yy}}} < \frac{d}{t_f} \le 260 \end{cases}$$

$F_{cr} = 27.6 \cdot ksi$

$M_{nx} := Z_x \cdot F_{yy}$ $\quad M_{nx} = 64.783 \cdot k \cdot ft$ $\quad M_p := M_{nx}$

$$M_{nlt} := \begin{cases} \text{"Lateral Torsional buckling does not apply"} & \text{if } \lambda_{steel} \le \lambda p \\ \left[M_p - (M_p - F_{yy} \cdot S_x) \cdot \left(3.57 \cdot \frac{b_f}{t_f} \cdot \sqrt{\frac{F_{yy}}{E_s}} - 4.0\right)\right] & \text{if } \lambda_{steel} > \lambda p \\ (F_{cr} \cdot S_x) & \text{if } \lambda_{steel} > \lambda r \end{cases}$$

M_{nlt} = "Lateral Torsional buckling does not apply"

$M_{nx} := \min(M_{nx})$ $\quad M_{nx} = 64.783 \cdot k \cdot ft$

$M_{cx} := \phi_b \cdot M_{nx}$ $\quad M_{cx} = 58.305 \cdot k \cdot ft$

check := if($M_{cx} \ge M_{h1}$, "OK", "Not OK") $\quad$ check = "OK"

$M_{ny} := Z_y \cdot F_{yy}$ $\quad M_{ny} = 53.283 \cdot k \cdot ft$

$M_{cy} := \phi_b \cdot M_{ny}$ $\quad M_{cy} = 47.955 \cdot k \cdot ft$

check := if($M_{cy} \ge M_{h1y}$, "OK", "Not OK") $\quad$ check = "OK"

Check combined compression and bending capacity:

$P_n := F_{yy} \cdot A_g$ $\quad P_n = 283.82 \cdot k$ $\quad \phi_t := 0.9$ $\quad P_c := \phi_t \cdot P_n$ $\quad P_c = 255.438 \cdot k$ $\quad P_r := 0k$

$A_w := 2 \cdot (d - 3 \cdot t_f) \cdot t_f$ $\quad A_w = 3.402 \cdot in^2$ $\quad C_v := 1.0$ $\quad \phi_v := 1.0$

$V_n := 0.6 \cdot F_{yy} \cdot A_w \cdot C_v$ $\quad V_n = 93.903 \cdot k$ $\quad V_c := \phi_v \cdot V_n$ $\quad V_c = 93.903 \cdot k$

$$SF := \left(\frac{M_{h2}}{M_{cx}} + \frac{M_{h2y}}{M_{cy}}\right)$$

SF = 0.096 $\quad$ eq: H1

check := if(SF ≤ 1.0, "OK", "Not OK") $\quad$ check = "OK"

Check deflection:

$$\Delta_{h2} := \frac{5 \cdot w_{h2serv} \cdot L_{h2}^4}{384 \cdot E_s \cdot I_x}$$

$\Delta_{h2} = 0.015 \cdot in$

$\Delta allow := \frac{L_{h2}}{600}$ $\Delta allow = 0.16 \cdot in$ $\Delta_{max} := 0.3in$ $\Delta_{allow} := if(\Delta allow < \Delta_{max}, \Delta allow, \Delta_{max})$ $\Delta_{allow} = 0.16 \cdot in$

check := if($\Delta_{h2} < \Delta_{allow}$, "OK" , "Not OK") check = "OK"

Use HSS8x6x1/4 LLV, Header H2

Metal Stud Bearing:

$F_y := 33ksi$ $h_{st} := 15.33ft$ $a := 9.5ft$ $b := h_{st} - a$ $b = 5.83ft$ $V_{h1} = 2.277 \cdot k$ $V_{h1y} = 1075.055lbf$

$P_w = 20.988 \cdot psf$ $TL_{serv} = 48.2 \cdot psf$

using CSJ 6" 18 GA. metal studs spaced @ 16" o.c.:

$I_x := 2.316in^4$ $S_x := 0.772in^3$ $A := 0.447in^2$ $M_{allow} := 16764in \cdot (lbf)$

$P_{ax} := \frac{w_{h2} \cdot L_{h2}}{2}$ $P_{ax} = 1.301 \cdot k$

$P_{allow} = 3.23 \cdot k$ $P_{allow} = 3.23 \cdot k$ allowable axial load for 2 studs

check := if($P_{allow} > P_{ax}$, "OK" , "NOT OK") check = "OK"

$M_{stud} := \frac{V_{h2y} \cdot a \cdot b}{h_{st}}$ $M_{stud} = 26.633 \cdot k \cdot in$

check := if($M_{allow} \cdot 2 > M_{stud}$, "OK" , "NOT OK") check = "OK"

STEEL BEAM DESIGN:

Beam "B1" Outrigger (H1 support):

$L_{b1} := 18in$ $F_{yy} := 46ksi$ $w_b := 18.99plf$ $\phi_b := 0.90$

$w_{u1} := 1.2 \cdot w_b$ $w_{u1} = 22.788 \cdot plf$

$w_{u1serv} := w_b$ $w_{u1serv} = 18.99 \cdot plf$

$V_{u1} := w_{u1} \cdot L_{b1} + V_{h1} \cdot 2$ $V_{u1} = 4.589 \cdot k$

$V_{u1serv} := w_{u1serv} \cdot L_{b1} + V_{h1serv} \cdot 2$ $V_{u1serv} = 3.656 \cdot k$

$M_{u1} := \frac{w_{u1} \cdot L_{b1}^2}{2} + V_{h1} \cdot 2 \cdot L_{b1}$ $M_{u1} = 6.857 \cdot k \cdot ft$

$\begin{pmatrix} I_x \\ d \\ t_w \\ t_f \\ b_f \\ A_g \\ w_b \\ r_y \\ r_{ts} \\ Z_x \\ Z_y \\ C_w \\ S_x \\ S_y \\ I_y \\ J \\ b_T \\ h_T \\ c \end{pmatrix} :=$

Beam Section

Section :	HSS9X5X1/4		*Chosen from dropdown of AISC Shapes*
I =	66.1	in^4	*lookup from AISC table1-1*
d =	9.0	in	*lookup from AISC table1-1*
t_w =	0.233	in	*lookup from AISC table1-1*
tf =	0.233	in	*lookup from AISC table1-1*
bf =	5.000	in	*lookup from AISC table1-2*
Ag =	6.170	in^2	*lookup from AISC table1-2*
Wb	22.389	plf	*lookup from AISC table1-3*
r_y =	2.08	in	
r_{ts} =	0.42	in	*Table 1, eq. 9.6.7*
Zx Provided =	18.1		*from AISC table 3-2 lookup, change to small*
Zy Provided =	12.0		
C_w =	0.25	in^6	
S_x =	14.70	in^3	
Sy =	10.60	in^3	
I_y =	26.60	in^4	
J =	61.20	in^4	
b/t=	18.50		
h/t	35.60		
c =	19.4	in^3	
E =	29000	ksi	*Steel Modulus*
F_y =	46	ksi	*AISC 14th ed. HSS Sections*

$I_x := I_x \cdot in^4$ $\quad I_x = 66.1 \cdot in^4$

$d := d \cdot in$ $\quad d = 9 \cdot in$

$t_w := t_w \cdot in$ $\quad t_w = 0.233 \cdot in$

$t_f := t_f \cdot in$ $\quad t_f = 0.233 \cdot in$

$b_f := b_f \cdot in$ $\quad b_f = 5 \cdot in$

$A_g := A_g \cdot in^2$ $\quad A_g = 0.043 ft^2$

$r_y := r_y \cdot in$ $\quad r_y = 2.08 \cdot in$

$r_{ts} := r_{ts} \cdot in$ $\quad r_{ts} = 0.419 \cdot in$

$Z_x := Z_x \cdot in^3$ $\quad Z_x = 18.1 \cdot in^3$

$Z_y := Z_y \cdot in^3$ $\quad Z_y = 12 \cdot in^3$

$C_w := C_w \cdot in^6$ $\quad C_w = 0.25 \cdot in^6$

$S_x := S_x \cdot in^3$ $\quad S_x = 14.7 \cdot in^3$

$S_y := S_y \cdot in^3$ $\quad S_y = 10.6 \cdot in^3$

$I_y := I_y \cdot in^4$ $\quad I_y = 26.6 \cdot in^4$

$J := J \cdot in^4$ $\quad J = 61.2 \cdot in^4$

$c = 19.4$

$F_y := 46 ksi$

$$Zx := \frac{M_{u1}}{\phi_b \cdot F_{yy}}$$ $Zx = 1.988 \cdot in^3$ Required Zx

check := if($Zx \le Z_x$, "OK", "Not OK") $\quad$ check = "OK"

$\lambda p := 1.12 \cdot \sqrt{\frac{E_s}{F_{yy}}}$ $\quad \lambda p = 28.121$ $\quad \lambda r := 1.40 \cdot \sqrt{\frac{E_s}{F_{yy}}}$ $\quad \lambda r = 35.152$ $\quad \lambda steel := \frac{b_f}{t_f}$ $\quad \lambda steel = 21.459$

check :=
- "Section is Compact" if $\lambda steel \le \lambda p$
- "Section is non campact" if $\lambda steel > \lambda p$
- "Section is slender" if $\lambda steel > \lambda r$

check = "Section is Compact"

$$Sx := \begin{cases} \frac{M_{u1}}{0.66 \cdot F_{yy}} & \text{if } \lambda steel \le \lambda p \\ \frac{M_{u1}}{F_{yy}} & \text{if } \lambda steel > \lambda p \end{cases}$$

$Sx = 2.71 \cdot in^3$

check := if($Sx \le S_x$, "OK", "Not OK") $\quad$ check = "OK"

$$F_{cr} := \begin{cases} (0.6 \cdot F_{yy}) & \text{if } \frac{d}{t_f} \le 2.45 \cdot \sqrt{\frac{E_s}{F_{yy}}} \\ \frac{0.6 \cdot F_{yy} \cdot \left(2.45 \cdot \sqrt{\frac{E_s}{F_{yy}}}\right)}{\frac{d}{t_f}} & \text{if } 2.45 \cdot \sqrt{\frac{E_s}{F_{yy}}} < \frac{d}{t_f} \le 3.07 \cdot \sqrt{\frac{E_s}{F_{yy}}} \\ \frac{0.458 \cdot \pi^2 \cdot E_s}{\left(\frac{d}{t_f}\right)^2} & \text{if } 3.07 \cdot \sqrt{\frac{E_s}{F_{yy}}} < \frac{d}{t_f} \le 260 \end{cases}$$

$F_{cr} = 27.6 \cdot ksi$

$M_{nx} := Z_x \cdot F_{yy}$ $\quad M_{nx} = 69.383 \cdot k \cdot ft$ $\quad M_p := M_{nx}$

$M_{nlt} :=$ | "Lateral Torsional buckling does not apply" if $\lambda_{steel} \le \lambda p$
| $\left[M_p - (M_p - F_{yy} \cdot S_x) \cdot \left(3.57 \cdot \frac{b_f}{t_f} \cdot \sqrt{\frac{F_{yy}}{E_s}} - 4.0\right)\right]$ if $\lambda_{steel} > \lambda p$
| $(F_{cr} \cdot S_x)$ if $\lambda_{steel} > \lambda r$

$M_{nlt} =$ "Lateral Torsional buckling does not apply"

$M_{nx} := \min(M_{nx})$ $\qquad M_{nx} = 69.383 \cdot k \cdot ft$

$M_{cx} := \phi_b \cdot M_{nx}$ $\qquad M_{cx} = 62.445 \cdot k \cdot ft$

check := if($M_{cx} \ge M_{u1}$, "OK" , "Not OK") $\qquad$ check = "OK"

Check deflection:

$$\Delta_1 := \frac{5 \cdot w_{u1serv} \cdot L_{b1}^4}{384 \cdot E_s \cdot I_x} + \frac{V_{h1serv} \cdot 2 \cdot L_{b1}^3}{3 \cdot E_s \cdot I_x} \qquad \Delta_1 = 0.004 \cdot in$$

$$\Delta allow := \frac{L_{b1}}{360} \qquad \Delta allow = 0.05 \cdot in$$

check := if($\Delta_1 < \Delta allow$, "OK" , "Not OK") $\qquad$ check = "OK"

Use HSS9x5x1/4 LLV, Beam B1

Beam "B2" over front openings:

$L_{b2} := 14.0 ft$ $\qquad h_m := 9.33 ft$ $\qquad F_y := 50 ksi$ $\qquad w_b := 26 plf$ $\qquad \phi_b := 0.90$

$$w_{u2} := TL \cdot \left(\frac{S_j}{2}\right) + 1.2 \cdot w_m \cdot h_m + 1.2 \cdot w_b \qquad w_{u2} = 720.3 \cdot plf$$

$$w_{u2serv} := TL_{serv} \cdot \left(\frac{S_j}{2}\right) + w_m \cdot h_m + w_b \qquad w_{u2serv} = 590.45 \cdot plf$$

$$V_{u2} := \frac{w_{u2} \cdot L_{b2}}{2} \qquad V_{u2} = 5.042 \cdot k$$

$$M_{u2} := \frac{w_{u2} \cdot L_{b2}^2}{8} \qquad M_{u2} = 17.647 \cdot ft \cdot k$$

$\begin{pmatrix} I_x \\ d \\ t_w \\ t_f \\ b_f \\ A_g \\ w_b \\ A_w \\ r_y \\ r_{ts} \\ Z_x \\ Z_y \\ C_w \\ S_x \\ S_y \\ I_y \\ J \\ h_o \\ bf2tf \\ k_b \end{pmatrix} :=$

Beam Section

Section :	W16X26		*Chosen from dropdown of AISC Shapes*
I =	301.0	in^4	*lookup from AISC table1-1*
d =	15.7	in	*lookup from AISC table1-1*
t_w =	0.250	in	*lookup from AISC table1-1*
tf =	0.345	in	*lookup from AISC table1-1*
bf =	5.500	in	*lookup from AISC table1-2*
Ag =	7.680	in^2	*lookup from AISC table1-2*
wb=	26	plf	
A_w =	3.9	in^2	*d x tw*
r_y =	1.12	in	
r_{ts} =	1.38	in	*Table 1, eq. 9.6.7*
Zx Provided =	44.2		*from AISC table 3-2 lookup, change to smaller section j*
Zy Provided =	5.5		
C_w =	565.00	in^6	
S_x =	38.40	in^3	
Sy =	3.49	in^3	
I_y =	9.59	in^4	
J =	0.26	in^4	
h_o =	15.36	in	Table 1
$b_f/2_{tf}$ =	7.97		Table 1
kb =	0.747	in	k.des
c =	1		1.0 for I-Shape
E =	29000	ksi	*Steel Modulus*
F_y =	50	ksi	*AISC 14th ed. Assumes Rolled Shapes are 5*

$I_x := I_x \cdot in^4$ $I_x = 301 \cdot in^4$ $A_w := A_w \cdot in^2$ $A_w = 3.925 \cdot in^2$ $S_x := S_x \cdot in^3$ $S_x = 38.4 \cdot in^3$

$d := d \cdot in$ $d = 15.7 \cdot in$ $S_y := S_y \cdot in^3$ $S_y = 3.49 \cdot in^3$

$t_w := t_w \cdot in$ $t_w = 0.25 \cdot in$ $r_y := r_y \cdot in$ $r_y = 1.12 \cdot in$ $I_y := I_y \cdot in^4$ $J = 0.262$

$t_f := t_f \cdot in$ $t_f = 0.345 \cdot in$ $r_{ts} := r_{ts} \cdot in$ $r_{ts} = 1.385 \cdot in$ $J := J \cdot in^4$ $h_o = 15.355$

$b_f := b_f \cdot in$ $b_f = 5.5 \cdot in$ $Z_x := Z_x \cdot in^3$ $Z_x = 44.2 \cdot in^3$ $h_o := h_o \cdot in$ $h_o = 15.355 \cdot in$

$A_g := A_g \cdot in^2$ $A_g = 7.68 \cdot in^2$ $Z_y := Z_y \cdot in^3$ $Z_y = 5.48 \cdot in^3$ $k_b := k_b \cdot in$ $k_b = 0.062 ft$

$k_b = 0.062 ft$

$c := 1$

$F_y := 50 ksi$ $C_b := 1.0$ $P_c := 131 k$ $\phi v := 1.0$

$Zx := \frac{M_{u2}}{\phi_b \cdot F_y}$ $Zx = 4.706 \cdot in^3$ Required Zx

check := if($Zx \le Z_x$, "OK", "Not OK") check = "OK"

$\lambda p := 0.38 \cdot \sqrt{\frac{E_s}{F_y}}$ $\lambda p = 9.152$ $\lambda r := 1.0 \cdot \sqrt{\frac{E_s}{F_y}}$ $\lambda r = 24.083$ $\lambda_{steel} := \frac{b_f \cdot 0.5}{t_f}$ $\lambda_{steel} = 7.971$

check := | "Section is Compact" if $\lambda_{steel} \le \lambda p$
| "Section is non campact" if $\lambda_{steel} > \lambda p$
| "Section is slender" if $\lambda_{steel} > \lambda r$

check = "Section is Compact"

$$Sx := \begin{cases} \frac{M_{u2}}{0.66 \cdot F_y} & \text{if } \lambda_{steel} \le \lambda p \\ \frac{M_{u2}}{F_y} & \text{if } \lambda_{steel} > \lambda p \end{cases}$$

$Sx = 6.417 \cdot in^3$

check := if($Sx \le S_x$, "OK", "Not OK") check = "OK"

$M_{nx} := Z_x \cdot F_y$ $M_{nx} = 184.167 \cdot k \cdot ft$ $M_p := M_{nx}$

$L_p := 3.96 ft$ $L_r := 11.2 ft$ $r_{ts} := 1.38 in$ $\phi_T := 0.9$ $P_r := 0k$

$$F_{cr} := \frac{C_b \cdot \pi^2 \cdot E_s}{\left(\frac{L_{b2}}{r_{ts}}\right)^2} \cdot \sqrt{1 + 0.078 \cdot \frac{J \cdot c}{S_x \cdot h_o} \cdot \left(\frac{L_{b2}}{r_{ts}}\right)^2}$$

$F_{cr} = 23.76 \cdot ksi$

$$M_{nlt} := \begin{cases} \text{"Lateral Torsional buckling does not apply"} & \text{if } L_{b2} \le L_p \\ \left[C_b \cdot \left[M_p - \left(M_p - 0.7 \cdot F_y \cdot S_x\right) \cdot \left(\frac{L_{b2} - L_p}{L_r - L_p}\right)\right]\right] & \text{if } L_p < L_{b2} \le L_r \\ \left(F_{cr} \cdot S_x\right) & \text{if } L_{b2} > L_r \end{cases}$$

$M_{nlt} = 76.033 \cdot k \cdot ft$

$M_{nx} := \min(M_{nx}, M_{nlt})$ $M_{nx} = 76.033 \cdot k \cdot ft$

$M_{cx} := \phi_b \cdot M_{nx}$ $M_{cx} = 68.43 \cdot k \cdot ft$

check := if($M_{cx} \ge M_{u2}$, "OK", "Not OK") check = "OK"

Check deflection:

$$\Delta_2 := \frac{5 \cdot w_{u2serv} \cdot L_{b2}^4}{384 \cdot E_s \cdot I_x}$$ $\Delta_2 = 0.058 \cdot in$

$\Delta allow := \frac{L_{b2}}{600}$ $\Delta allow = 0.28 \cdot in$ $\Delta_{max} := 0.3in$ $\Delta allow := if(\Delta allow < \Delta_{max}, \Delta allow, \Delta_{max})$ $\Delta allow = 0.28 \cdot in$

check := if($\Delta_2 < \Delta_{allow}$, "OK", "Not OK") check = "OK"

Stiffener Check:

$htw := 56.8$ $kv := 5$ web plate buckling coefficient, for unstiffened webs

$a := 16in$ distance between stiffeners $h := 13.625in$ $kvs := 5 + \frac{5}{\left(\frac{a}{h}\right)^2}$ $kvs = 8.626$ for stiffened webs

$$Cv := \begin{cases} 1.0 & \text{if } htw \le 2.24 \cdot \sqrt{\frac{E_s}{F_y}} \\ 1.0 & \text{if } htw \le 1.1 \cdot \sqrt{\frac{kv \cdot E_s}{F_y}} \\ \frac{1.1 \cdot \sqrt{\frac{kv \cdot E_s}{F_y}}}{htw} & \text{if } 1.1 \cdot \sqrt{\frac{kv \cdot E_s}{F_y}} < htw \le 1.37 \cdot \sqrt{\frac{kv \cdot E_s}{F_y}} \\ \frac{1.51 \cdot E_s \cdot kv}{htw^2 \cdot F_y} & \text{if } htw > 1.37 \cdot \sqrt{\frac{kv \cdot E_s}{F_y}} \end{cases}$$

$Cv = 1$

$V_n := 0.6 \cdot F_y \cdot A_w \cdot Cv$ $V_n = 117.75 \cdot k$

check := if($V_n \ge V_{u2}$, "OK", "need web stiffeners") check = "OK"

Use W16x26, A992 Beam B2

Column "C1" Design:

$P_{ult} := V_{u1} + V_{u2} \cdot 2$ $\quad P_{ult} = 14.673 \cdot k \quad P_r := P_{ult} \quad P_r = 14.673 \cdot k$

$\phi cPn := 115k$ on HSS 5x5x1/4 at 13'-0" high column $\quad P_c := \phi cPn \quad P_c = 115 \cdot k$

$check := if(P_{ult} \le \phi cPn, \text{"OK"}, \text{"Not OK"})$ $\quad check = \text{"OK"}$

Use HSS 5x5x1/4 columns

$L_{C1} := 13.33ft \quad \phi_b := 0.90 \quad b_f := 5in \quad F_{yy} := 46ksi$

Try HSS5x5x1/4 $\quad d := 5in \quad t_w := 0.233in \quad S_y := 6.41in^3 \quad t_f := 0.233in \quad I_x := 16.0in^4 \quad S_x := 6.41in^3 \quad Z_x := 7.61in^3$

$I_y := 16.0in^4 \quad Aw := d \cdot t_w \quad Aw = 1.165 \cdot in^2 \quad \phi v := 1.0 \quad r_y := 1.93in \quad b_T := 18.5 \quad J := 25.8in^4 \quad C := 10.5in^3$

$c := 1.0 \quad C_b := 1.0 \quad Z_y := 7.61in^3 \quad h_T := 18.5 \quad A_g := 4.30in^2$

$$M_C := \frac{V_{h1y} \cdot 4ft \cdot 9.33ft \cdot 2}{h_w} + M_{u1} \qquad M_C = 12.877 \cdot k \cdot ft$$

$$\lambda p := 1.12 \cdot \sqrt{\frac{E_s}{F_{yy}}} \quad \lambda p = 28.121 \qquad \lambda r := 1.40 \cdot \sqrt{\frac{E_s}{F_{yy}}} \quad \lambda r = 35.152 \qquad \lambda steel := \frac{b_f}{t_f} \quad \lambda steel = 21.459$$

$$check := \begin{cases} \text{"Section is Compact"} & \text{if } \lambda steel \le \lambda p \\ \text{"Section is non campact"} & \text{if } \lambda steel > \lambda p \\ \text{"Section is slender"} & \text{if } \lambda steel > \lambda r \end{cases} \qquad check = \text{"Section is Compact"}$$

$$Sx := \begin{cases} \dfrac{M_C}{0.66 \cdot F_{yy}} & \text{if } \lambda steel \le \lambda p \\ \dfrac{M_C}{F_{yy}} & \text{if } \lambda steel > \lambda p \end{cases} \qquad Sx = 5.09 \cdot in^3$$

$check := if(Sx \le S_x, \text{"OK"}, \text{"Not OK"})$ $\quad check = \text{"OK"}$

$M_{nx} := Z_x \cdot F_{yy} \quad M_{nx} = 29.172 \cdot k \cdot ft \quad M_p := M_{nx}$

Check Torsional Capacity:

$$F_{cr} := \begin{cases} (0.6 \cdot F_{yy}) & \text{if } \frac{d}{t_f} \le 2.45 \cdot \sqrt{\frac{E_s}{F_{yy}}} \\ \dfrac{0.6 \cdot F_{yy} \cdot \left(2.45 \cdot \sqrt{\frac{E_s}{F_{yy}}}\right)}{\frac{d}{t_f}} & \text{if } 2.45 \cdot \sqrt{\frac{E_s}{F_{yy}}} < \frac{d}{t_f} \le 3.07 \cdot \sqrt{\frac{E_s}{F_{yy}}} \\ \dfrac{0.458 \cdot \pi^2 \cdot E_s}{\left(\frac{d}{t_f}\right)^2} & \text{if } 3.07 \cdot \sqrt{\frac{E_s}{F_{yy}}} < \frac{d}{t_f} \le 260 \end{cases}$$

$F_{cr} = 27.6 \cdot ksi$

$$M_{nlt} := \begin{cases} \text{"Lateral Torsional buckling does not apply"} & \text{if } \lambda_{steel} \le \lambda p \\ \left[M_p - (M_p - F_{yy} \cdot S_x) \cdot \left(3.57 \cdot \frac{b_f}{t_f} \cdot \sqrt{\frac{F_{yy}}{E_s}} - 4.0\right)\right] & \text{if } \lambda_{steel} > \lambda p \\ (F_{cr} \cdot S_x) & \text{if } \lambda_{steel} > \lambda r \end{cases}$$

$M_{nlt} =$ "Lateral Torsional buckling does not apply"

$M_{nx} := \min(M_{nx})$ $M_{nx} = 29.172 \cdot k \cdot ft$

$M_{cx} := \phi_b \cdot M_{nx}$ $M_{cx} = 26.255 \cdot k \cdot ft$

check := if($M_{cx} \ge M_C$, "OK" , "Not OK") check = "OK"

$A_w := 2 \cdot (d - 3 \cdot t_f) \cdot t_f$ $A_w = 2.004 \cdot in^2$ $C_v := 1.0$ $\phi_v := 1.0$

$V_n := 0.6 \cdot F_y \cdot A_w \cdot C_v$ $V_n = 60.128 \cdot k$ $V_c := \phi_v \cdot V_n$ $V_c = 60.128 \cdot k$

Check combined compression and bending capacity:

$$SF := \begin{cases} \left[\frac{P_r}{P_c} + \frac{8}{9} \cdot \left(\frac{M_C}{M_{cx}}\right)\right] & \text{if } \frac{P_r}{P_c} \ge 0.2 \\ \left[\frac{P_r}{2 \cdot P_c} + \left(\frac{M_C}{M_{cx}}\right)\right] & \text{if } \frac{P_r}{P_c} < 0.2 \end{cases}$$

$SF = 0.554$

check := if($SF \le 1.0$, "OK" , "Not OK") check = "OK"

Use HSS 5x5x1/4 for column

Column Base Plate A:

$d_c := 5in$ $b_f := 5in$ $N := 12in$ $B := 12in$ $F_y := 36ksi$

$$m := \frac{N - 0.95 \cdot d_c}{2}$$ $m = 3.625 \cdot in$

$$n := \frac{B - 0.8 \cdot b_f}{2}$$ $n = 4 \cdot in$

$np := \frac{\sqrt{d_c \cdot b_f}}{4}$ $np = 1.25 \cdot in$

$X := \left[\frac{4 \cdot d_c \cdot b_f}{(d_c + b_f)^2}\right] \cdot \frac{P_{ult}}{\phi cPn}$ $X = 0.128$

$\lambda_{plate} := \frac{2 \cdot \sqrt{X}}{1 + \sqrt{1 - X}}$ $\lambda_{plate} = 0.369$

$\lambda n := \lambda_{plate} \cdot np$ $\lambda n = 0.462 \cdot in$

$l := \max(m, n, \lambda n)$ $l = 4 \cdot in$

$t_p := l \cdot \sqrt{\frac{2 \cdot P_{ult}}{0.9 \cdot F_y \cdot B \cdot N}}$ $t_p = 0.317 \cdot in$

Use 3/4"x12"x12" column base plate A

Column "C1" Footing Design:

$SBC := 2000psf$ $f_c := 3000psi$ $\phi := 0.75$ $f_y := 60ksi$ $\beta_1 := 0.85$ $m := 5in$

$P_{serv} := w_{u1serv} \cdot L_{b1} + V_{h1serv} \cdot 2 + \frac{w_{u2serv} \cdot L_{b2}}{2} \cdot 2$ $P_{serv} = 11.923 \cdot k$

$P_{ult} := w_{u1} \cdot L_{b1} + V_{h1} \cdot 2 + V_{u2} \cdot 2$ $P_{ult} = 14.673 \cdot k$

$Areq := \frac{P_{serv}}{SBC}$ $Areq = 5.961 ft^2$ $L := \sqrt{Areq}$ $L = 2.442ft$ say $L := 4.0ft$ $D := 1ft$

Try 4'-0" x 4'-0" x 1'-0" $d := D - 3in$ $d = 9 \cdot in$

check for punching shear:

$qu := \frac{P_{ult}}{L \cdot L}$ $qu = 917.055 \cdot psf$

$b_o := 4 \cdot (b_f + m + D)$ $b_o = 7.333ft$

$V_u := P_{ult} - qu \cdot (N + m + d)^2$ $V_u = 10.368 \cdot k$

$\phi V_c := 4 \cdot \phi \cdot d \cdot b_o \cdot \sqrt{\frac{f_c}{psi}} \cdot psi$ $\phi V_c = 130.139 \cdot k$

check := if($\phi V_c > V_u$, "OK" ,"Not OK") check = "OK"

check for flexural shear:

$x := \frac{L}{2} - \frac{b_f}{2} - \frac{n}{2} - d$ $x = 0.875ft$

$V_u := qu \cdot L \cdot x$ $V_u = 3.21 \cdot k$

$\phi V_c := 2 \cdot \phi \cdot L \cdot d \cdot \sqrt{\frac{f_c}{psi}} \cdot psi$ $\phi V_c = 35.492 \cdot k$

check := if($\phi V_c > V_u$, "OK" , "Not OK") check = "OK"

check for flexure:

$$M_u := \frac{qu \cdot L \cdot \left(\frac{L}{2} - \frac{b_f}{2} - \frac{n}{2}\right)^2}{2}$$ $M_u = 4.843 \cdot k \cdot ft$

Assume a tension controlled section:

$$\rho := \frac{0.85 \cdot f_c \cdot \left(1 - \sqrt{1 - \frac{M_u}{0.383 \cdot L \cdot d^2 \cdot f_c}}\right)}{f_y}$$ $\rho = 0.0003$

$\rho_t := 0.319 \cdot \beta_1 \cdot \frac{f_c}{f_y}$ $\rho_t = 0.014$

check := if($\rho_t > \rho$, "Section is tension controlled" , "Section is not tension controlled")

check = "Section is tension controlled"

$A_s := \rho \cdot L \cdot d$ $A_s = 0.12 \cdot in^2$ $A_5 := 0.31 in^2$ $d_b := 0.625 in$ $n_b := 5$ $f_c := 3000 psi$

$A_{sact} := n_b \cdot A_5$ $A_{sact} = 1.55 \cdot in^2$

check := if($A_{sact} \geq A_s$, "OK" , "Not OK") check = "OK"

$A_{smin} := 0.0018 \cdot L \cdot D$ $A_{smin} = 1.037 \cdot in^2$

check := if($A_{sact} \geq A_{smin}$, "OK" , "Not OK") check = "OK"

$A_{sratio} := \frac{A_{smin}}{A_{sact}}$ $A_{sratio} = 0.669$

$$l_d := \frac{0.075 \cdot 0.8 \cdot d_b \cdot f_y}{2.5 \cdot \sqrt{\frac{f_c}{psi}} \cdot psi} \cdot A_{sratio}$$ $l_d = 0.916 ft$

$l_a := \frac{L}{2} - \frac{b_f}{2} - 3in$ $l_a = 1.542 ft$

check := if($l_a \geq l_d$, "OK" , "Not OK") check = "OK"

Use 4'-0" x 4'-0" x 1'-0" w/ 5-#5 LWB

Beam "B3" over vestibule entrance (front):

$L_{b3} := 4.67 ft$ $h_m := 3.58 ft$ $w_m = 45 \cdot psf$ $F_y := 50 ksi$ $w_b := 15 plf$ $\phi_b := 0.90$

$w_{u3} := TL \cdot \left(\frac{S_j}{2} + 4ft\right) + 1.2 \cdot w_m \cdot h_m + 1.2 \cdot w_b$ $\qquad w_{u3} = 643.64 \cdot plf$

$w_{u3serv} := TL_{serv} \cdot \left(\frac{S_j}{2} + 4ft\right) + w_m \cdot h_m + w_b$ $\qquad w_{u3serv} = 513.5 \cdot plf$

$V_{u3} := \frac{w_{u3} \cdot L_{b3}}{2}$ $\qquad V_{u3} = 1.503 \cdot k$

$M_{u3} := \frac{w_{u3} \cdot L_{b3}^{\ 2}}{8}$ $\qquad M_{u3} = 1.755 \cdot ft \cdot k$

$P_{wu} = 69.193 \cdot psf$ $\qquad P_{max} = 51.193 \cdot psf$

$V_{u3y} := \frac{(P_{max} \cdot 4ft \cdot L_{b3})}{2}$ $\qquad V_{u3y} = 0.478 \cdot k$

$M_{b3y} := \frac{(P_{max} \cdot 4ft \cdot L_{b3}) \cdot L_{b3}}{4}$ $\qquad M_{b3y} = 1.116 \cdot k \cdot ft$

$\begin{pmatrix} I_x \\ d \\ t_w \\ t_f \\ b_f \\ A_g \\ w_b \\ A_w \\ r_y \\ r_{ts} \\ Z_x \\ Z_y \\ C_w \\ S_x \\ S_y \\ I_y \\ J \\ h_o \\ bf2tf \\ k_b \end{pmatrix} :=$

Beam Section

Section :	W8X15		*Chosen from dropdown of AISC Shapes*
I =	48.0	in^4	*lookup from AISC table1-1*
d =	8.1	in	*lookup from AISC table1-1*
t_w =	0.245	in	*lookup from AISC table1-1*
tf =	0.315	in	*lookup from AISC table1-1*
bf =	4.010	in	*lookup from AISC table1-2*
Ag =	4.440	in^2	*lookup from AISC table1-2*
wb=	15	plf	
A_w =	2.0	in^2	*d x tw*
r_y =	0.88	in	
r_{ts} =	1.06	in	*Table 1, eq. 9.6.7*
Zx Provided =	13.6		*from AISC table 3-2 lookup, change to smaller section j*
Zy Provided =	2.7		

C_w =	51.80	in^6		
S_x =	11.80	in^3		
Sy =	1.70	in^3		
I_y =	3.41	in^4		
J =	0.14	in^4		
h_o =	7.80	in	Table 1	
$b_f/2_{tf}$ =	6.37		Table 1	
kb =	0.615	in	k.des	
c =	1	1.0 for I-Shape		
E =	29000	ksi		*Steel Modulus*
F_y =	50	ksi		*AISC 14th ed. Assumes Rolled Shapes are 5*

$I_x := I_x \cdot in^4$ $\quad I_x = 48 \cdot in^4$ $\quad A_w := A_w \cdot in^2$ $\quad A_w = 0.014 ft^2$ $\quad S_x := S_x \cdot in^3$ $\quad S_x = 11.8 \cdot in^3$

$d := d \cdot in$ $\quad d = 8.11 \cdot in$ $\quad r_y := r_y \cdot in$ $\quad r_y = 0.876 \cdot in$ $\quad S_y := S_y \cdot in^3$ $\quad S_y = 1.7 \cdot in^3$

$t_w := t_w \cdot in$ $\quad t_w = 0.245 \cdot in$ $\quad I_y := I_y \cdot in^4$ $\quad J = 0.137$

$t_f := t_f \cdot in$ $\quad t_f = 0.315 \cdot in$ $\quad r_{ts} := r_{ts} \cdot in$ $\quad r_{ts} = 1.061 \cdot in$ $\quad h_o = 7.795$

$b_f := b_f \cdot in$ $\quad b_f = 4.01 \cdot in$ $\quad Z_x := Z_x \cdot in^3$ $\quad Z_x = 13.6 \cdot in^3$ $\quad J := J \cdot in^4$

$A_g := A_g \cdot in^2$ $\quad A_g = 4.44 \cdot in^2$ $\quad h_o := h_o \cdot in$ $\quad h_o = 7.795 \cdot in$

$Z_y := Z_y \cdot in^3$ $\quad Z_y = 2.67 \cdot in^3$ $\quad k_b := k_b \cdot in$ $\quad k_b = 0.051 ft$

$k_b = 0.051 ft$

$c := 1$

$F_y := 50 ksi$ $\quad C_b := 1.0$ $\quad P_c := 68k$ $\quad \phi v := 1.0$

$$Zx := \frac{M_{u3}}{\phi b \cdot F_y}$$ $Zx = 0.468 \cdot in^3$ Required Zx

check := if$(Zx \le Z_x$, "OK" , "Not OK"$)$ $\quad$ check = "OK"

$$Zy := \frac{M_{b3y}}{\phi b \cdot F_y}$$ $Zy = 0.298 \cdot in^3$ Required Zy

check := if$(Zy \le Z_y$, "OK" , "Not OK"$)$ $\quad$ check = "OK"

$\lambda p := 0.38 \cdot \sqrt{\frac{E_s}{F_y}}$ $\quad \lambda p = 9.152$ $\quad \lambda r := 1.0 \cdot \sqrt{\frac{E_s}{F_y}}$ $\quad \lambda r = 24.083$ $\quad \lambda_{steel} := \frac{b_f \cdot 0.5}{t_f}$ $\quad \lambda_{steel} = 6.365$

check := | "Section is Compact" if $\lambda_{steel} \le \lambda p$
| "Section is non campact" if $\lambda_{steel} > \lambda p$
| "Section is slender" if $\lambda_{steel} > \lambda r$

check = "Section is Compact"

$$S_x := \begin{cases} \dfrac{M_{u3}}{0.66 \cdot F_y} & \text{if } \lambda_{steel} \le \lambda p \\ \dfrac{M_{u3}}{F_y} & \text{if } \lambda_{steel} > \lambda p \end{cases}$$

$S_x = 0.638 \cdot in^3$

check := if($S_x \le S_x$, "OK" , "Not OK") check = "OK"

$M_{nx} := Z_x \cdot F_y$ $M_{nx} = 56.667 \cdot k \cdot ft$ $M_p := M_{nx}$

$L_p := 3.09ft$ $L_r := 10.0ft$ $r_{ts} := 1.06in$ $\phi_T := 0.9$ $P_r := 0k$

$$F_{cr} := \frac{C_b \cdot \pi^2 \cdot E_s}{\left(\frac{L_{b3}}{r_{ts}}\right)^2} \cdot \sqrt{1 + 0.078 \cdot \frac{J \cdot c}{S_x \cdot h_o} \cdot \left(\frac{L_{b3}}{r_{ts}}\right)^2}$$

$F_{cr} = 117.862 \cdot ksi$

$$M_{nlt} := \begin{cases} \text{"Lateral Torsional buckling does not apply"} & \text{if } L_{b3} \le L_p \\ \left[C_b \cdot \left[M_p - \left(M_p - 0.7 \cdot F_y \cdot S_x\right) \cdot \left(\frac{L_{b3} - L_p}{L_r - L_p}\right)\right]\right] & \text{if } L_p < L_{b3} \le L_r \\ \left(F_{cr} \cdot S_x\right) & \text{if } L_{b3} > L_r \end{cases}$$

$M_{nlt} = 51.579 \cdot k \cdot ft$

$M_{nx} := \min(M_{nx}, M_{nlt})$ $M_{nx} = 51.579 \cdot k \cdot ft$

$M_{cx} := \phi_b \cdot M_{nx}$ $M_{cx} = 46.421 \cdot k \cdot ft$

check := if($M_{cx} \ge M_{u3}$, "OK" , "Not OK") check = "OK"

$M_{ny} := Z_y \cdot F_y$ $M_{ny} = 11.125 \cdot k \cdot ft$

$M_{cy} := \phi_b \cdot M_{ny}$ $M_{cy} = 10.012 \cdot k \cdot ft$

check := if($M_{cy} \ge M_{b3y}$, "OK" , "Not OK") check = "OK"

Check combined compression and bending capacity:

$$SF := \begin{cases} \left[\frac{P_r}{P_c} + \frac{8}{9} \cdot \left(\frac{M_{u3}}{M_{cx}} + \frac{M_{b3y}}{M_{cy}}\right)\right] & \text{if } \frac{P_r}{P_c} \ge 0.2 \\ \left[\frac{P_r}{2 \cdot P_c} + \left(\frac{M_{u3}}{M_{cx}} + \frac{M_{b3y}}{M_{cy}}\right)\right] & \text{if } \frac{P_r}{P_c} < 0.2 \end{cases}$$

$SF = 0.149$

check := if($SF \le 1.0$, "OK" , "Not OK") check = "OK"

$$\Delta_3 := \frac{5 \cdot w_{u3} \cdot L_{b3}^4}{384 \cdot E_s \cdot I_x}$$

$\Delta_3 = 0.005 \cdot in$

$\Delta allow := \frac{L_{b3}}{600}$ $\Delta allow = 0.093 \cdot in$ $\Delta_{max} := 0.3in$ $\Delta_{allow} := if(\Delta allow < \Delta_{max}, \Delta allow, \Delta_{max})$ $\Delta_{allow} = 0.093 \cdot in$

$check := if(\Delta_3 < \Delta_{allow}, \text{"OK"}, \text{"Not OK"})$ $check = \text{"OK"}$

$htw := 28.1$ $kv := 5$ web plate buckling coefficient, for unstiffened webs

$a := 16in$ distance between stiffeners $h := 6.5in$ $kvs := 5 + \frac{5}{\left(\frac{a}{h}\right)^2}$ $kvs = 5.825$ for stiffened webs

$$Cv := \begin{cases} 1.0 & \text{if } htw \le 2.24 \cdot \sqrt{\frac{E_s}{F_y}} \\ 1.0 & \text{if } htw \le 1.1 \cdot \sqrt{\frac{kv \cdot E_s}{F_y}} \\ \frac{1.1 \cdot \sqrt{\frac{kv \cdot E_s}{F_y}}}{htw} & \text{if } 1.1 \cdot \sqrt{\frac{kv \cdot E_s}{F_y}} < htw \le 1.37 \cdot \sqrt{\frac{kv \cdot E_s}{F_y}} \\ \frac{1.51 \cdot E_s \cdot kv}{htw^2 \cdot F_y} & \text{if } htw > 1.37 \cdot \sqrt{\frac{kv \cdot E_s}{F_y}} \end{cases}$$

$Cv = 1$

$V_n := 0.6 \cdot F_y \cdot A_w \cdot Cv$ $V_n = 59.608 \cdot k$

$check := if(V_n \ge V_{u3}, \text{"OK"}, \text{"need web stiffeners"})$ $check = \text{"OK"}$

Use W8x15, A992 Beam B3

Bearing Plate 1:

$P := max(V_{u2}, V_{u3})$ $P = 5.042 \cdot k$ $\phi := 1.0$ $F_y := 36ksi$ $\rho := 150psi$

$R_{nreq} := \frac{P}{\phi}$ $R_{nreq} = 5.042 \cdot k$

$N := \frac{R_{nreq}}{F_y \cdot t_w} - 2.5 \cdot k_b$ $N = -0.966 \cdot in$ try $N := 10in$

$Areqd := \frac{P}{\rho}$ $Areqd = 33.614 \cdot in^2$

Try Bearing Plate 5"x10": $B := 5in$

$A_a := B \cdot N$ $A_a = 50 \cdot in^2$

$check := if(A_a \ge Areqd, \text{"OK"}, \text{"Not OK"})$ $check = \text{"OK"}$

check local web yielding:

$$R_n := \begin{cases} (2.5 \cdot k_b + N) \cdot F_y \cdot t_w & \text{if } \frac{N}{2} < d \\ (5 \cdot k_b + N) \cdot F_y \cdot t_w & \text{if } \frac{N}{2} > d \end{cases}$$

$R_n = 101.761 \cdot k$

check := if($\phi \cdot R_n \geq P$, "Stiffeners not required" , "Stiffeners Required")

check = "Stiffeners not required"

check web crippling: $\phi := 0.75$

$$R_n := \begin{cases} 0.8 \cdot t_w^2 \cdot \left[1 + 3 \cdot \frac{N}{d} \cdot \left(\frac{t_w}{t_f}\right)^{1.5}\right] \cdot \sqrt{\frac{E_s \cdot F_y \cdot t_f}{t_w}} & \text{if } \frac{N}{2} \geq \frac{d}{2} \\ \left[0.4 \cdot t_w^2 \cdot \left[1 + 3 \cdot \frac{N}{d} \cdot \left(\frac{t_w}{t_f}\right)^{1.5}\right] \cdot \sqrt{\frac{E_s \cdot F_y \cdot t_f}{t_w}}\right] & \text{if } \frac{N}{d} \leq 0.2 \\ \left[0.4 \cdot t_w^2 \left[1 + \left(\frac{4 \cdot N}{d} - 0.2\right) \cdot \left(\frac{t_w}{t_f}\right)^{1.5}\right] \cdot \sqrt{\frac{E_s \cdot F_y \cdot t_f}{t_w}}\right] & \text{if } \frac{N}{d} > 0.2 \end{cases}$$

$R_n = 118.111 \cdot k$

check := if($\phi \cdot R_n \geq V_{u2}$, "Stiffeners not required" , "Stiffeners required")

check = "Stiffeners not required"

$f_p := \frac{P}{B \cdot N}$ $f_p = 0.101 \cdot ksi$ bearing pressure on the plate

$n := \frac{B}{2} - k_b$ $n = 1.885 \cdot in$

$F_b := 0.75 \cdot F_y$ $F_b = 27 \cdot ksi$ allowable bending stress

$t_p := \sqrt{\frac{3 \cdot f_p \cdot n^2}{F_b}}$ $t_p = 0.2 \cdot in$ bearing plate thickness

Use bearing plate BP1 = 3/8"x5"x10"

Try 2-1/2"ϕ x 6" headed anchors in masonry grouted solid: $\phi_{hs} := 0.5in$ $l_b := 6in$ $b_w := 7.63in$ $f_m := 1500psi$ $f_y := 36ksi$

$X := 0.5 \cdot \sqrt{4 \cdot l_b^2 - b_w^2}$ $X = 4.631 \cdot in$

$Y := l_b - X$ $Y = 1.369 \cdot in$

$Z := N - 2 \cdot 2in$ $Z = 6 \cdot in$ spacing between anchors

$A_{pt} := (l_b + Z + l_b) \cdot b_w - Y \cdot \frac{2}{3} \cdot b_w$ $A_{pt} = 130.376 \cdot in^2$ projected area for axial tension

$A_b := \pi \cdot \left(\frac{\phi_{hs}}{2}\right)^2$ $A_b = 0.196 \cdot in^2$

$B_{ab} := 1.25 \cdot A_{pt} \cdot \sqrt{\frac{f_m}{psi}} \cdot psi$ $B_{ab} = 6.312 \cdot k$ allowable axial tensile load governed by masonry breakout

$B_{as} := 0.6 \cdot A_b \cdot f_y$ $B_{as} = 4.241 \cdot k$ allowable axial tensile load governed by steel yielding

$B_a := \min(B_{ab}, B_{as})$ $\quad B_a = 4.241 \cdot k$

$check := if(B_a \cdot 2 \geq P \cdot 0.5, "OK", "not OK")$ $\quad check = "OK"$

use 2-1/2"ϕ x 6" headed anchors in masonry grouted solid

Beam "B4" over arcade openings:

$L_{b4} := 8.0ft$ $\quad h_m := 9.33ft$ $\quad F_y := 50ksi$ $\quad w_b := 15plf$ $\quad \phi b := 0.90$

$w_{u4} := TL \cdot \left(\frac{L_j}{2}\right) + 1.2 \cdot w_m \cdot h_m + 1.2 \cdot w_b$ $\quad w_{u4} = 1870.35 \cdot plf$

$w_{u4serv} := TL_{serv} \cdot \left(\frac{L_j}{2}\right) + w_m \cdot h_m + w_b$ $\quad w_{u4serv} = 1487.297 \cdot plf$

$V_{u4} := \frac{w_{u4} \cdot L_{b4}}{2}$ $\quad V_{u4} = 7.481 \cdot k$

$M_{u4} := \frac{w_{u4} \cdot L_{b4}^2}{8}$ $\quad M_{u4} = 14.963 \cdot ft \cdot k$

Try W8x15 $\quad d := 8.11in$ $\quad t_w := 0.245in$ $\quad b_f := 4.02in$ $\quad t_f := 0.315in$ $\quad I_x := 48in^4$ $\quad S_x := 11.8in^3$ $\quad Z_x := 13.6in^3$

$I_y := 3.41in^4$ $\quad Aw := d \cdot t_w$ $\quad Aw = 1.987 \cdot in^2$ $\quad \phi v := 1.0$ $\quad r_y := .876in$ $\quad h_o := 7.8in$ $\quad J := 0.137in^4$ $\quad C_w := 51.8in^6$

$c := 1.0$ $\quad C_b := 1.0$ $\quad P_c := 83.03k$ $\quad S_y := 1.7in^3$ $\quad Z_y := 2.67in^3$ $\quad k_b := 0.615in$

$Zx := \frac{M_{u4}}{\phi b \cdot F_y}$ $\quad Zx = 3.99 \cdot in^3$ $\quad$ Required Zx

$check := if(Zx \leq Z_x, "OK", "Not OK")$ $\quad check = "OK"$

$\lambda p := 0.38 \cdot \sqrt{\frac{E_s}{F_y}}$ $\quad \lambda p = 9.152$ $\quad \lambda r := 1.0 \cdot \sqrt{\frac{E_s}{F_y}}$ $\quad \lambda r = 24.083$ $\quad \lambda_{steel} := \frac{b_f \cdot 0.5}{t_f}$ $\quad \lambda_{steel} = 6.381$

$$check := \begin{cases} \text{"Section is Compact"} & \text{if } \lambda_{steel} \leq \lambda p \\ \text{"Section is non campact"} & \text{if } \lambda_{steel} > \lambda p \\ \text{"Section is slender"} & \text{if } \lambda_{steel} > \lambda r \end{cases}$$

$check = "Section is Compact"$

$$Sx := \begin{cases} \frac{M_{u4}}{0.66 \cdot F_y} & \text{if } \lambda_{steel} \leq \lambda p \\ \frac{M_{u4}}{F_y} & \text{if } \lambda_{steel} > \lambda p \end{cases}$$

$Sx = 5.441 \cdot in^3$

$check := if(Sx \leq S_x, "OK", "Not OK")$ $\quad check = "OK"$

$M_{nx} := Z_x \cdot F_y$ $\quad M_{nx} = 56.667 \cdot k \cdot ft$ $\quad M_p := M_{nx}$

$L_p := 3.09ft$ $\quad L_r := 10.0ft$ $\quad r_{ts} := 1.06in$ $\quad \phi_T := 0.9$ $\quad P_r := 0k$

$$F_{cr} := \frac{C_b \cdot \pi^2 \cdot E_s}{\left(\frac{L_{b4}}{r_{ts}}\right)^2} \cdot \sqrt{1 + 0.078 \cdot \frac{J \cdot c}{S_x \cdot h_o} \cdot \left(\frac{L_{b4}}{r_{ts}}\right)^2}$$

$F_{cr} = 48.757 \cdot ksi$

$$M_{nlt} := \begin{cases} \text{"Lateral Torsional buckling does not apply"} & \text{if } L_{b4} \le L_p \\ \left[C_b \cdot \left[M_p - \left(M_p - 0.7 \cdot F_y \cdot S_x\right) \cdot \left(\frac{L_{b4} - L_p}{L_r - L_p}\right)\right]\right] & \text{if } L_p < L_{b4} \le L_r \\ \left(F_{cr} \cdot S_x\right) & \text{if } L_{b4} > L_r \end{cases}$$

$M_{nlt} = 40.857 \cdot k \cdot ft$

$M_{nx} := \min\left(M_{nx}, M_{nlt}\right)$ $M_{nx} = 40.857 \cdot k \cdot ft$

$M_{cx} := \phi_b \cdot M_{nx}$ $M_{cx} = 36.771 \cdot k \cdot ft$

check := if($M_{cx} \ge M_{u4}$, "OK", "Not OK") check = "OK"

Check deflection:

$$\Delta_4 := \frac{5 \cdot w_{u4serv} \cdot L_{b4}^4}{384 \cdot E_s \cdot I_x}$$

$\Delta_4 = 0.098 \cdot in$

$\Delta allow := \frac{L_{b4}}{600}$ $\Delta allow = 0.16 \cdot in$ $\Delta_{max} := 0.3 in$ $\Delta_{allow} := \text{if}\left(\Delta allow < \Delta_{max}, \Delta allow, \Delta_{max}\right)$ $\Delta_{allow} = 0.16 \cdot in$

check := if($\Delta_4 < \Delta_{allow}$, "OK", "Not OK") check = "OK"

Stiffener Check:

$htw := 28.1$ $kv := 5$ web plate buckling coefficient, for unstiffened webs

$a := 16 in$ distance between stiffeners $h := 6.5 in$ $kvs := 5 + \frac{5}{\left(\frac{a}{h}\right)^2}$ $kvs = 5.825$ for stiffened webs

$$Cv := \begin{cases} 1.0 & \text{if } htw \le 2.24 \cdot \sqrt{\frac{E_s}{F_y}} \\ 1.0 & \text{if } htw \le 1.1 \cdot \sqrt{\frac{kv \cdot E_s}{F_y}} \\ \frac{1.1 \cdot \sqrt{\frac{kv \cdot E_s}{F_y}}}{htw} & \text{if } 1.1 \cdot \sqrt{\frac{kv \cdot E_s}{F_y}} < htw \le 1.37 \cdot \sqrt{\frac{kv \cdot E_s}{F_y}} \\ \frac{1.51 \cdot E_s \cdot kv}{htw^2 \cdot F_y} & \text{if } htw > 1.37 \cdot \sqrt{\frac{kv \cdot E_s}{F_y}} \end{cases}$$

$Cv = 1$

$V_n := 0.6 \cdot F_y \cdot A_w \cdot Cv$ $V_n = 59.608 \cdot k$

$check := if(V_n \geq V_{u4}, \text{"OK"}, \text{"need web stiffeners"})$ $check = \text{"OK"}$

Use W8x15, A992 Beam B4

Beam "B5" over window opening, non-DT side:

$L_{b5} := 10.66ft$ $h_m := 9.33ft$ $F_y := 50ksi$ $\phi_b := 0.90$

$$w_{u5} := TL \cdot \left(\frac{L_j}{2} + 4ft\right) + 1.2 \cdot w_b + 1.2 \cdot w_m \cdot h_m \qquad w_{u5} = 2117.39 \cdot plf$$

$$w_{u5serv} := TL_{serv} \cdot \left(\frac{L_j}{2} + 4ft\right) + w_b + w_m \cdot h_m \qquad w_{u5serv} = 1680.097 \cdot plf$$

$$w_{ub} := 1.2 \cdot w_m \cdot h_m \qquad w_{ub} = 503.82 \cdot plf$$

$$V_{u5} := \frac{w_{u5} \cdot L_{b5}}{2} \qquad V_{u5} = 11.286 \cdot k$$

$$M_{u5} := \frac{w_{u5} \cdot L_{b5}^2}{8} \qquad M_{u5} = 30.076 \cdot ft \cdot k$$

$P_{wu} = 69.193 \cdot psf$ $P_{max} = 51.193 \cdot psf$

$$V_{u5y} := \frac{(P_{max} \cdot 4ft \cdot L_{b5})}{2} \qquad V_{u5y} = 1.091 \cdot k$$

$$M_{u5y} := \frac{(P_{max} \cdot 4ft \cdot L_{b5}) \cdot L_{b5}}{4} \qquad M_{u5y} = 5.817 \cdot k \cdot ft$$

$\begin{pmatrix} I_x \\ d \\ t_w \\ t_f \\ b_f \\ A_g \\ w_b \\ A_w \\ r_y \\ r_{ts} \\ Z_x \\ Z_y \\ C_w \\ S_x \\ S_y \\ I_y \\ J \\ h_o \\ bf2tf \\ k_b \end{pmatrix} :=$

Beam Section

Section :	W16X36		*Chosen from dropdown of AISC Shapes*
I =	448.0	in^4	*lookup from AISC table1-1*
d =	15.9	in	*lookup from AISC table1-1*
t_w =	0.295	in	*lookup from AISC table1-1*
tf =	0.430	in	*lookup from AISC table1-1*
bf =	6.990	in	*lookup from AISC table1-2*
Ag =	10.600	in^2	*lookup from AISC table1-2*
wb=	36	plf	
A_w =	4.7	in^2	*d x tw*
r_y =	1.52	in	
r_{ts} =	1.83	in	*Table 1, eq. 9.6.7*
Zx Provided =	64.0		*from AISC table 3-2 lookup, change to smaller section j*
Zy Provided =	10.8		
C_w =	1460.00	in^6	
S_x =	56.50	in^3	
Sy =	7.00	in^3	
I_y =	24.50	in^4	
J =	0.55	in^4	
h_o =	15.47	in	Table 1
$b_f/2_{tf}$ =	8.12		Table 1
kb =	0.832	in	k.des
c =	1		1.0 for I-Shape
E =	29000	ksi	*Steel Modulus*
F_y =	50	ksi	*AISC 14th ed. Assumes Rolled Shapes are 5*

$I_x := I_x \cdot in^4$	$I_x = 448 \cdot in^4$	$A_w := A_w \cdot in^2$	$A_w = 0.033 ft^2$	$S_x := S_x \cdot in^3$	$S_x = 56.5 \cdot in^3$
$d := d \cdot in$	$d = 15.9 \cdot in$			$S_y := S_y \cdot in^3$	$S_y = 7 \cdot in^3$
$t_w := t_w \cdot in$	$t_w = 0.295 \cdot in$	$r_y := r_y \cdot in$	$r_y = 1.52 \cdot in$	$I_y := I_y \cdot in^4$	$J = 0.545$
$t_f := t_f \cdot in$	$t_f = 0.43 \cdot in$	$r_{ts} := r_{ts} \cdot in$	$r_{ts} = 1.83 \cdot in$	$J := J \cdot in^4$	$h_o = 15.47$
$b_f := b_f \cdot in$	$b_f = 6.99 \cdot in$	$Z_x := Z_x \cdot in^3$	$Z_x = 64 \cdot in^3$	$h_o := h_o \cdot in$	$h_o = 15.47 \cdot in$
$A_g := A_g \cdot in^2$	$A_g = 10.6 \cdot in^2$	$Z_y := Z_y \cdot in^3$	$Z_y = 10.8 \cdot in^3$	$k_b := k_b \cdot in$	$k_b = 0.069 ft$

$k_b = 0.069 ft$

$c := 1$

$F_y := 50 ksi \quad C_b := 1.0 \quad P_c := 131 k \quad \phi v := 1.0$

$Zx := \frac{M_{u5}}{\phi_b \cdot F_y}$ $\quad Zx = 8.02 \cdot in^3$ Required Zx

check := if(Zx ≤ Z_x, "OK", "Not OK") $\quad$ check = "OK"

$Zy := \frac{M_{u5y}}{F_y}$ $\quad Zy = 1.396 \cdot in^3$ Required Zy

check := if(Zy ≤ Z_y, "OK", "Not OK") $\quad$ check = "OK"

$\lambda p := 0.38 \cdot \sqrt{\frac{E_s}{F_y}}$ $\quad \lambda p = 9.152$ $\quad \lambda r := 1.0 \cdot \sqrt{\frac{E_s}{F_y}}$ $\quad \lambda r = 24.083$ $\quad \lambda := \frac{b_f \cdot 0.5}{t_f}$ $\quad \lambda = 8.128$

check :=
- "Section is Compact" if $\lambda \le \lambda p$
- "Section is non campact" if $\lambda > \lambda p$
- "Section is slender" if $\lambda > \lambda r$

check = "Section is Compact"

$$Sx := \begin{cases} \frac{M_{u5}}{0.66 \cdot F_y} & \text{if } \lambda \le \lambda p \\ \frac{M_{u5}}{F_y} & \text{if } \lambda > \lambda p \end{cases}$$

$Sx = 10.937 \cdot in^3$

check := if(Sx ≤ S_x, "OK", "Not OK") $\quad$ check = "OK"

$M_{nx} := Z_x \cdot F_y$ $\quad M_{nx} = 266.667 \cdot k \cdot ft$ $\quad M_p := M_{nx}$

$L_p := 5.37 ft \quad L_r := 15.2 ft \quad r_{ts} := 1.83 in \quad \phi_T := 0.9 \quad P_r := 0 k$

$F_{cr} := \frac{C_b \cdot \pi^2 \cdot E_s}{\left(\frac{L_{b5}}{r_{ts}}\right)^2} \cdot \sqrt{1 + 0.078 \cdot \frac{J \cdot c}{S_x \cdot h_o} \cdot \left(\frac{L_{b5}}{r_{ts}}\right)^2}$ $\quad F_{cr} = 65.166 \cdot ksi$

$M_{nlt} := \begin{cases} \text{"Lateral Torsional buckling does not apply"} & \text{if } L_{b5} \le L_p \\ \left[C_b \cdot \left[M_p - (M_p - 0.7 \cdot F_y \cdot S_x) \cdot \left(\frac{L_{b5} - L_p}{L_r - L_p}\right)\right]\right] & \text{if } L_p < L_{b5} \le L_r \\ (F_{cr} \cdot S_x) & \text{if } L_{b5} > L_r \end{cases}$ $\quad M_{nlt} = 211.843 \cdot k \cdot ft$

$M_{nx} := \min(M_{nx}, M_{nlt})$ $\quad M_{nx} = 211.843 \cdot k \cdot ft$

$M_{cx} := \phi_b \cdot M_{nx}$ $\quad M_{cx} = 190.659 \cdot k \cdot ft$

check := if($M_{cx} \ge M_{u5}$, "OK" , "Not OK") $\quad$ check = "OK"

$M_{ny} := Z_y \cdot F_y$ $\quad M_{ny} = 45 \cdot k \cdot ft$

$M_{cy} := \phi_b \cdot M_{ny}$ $\quad M_{cy} = 40.5 \cdot k \cdot ft$

check := if($M_{cy} \ge M_{u5y}$, "OK" , "Not OK") $\quad$ check = "OK"

Check combined compression and bending capacity:

$SF := \begin{cases} \left[\frac{P_r}{P_c} + \frac{8}{9} \cdot \left(\frac{M_{u5}}{M_{cx}} + \frac{M_{u5y}}{M_{cy}}\right)\right] & \text{if } \frac{P_r}{P_c} \ge 0.2 \\ \left[\frac{P_r}{2 \cdot P_c} + \left(\frac{M_{u5}}{M_{cx}} + \frac{M_{u5y}}{M_{cy}}\right)\right] & \text{if } \frac{P_r}{P_c} < 0.2 \end{cases}$ $\quad SF = 0.301$

check := if(SF ≤ 1.0, "OK" , "Not OK") $\quad$ check = "OK"

$\Delta_5 := \frac{5 \cdot w_{u5serv} \cdot L_{b5}^4}{384 \cdot E_s \cdot I_x}$ $\quad \Delta_5 = 0.038 \cdot in$

$\Delta allow := \frac{L_{b5}}{600}$ $\quad \Delta allow = 0.213 \cdot in$ $\quad \Delta_{max} := 0.3 in$ $\quad \Delta_{allow} := if(\Delta allow < \Delta_{max}, \Delta allow, \Delta_{max})$ $\quad \Delta_{allow} = 0.213 \cdot in$

check := if($\Delta_5 < \Delta_{allow}$, "OK" , "Not OK") $\quad$ check = "OK"

htw := 48.1 $\quad$ kv := 5 $\quad$ web plate buckling coefficient, for unstiffened webs

$a := 16\,in$ distance between stiffeners $h := 13.625\,in$ $kvs := 5 + \frac{5}{\left(\frac{a}{h}\right)^2}$ $kvs = 8.626$ for stiffened webs

$$Cv := \begin{cases} 1.0 & \text{if } htw \le 2.24\cdot\sqrt{\frac{E_s}{F_y}} \\ 1.0 & \text{if } htw \le 1.1\cdot\sqrt{\frac{kv\cdot E_s}{F_y}} \\ \frac{1.1\cdot\sqrt{\frac{kv\cdot E_s}{F_y}}}{htw} & \text{if } 1.1\cdot\sqrt{\frac{kv\cdot E_s}{F_y}} < htw \le 1.37\cdot\sqrt{\frac{kv\cdot E_s}{F_y}} \\ \frac{1.51\cdot E_s\cdot kv}{htw^2\cdot F_y} & \text{if } htw > 1.37\cdot\sqrt{\frac{kv\cdot E_s}{F_y}} \end{cases}$$

$Cv = 1$

$V_n := 0.6\cdot F_y\cdot Aw\cdot Cv$ $V_n = 59.608\cdot k$

check := if($V_n \ge V_{u5}$, "OK" , "need web stiffeners") check = "OK"

Use W16x36, A992 Beam B5

Bearing Plate 2:

$P := \max(V_{u4}, V_{u5})$ $P = 11.286\cdot k$ $\phi := 1.0$ $F_y := 36\,ksi$ $\rho := 250\,psi$

$R_{nreq} := \frac{P}{\phi}$ $R_{nreq} = 11.286\cdot k$

$N := \frac{R_{nreq}}{F_y\cdot t_w} - 2.5\cdot k_b$ $N = -1.017\cdot in$ try $N := 12\,in$

$Areqd := \frac{P}{\rho}$ $Areqd = 45.143\cdot in^2$

Try Bearing Plate 6"x12": $B := 6\,in$

$A_a := B\cdot N$ $A_a = 72\cdot in^2$

check := if($A_a \ge Areqd$, "OK" , "Not OK") check = "OK"

check local web yielding:

$$R_n := \begin{cases} (2.5\cdot k_b + N)\cdot F_y\cdot t_w & \text{if } \frac{N}{2} < d \\ (5\cdot k_b + N)\cdot F_y\cdot t_w & \text{if } \frac{N}{2} > d \end{cases}$$

$R_n = 149.53\cdot k$

check := if($\phi\cdot R_n \ge P$, "Stiffeners not required" , "Stiffeners Required") check = "Stiffeners not required" check web crippling: $\phi := 0.75$

$$R_n := \begin{cases} 0.8 \cdot t_w^2 \cdot \left[1 + 3 \cdot \frac{N}{d} \cdot \left(\frac{t_w}{t_f}\right)^{1.5}\right] \cdot \sqrt{\frac{E_s \cdot F_y \cdot t_f}{t_w}} & \text{if } \frac{N}{2} \geq \frac{d}{2} \\ \left[0.4 \cdot t_w^2 \cdot \left[1 + 3 \cdot \frac{N}{d} \cdot \left(\frac{t_w}{t_f}\right)^{1.5}\right] \cdot \sqrt{\frac{E_s \cdot F_y \cdot t_f}{t_w}}\right] & \text{if } \frac{N}{d} \leq 0.2 \\ \left[0.4 \cdot t_w^2 \cdot \left[1 + \left(\frac{4 \cdot N}{d} - 0.2\right) \cdot \left(\frac{t_w}{t_f}\right)^{1.5}\right] \cdot \sqrt{\frac{E_s \cdot F_y \cdot t_f}{t_w}}\right] & \text{if } \frac{N}{d} > 0.2 \end{cases}$$

$R_n = 111.725 \cdot k$

check := if($\phi \cdot R_n \geq P$, "Stiffeners not required", "Stiffeners required") check = "Stiffeners not required"

$f_p := \frac{P}{B \cdot N}$ $f_p = 0.157 \cdot ksi$ bearing pressure on the plate

$n := \frac{B}{2} - k_b$ $n = 2.168 \cdot in$

$F_b := 0.75 \cdot F_y$ $F_b = 27 \cdot ksi$ allowable bending stress

$t_p := \sqrt{\frac{3 \cdot f_p \cdot n^2}{F_b}}$ $t_p = 0.286 \cdot in$ bearing plate thickness

Use bearing plate BP2 = 3/8"x6"x12"

Try 2-1/2"ϕ x 6" headed anchors in masonry grouted solid: $\phi_{hs} := 0.5in$ $l_b := 6in$ $b_w := 7.63in$ $f_m := 1500psi$ $f_y := 36ksi$

$X := 0.5 \cdot \sqrt{4 \cdot l_b^2 - b_w^2}$ $X = 4.631 \cdot in$

$Y := l_b - X$ $Y = 1.369 \cdot in$

$Z := N - 2 \cdot 2in$ $Z = 8 \cdot in$ spacing between anchors

$A_{pt} := (l_b + Z + l_b) \cdot b_w - Y \cdot \frac{2}{3} \cdot b_w$ $A_{pt} = 145.636 \cdot in^2$ projected area for axial tension

$A_b := \pi \cdot \left(\frac{\phi_{hs}}{2}\right)^2$ $A_b = 0.196 \cdot in^2$

$B_{ab} := 1.25 \cdot A_{pt} \cdot \sqrt{\frac{f_m}{psi}} \cdot psi$ $B_{ab} = 7.051 \cdot k$ allowable axial tensile load governed by masonry breakout

$B_{as} := 0.6 \cdot A_b \cdot f_y$ $B_{as} = 4.241 \cdot k$ allowable axial tensile load governed by steel yielding

$B_a := \min(B_{ab}, B_{as})$ $B_a = 4.241 \cdot k$

check := if($B_a \cdot 2 \geq P \cdot 0.33$, "OK", "not OK") check = "OK"

use 2-1/2"ϕ x 6" headed anchors in masonry grouted solid

Column Design(Not Used):

$P_{ult} := 2V_{u5}$ $P_{ult} = 22.571 \cdot k$ $P_r := P_{ult}$ $P_r = 22.571 \cdot k$

$\phi cPn := 81.5k$ on HSS 4x4x5/16 at 13'-0" high column $P_c := \phi cPn$ $P_c = 81.5 \cdot k$

$check := if(P_{ult} \le \phi cPn, "OK", "Not OK")$ $check = "OK"$

Use HSS 4x4x5/16 columns

$L_{C3} := 13.33ft$ $\phi_b := 0.90$ $b_f := 4in$ $F_{yy} := 46ksi$

Try HSS4x4x5/16 $d := 4in$ $t_w := 0.291in$ $S_y := 4.57in^3$ $t_f := 0.291in$ $I_x := 9.14in^4$ $S_x := 4.57in^3$ $Z_x := 5.59in^3$

$I_y := 9.14in^4$ $Aw := d \cdot t_w$ $Aw = 1.164 \cdot in^2$ $\phi v := 1.0$ $r_y := 1.49in$ $b_T := 10.7$ $J := 15.3in^4$ $C := 7.91in^3$

$c := 1.0$ $C_b := 1.0$ $Z_y := 5.59in^3$ $h_T := 10.7$ $A_g := 4.10in^2$

$$M_C := \frac{V_{u5y} \cdot 4ft \cdot 9.33ft}{h_w}$$ $M_C = 3.056 \cdot k \cdot ft$

$\lambda p := 1.12 \cdot \sqrt{\frac{E_s}{F_{yy}}}$ $\lambda p = 28.121$ $\lambda r := 1.40 \cdot \sqrt{\frac{E_s}{F_{yy}}}$ $\lambda r = 35.152$ $\lambda steel := \frac{b_f}{t_f}$ $\lambda steel = 13.746$

$$check := \begin{cases} "Section is Compact" & \text{if } \lambda_{steel} \le \lambda p \\ "Section is non campact" & \text{if } \lambda_{steel} > \lambda p \\ "Section is slender" & \text{if } \lambda_{steel} > \lambda r \end{cases}$$

$check = "Section is Compact"$

$$Sx := \begin{cases} \frac{M_C}{0.66 \cdot F_{yy}} & \text{if } \lambda_{steel} \le \lambda p \\ \frac{M_C}{F_{yy}} & \text{if } \lambda_{steel} > \lambda p \end{cases}$$

$Sx = 1.208 \cdot in^3$

$check := if(Sx \le S_x, "OK", "Not OK")$ $check = "OK"$

$M_{nx} := Z_x \cdot F_{yy}$ $M_{nx} = 21.428 \cdot k \cdot ft$ $M_p := M_{nx}$

Check Torsional Capacity:

$$F_{cr} := \begin{cases} (0.6 \cdot F_{yy}) & \text{if } \frac{d}{t_f} \le 2.45 \cdot \sqrt{\frac{E_s}{F_{yy}}} \\ \dfrac{0.6 \cdot F_{yy} \cdot \left(2.45 \cdot \sqrt{\frac{E_s}{F_{yy}}}\right)}{\frac{d}{t_f}} & \text{if } 2.45 \cdot \sqrt{\frac{E_s}{F_{yy}}} < \frac{d}{t_f} \le 3.07 \cdot \sqrt{\frac{E_s}{F_{yy}}} \\ \dfrac{0.458 \cdot \pi^2 \cdot E_s}{\left(\frac{d}{t_f}\right)^2} & \text{if } 3.07 \cdot \sqrt{\frac{E_s}{F_{yy}}} < \frac{d}{t_f} \le 260 \end{cases}$$

$F_{cr} = 27.6 \cdot ksi$

$$M_{nlt} := \begin{cases} \text{"Lateral Torsional buckling does not apply"} & \text{if } \lambda_{steel} \le \lambda p \\ \left[M_p - (M_p - F_{yy} \cdot S_x) \cdot \left(3.57 \cdot \frac{b_f}{t_f} \cdot \sqrt{\frac{F_{yy}}{E_s}} - 4.0\right)\right] & \text{if } \lambda_{steel} > \lambda p \\ (F_{cr} \cdot S_x) & \text{if } \lambda_{steel} > \lambda r \end{cases}$$

$M_{nlt} =$ "Lateral Torsional buckling does not apply"

$M_{nx} := \min(M_{nx})$ $\quad M_{nx} = 21.428 \cdot k \cdot ft$

$M_{cx} := \phi_b \cdot M_{nx}$ $\quad M_{cx} = 19.285 \cdot k \cdot ft$

check := if($M_{cx} \ge M_C$, "OK" , "Not OK") $\quad$ check = "OK"

$A_w := 2 \cdot (d - 3 \cdot t_f) \cdot t_f$ $\quad A_w = 1.82 \cdot in^2$ $\quad C_v := 1.0$ $\quad \phi_v := 1.0$

$V_n := 0.6 \cdot F_y \cdot A_w \cdot C_v$ $\quad V_n = 39.31 \cdot k$ $\quad V_c := \phi_v \cdot V_n$ $\quad V_c = 39.31 \cdot k$

Check combined compression and bending capacity:

$$SF := \begin{cases} \left[\frac{P_r}{P_c} + \frac{8}{9} \cdot \left(\frac{M_C}{M_{cx}}\right)\right] & \text{if } \frac{P_r}{P_c} \ge 0.2 \\ \left[\frac{P_r}{2 \cdot P_c} + \left(\frac{M_C}{M_{cx}}\right)\right] & \text{if } \frac{P_r}{P_c} < 0.2 \end{cases}$$

$SF = 0.418$

check := if(SF ≤ 1.0, "OK" , "Not OK") $\quad$ check = "OK"

Use HSS 4x4x5/16 for column

Column Base Plate A:

$d_c := 4in$ $\quad b_f := 4in$ $\quad N := 12in$ $\quad B := 12in$ $\quad F_y := 36ksi$

$$m := \frac{N - 0.95 \cdot d_c}{2}$$

$m = 4.1 \cdot in$

$n := \frac{B - 0.8 \cdot b_f}{2}$ $\quad n = 4.4 \cdot in$

$np := \frac{\sqrt{d_c \cdot b_f}}{4}$ $\quad np = 1 \cdot in$

$X := \left[\frac{4 \cdot d_c \cdot b_f}{(d_c + b_f)^2}\right] \cdot \frac{P_{ult}}{\phi cPn}$ $\quad X = 0.277$

$\lambda_{plate} := \frac{2 \cdot \sqrt{X}}{1 + \sqrt{1 - X}}$ $\quad \lambda_{plate} = 0.569$

$\lambda n := \lambda_{plate} \cdot np$ $\quad \lambda n = 0.569 \cdot in$

$l := \max(m, n, \lambda n)$ $\quad l = 4.4 \cdot in$

$t_p := l \cdot \sqrt{\frac{2 \cdot P_{ult}}{0.9 \cdot F_y \cdot B \cdot N}}$ $\quad t_p = 0.433 \cdot in$

Use 3/4"x12"x12" column base plate A

Column Footing Design:

$P_{serv} := w_{u5serv} \cdot \frac{(L_{b5} + 7ft)}{2}$ $\quad P_{serv} = 14.835 \cdot k$ Modify per length of secondary trib beam

$P_{ult} := w_{u5} \cdot \frac{(L_{b5} + 7ft)}{2}$ $\quad P_{ult} = 18.697 \cdot k$

$Areq := \frac{P_{serv}}{SBC}$ $\quad Areq = 7.418 ft^2$ $\quad L := \sqrt{Areq}$ $\quad L = 2.724 ft$ say $L := 4.0 ft$ $\quad D := 1 ft$

Try 4'-0" x 4'-0" x 1'-0" $\quad d := D - 3in$ $\quad d = 9 \cdot in$

check for punching shear:

$qu := \frac{P_{ult}}{L \cdot L}$ $\quad qu = 1168.534 \cdot psf$

$b_o := 4 \cdot (b_f + m + D)$ $\quad b_o = 6.7 ft$

$V_u := P_{ult} - qu \cdot (N + m + d)^2$ $\quad V_u = 13.584 \cdot k$

$\phi V_c := 4 \cdot \phi \cdot d \cdot b_o \cdot \sqrt{\frac{f_c}{psi}} \cdot psi$ $\quad \phi V_c = 118.9 \cdot k$

check := if($\phi V_c > V_u$, "OK", "Not OK") $\quad$ check = "OK"

check for flexural shear:

$x := \frac{L}{2} - \frac{b_f}{2} - \frac{n}{2} - d$ $\quad x = 0.9 ft$

$V_u := qu \cdot L \cdot x$ $\quad V_u = 4.207 \cdot k$

$\phi V_c := 2 \cdot \phi \cdot L \cdot d \cdot \sqrt{\frac{f_c}{psi}} \cdot psi$ $\qquad \phi V_c = 35.492 \cdot k$

check := if($\phi V_c > V_u$, "OK" , "Not OK") $\qquad$ check = "OK"

check for flexure:

$$M_u := \frac{qu \cdot L \cdot \left(\frac{L}{2} - \frac{b_f}{2} - \frac{n}{2}\right)^2}{2} \qquad M_u = 6.363 \cdot k \cdot ft$$

Assume a tension controlled section:

$$\rho := \frac{0.85 \cdot f_c \cdot \left(1 - \sqrt{1 - \frac{M_u}{0.383 \cdot L \cdot d^2 \cdot f_c}}\right)}{f_y} \qquad \rho = 0.0006$$

$$\rho_t := 0.319 \cdot \beta_1 \cdot \frac{f_c}{f_y} \qquad \rho_t = 0.023$$

check := if($\rho_t > \rho$, "Section is tension controlled" , "Section is not tension controlled")

check = "Section is tension controlled"

$A_s := \rho \cdot L \cdot d$ $\qquad A_s = 0.263 \cdot in^2$ $\qquad A_5 := 0.31 in^2$ $\qquad d_b := 0.625 in$ $\qquad n_b := 4$ $\qquad f_c := 3000 psi$

$A_{sact} := n_b \cdot A_5$ $\qquad A_{sact} = 1.24 \cdot in^2$

check := if($A_{sact} \ge A_s$, "OK" , "Not OK") $\qquad$ check = "OK"

$A_{smin} := 0.0018 \cdot L \cdot D$ $\qquad A_{smin} = 1.037 \cdot in^2$

check := if($A_{sact} \ge A_{smin}$, "OK" , "Not OK") $\qquad$ check = "OK"

$$A_{sratio} := \frac{A_{smin}}{A_{sact}} \qquad A_{sratio} = 0.836$$

$$l_d := \frac{0.075 \cdot 0.8 \cdot d_b \cdot f_y}{2.5 \cdot \sqrt{\frac{f_c}{psi}} \cdot psi} \cdot A_{sratio} \qquad l_d = 0.687 ft$$

$$l_a := \frac{L}{2} - \frac{b_f}{2} - 3in \qquad l_a = 1.583 ft$$

check := if($l_a \ge l_d$, "OK" , "Not OK") $\qquad$ check = "OK"

Use 4'-0" x 4'-0" x 1'-0" w/ 4-#5 LWB

Roof Diaphragm:

$Ls_A := 38 ft$ $\qquad Ls_B := 29.33 ft$ $\qquad Ls_C := 40 ft$ $\qquad Ls_D := 7.33 ft$

$V_{Lut} = 41.74 \cdot k$ $\qquad V_{LuL} = 26.361 \cdot k$

$v_{Lut} := \frac{V_{Lut}}{Lu_L}$ $\qquad v_{Lut} = 361.915 \cdot plf$

$v_{LuL} := \frac{V_{LuL}}{Lu_t}$ $\qquad v_{LuL} = 585.794 \cdot plf$

$LL := 71.25ft$ $\qquad LL_e := Lu_L - LL$ $\qquad LL_e = 44.08ft$

$V1 := v_{Lut} \cdot \frac{LL}{2}$ $\qquad V1 = 12.893 \cdot k$ $\qquad v1 := \frac{V1}{Lu_t}$ $\qquad v1 = 286.516 \cdot plf$

$V2 := v_{Lut} \cdot \frac{LL_e}{2}$ $\qquad V2 = 7.977 \cdot k$ $\qquad v2 := \frac{V2}{Lu_t}$ $\qquad v2 = 177.258 \cdot plf$

$V3 := \frac{v_{LuL} \cdot Lu_t}{2}$ $\qquad V3 = 13.18 \cdot k$ $\qquad v3 := \frac{V3}{LL}$ $\qquad v3 = 184.987 \cdot plf$

$V4 := V1 + V2$ $\qquad V4 = 20.87 \cdot k$ $\qquad v4 := \frac{V4}{Lu_t}$ $\qquad v4 = 463.774 \cdot plf$

Masonry Wall Check:

$h_w := 13.33ft$ $\qquad b_w := 7.625in$ $\qquad a := H_b - h_w$ $\qquad a = 5.34ft$ $\qquad w_m = 45 \cdot psf$ $\qquad A_n := b_w \cdot 1ft$ $\qquad A_n = 91.5 \cdot in^2$

$E_s = 29000 \cdot ksi$ $\qquad f_m := 1500psi$

$E_m := 900 \cdot f_m$ $\qquad E_m = 1350 \cdot ksi$ $\qquad$ for concrete masonry

$F_s := 24ksi$ $\qquad$ for grade 60 reinforcement $\qquad f_y := 60ksi$ $\qquad n := 29$ $\qquad I_n := 351.7in^4$

$F_b := 0.33 \cdot f_m$ $\qquad F_b = 495 \cdot psi$

$Result := if\left(\frac{10ft}{b_w} \le 18, "OK", "Not OK"\right)$ $\qquad Result = "OK"$ $\qquad$ per Table 2109.4.1- IBC 2006

$Pw_{clad} := P_w$ $\qquad Pw_{clad} = 20.988 \cdot \frac{plf}{ft}$

$I_p := 1.0$ $\qquad W_p := w_m \cdot H_b$ $\qquad W_p = 840.15 \cdot plf$ $\qquad h_{x1} := h_w$ $\qquad h_{x2} := 0ft$ $\qquad k_a := 2.0$

$W_p := w_m \cdot \left(H_b - \frac{h_w}{2}\right)$

$F_{p1} := 0.4 \cdot S_{ds} \cdot k_a \cdot I_p \cdot W_p$ $\qquad F_{p1} = 271.195 \cdot plf$

$F_{p1min} := .2 \cdot k_a \cdot I_p \cdot W_p$ $\qquad F_{p1min} = 216.09 \cdot plf$

$F_{p1} := if(F_{p1} < F_{p1min}, F_{p1min}, F_{p1})$ $\qquad F_{p1} = 271.195 \cdot plf$ $\qquad$ at roof level

$W_p := w_m \cdot \left(\frac{h_w}{2}\right)$

$F_{p2} := 0.4 \cdot S_{ds} \cdot k_a \cdot I_p \cdot W_p$ $\qquad F_{p2} = 150.563 \cdot plf$

$F_{p2min} := .2 \cdot k_a \cdot I_p \cdot W_p$ $\qquad F_{p2min} = 119.97 \cdot plf$

$F_{p2} := if(F_{p2} < F_{p2min}, F_{p2min}, F_{p2})$ $\qquad F_{p2} = 150.563 \cdot plf$ at base level

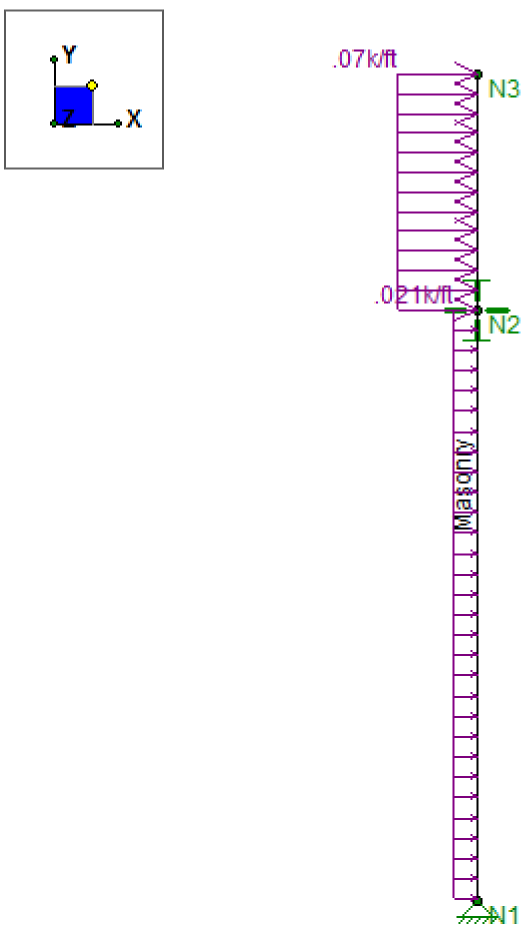
$f_p := 0.4 \cdot S_{ds} \cdot I_p \cdot w_m$

$f_{pmin} := 0.1 \cdot w_m$ $\qquad f_{pmin} = 4.5 \cdot psf$

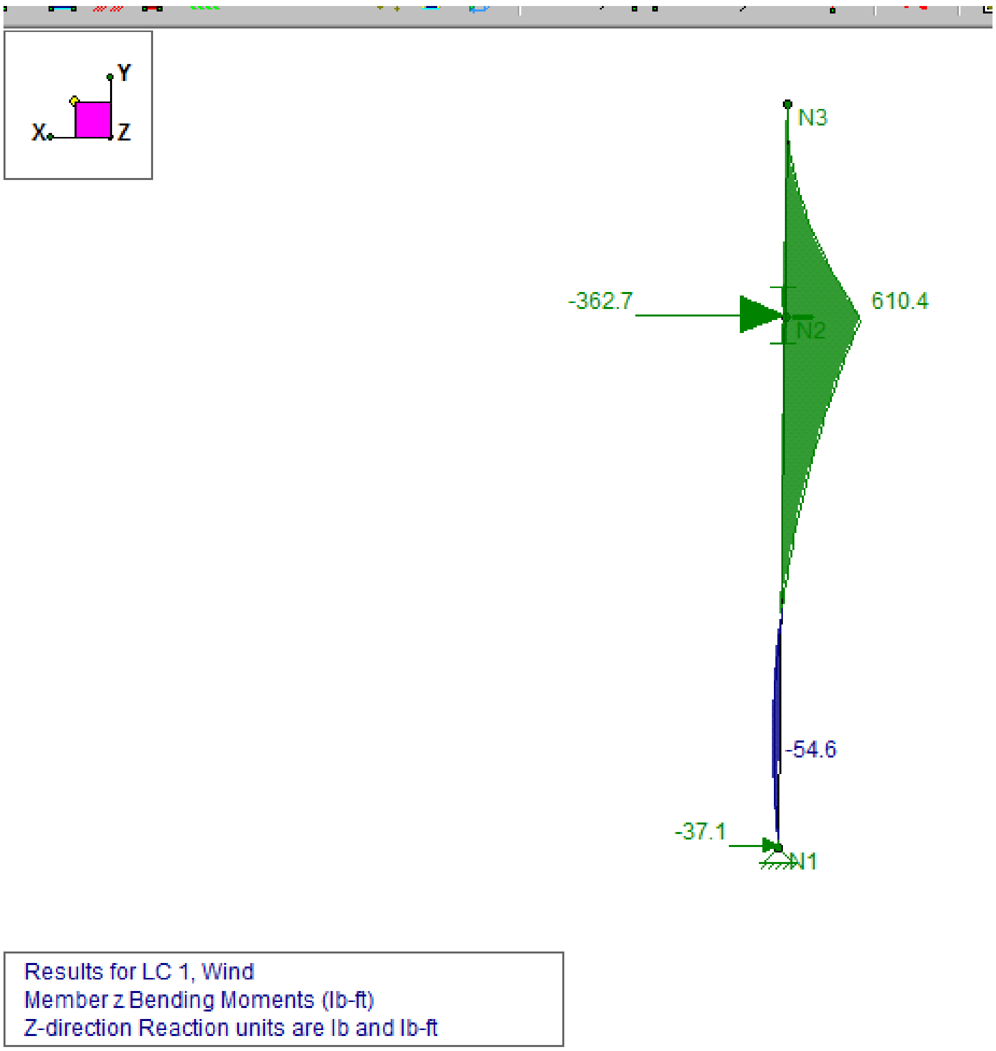
$f_p := if(f_p < f_{pmin}, f_{pmin}, f_p)$ $\qquad f_p = 11.295 \cdot psf$

$Cladding := max(f_p, Pw_{clad})$ $\qquad Cladding = 20.988 \cdot \frac{plf}{ft}$ Wind Governs

Model Wall in 1 foot section in Risa with Arbitrary material and properties set to the above values for masonry



Loads: BLC 1, Wind
Results for LC 1, Wind



$R_{wbase} := 60 lbf$ From Risa $R_{wbase} = 60 \cdot lbf$

$M_{mw} := 610 lbf \cdot ft$ From Risa $M_{mw} = 610 \cdot lbf \cdot ft$ at X

$X := 13.33ft$ $X = 13.33ft$ From Risa

$M_{cant} := 610lbf \cdot ft$ From Risa $M_{cant} = 610 \cdot lbf \cdot ft$

$\rho_{min} := 0.002$ $\rho_{min} = 0.002$ $\rho n := \rho_{min} \cdot n$ $\rho n = 0.058$

$K := \sqrt{2 \cdot \rho n + \rho n^2} - \rho n$ $K = 0.287$ $j := 1 - \frac{K}{3}$ $j = 0.904$

$A_{sreq} := \frac{M_{mw}}{j \cdot \frac{b_w}{2} \cdot F_s}$ $A_{sreq} = 0.088 \cdot in^2$ per foot

Try #5 vertical reinforcement $A_v := 0.31in^2 \cdot \frac{12in}{40in}$ $A_v = 0.093 \cdot in^2$ per foot

check := if($A_{sreq} \le A_v$, "OK" , "Not OK") check = "OK"

Use #5 @ 40" o.c.

$\rho := \frac{A_v}{\frac{b_w}{2} \cdot 1ft}$ $\rho = 0.002$ $\rho n := \rho \cdot n$ $\rho n = 0.059$

$K := \sqrt{2 \cdot \rho n + \rho n^2} - \rho n$ $K = 0.289$ $j := 1 - \frac{K}{3}$ $j = 0.904$

$f_b := \frac{2 \cdot M_{mw}}{j \cdot K \cdot b_w \cdot (1ft)^2}$ $f_b = 0.051 \cdot ksi$

check := if($F_b > f_b$, "OK" , "Not OK") check = "OK"

$f_s := \frac{M_{mw}}{j \cdot 1ft \cdot A_v}$ $f_s = 7.26 \cdot ksi$

check := if($F_s > f_s$, "OK" , "Not OK") check = "OK"

$W_{wall} := W_{w48} \cdot (H_b - X) \cdot 1.2$ $W_{wall} = 288.36 \cdot plf$ weight of wall above maximum moment

$W_{roof} := TL \cdot \frac{Lu_t}{2}$ $W_{roof} = 1389.6 \cdot plf$ weight of dead load, live load and flat snow load

$P_{ax} := W_{wall} + W_{roof}$ $P_{ax} = 1677.96 \cdot plf$

$\Delta_{main} := 0.009in$ From Risa $\Delta_{main} = 0.009 \cdot in$

$\Delta_{allow} := \frac{h_w}{600}$ $\Delta_{allow} = 0.267 \cdot in$

check := if($\Delta_{main} < \Delta_{allow}$, "OK" , "NOT OK") check = "OK"

$\Delta_{ppet} := 0.046in$ From Risa $\Delta_{ppet} = 0.046 \cdot in$

$\Delta_{allow} := \frac{a}{600}$ $\Delta_{allow} = 0.107 \cdot in$

check := if($\Delta_{ppet} < \Delta_{allow}$, "OK" , "NOT OK") check = "OK"

$f_a := \frac{P_{ax} \cdot 1ft}{A_n}$ $f_a = 18.338 \cdot psi$

$r := \sqrt{\frac{{b_w}^2}{12in \cdot in}} \cdot in$ $r = 2.201 \cdot in$

check slenderness ratio

$slend := \frac{h_w}{r}$ $slend = 72.671$

$$P_a := \begin{cases} \left[(0.25 \cdot f_m \cdot A_n + 0.65 \cdot Av \cdot F_s) \cdot \left[1 - \left(\frac{h_w}{140 \cdot r} \right)^2 \right] \right] & \text{if } slend < 99 \\ \left[(0.25 \cdot f_m \cdot A_n + 0.65 \cdot Av \cdot F_s) \cdot \left(\frac{70 \cdot r}{h_w} \right)^2 \right] & \text{if } slend \geq 99 \end{cases}$$

$P_a = 26.127 \cdot k$

$$SF := \frac{\frac{P_{ax} \cdot 1 \cdot ft}{lbf}}{\frac{P_a}{lbf}} + \frac{\frac{f_b}{ksi}}{\frac{F_b}{ksi}}$$

$SF = 0.167$

check := if(SF < 1, "OK" , "Not OK") check = "OK"

Horizontal Reinforcement

$A_8 := 0.79in^2$ $d_{b8} := 1in$

$A_6 := 0.44in^2$ $A_7 := 0.6in^2$ $A_5 := 0.31in^2$ $A_4 := 0.20in^2$ $d_{b6} := 0.75in$ $d_{b7} := 0.875in$ $d_{b5} := 0.625in$ $d_{b4} := 0.5in$

Chord Reinforcement:

$M_1 := \frac{v_{LuL} \cdot (Lu_t)^2}{8}$ $T_1 := \frac{M_1}{LL}$ $M_2 := \frac{v_{Lut} \cdot (LL)^2}{8}$ $T_2 := \frac{M_2}{Lu_t}$

$M1 = 5.456 \cdot k \cdot ft$ $T_1 = 2.081 \cdot k$ $M_2 = 229.661 \cdot k \cdot ft$ $T_2 = 5.104 \cdot k$

Chord Reinforcement:

$V := max(T_1, T_2)$ $V = 5.104 \cdot k$

$A_{sh} := \frac{V}{F_s}$ $A_{sh} = 0.213 \cdot in^2$

$A_{shact} := 1 \cdot A_5$ $A_{shact} = 0.31 \cdot in^2$

check := if($A_{shact} \geq A_{sh}$, "OK", "Need more reinfocement") check = "OK"

Shear Reinforcement:

$v := \max(v1, v3)$ $v = 286.516 \cdot plf$

$f_v := \frac{v \cdot Lu_t}{b_w \cdot j \cdot Lu_t}$ $f_v = 3.466 \cdot psi$

$F_v := \sqrt{\frac{f_m}{psi}} \cdot psi$ $F_v = 38.73 \cdot psi$ $F_{vmax} := 50psi$

check := if($F_v \leq F_{vmax}$, "use Fv", "use Fvmax") check = "use Fv"

check := if($f_v \leq F_v$, "Nominal horizontal reinforcement required", "Need reinforcement to handle shear force")

check = "Nominal horizontal reinforcement required"

Use 4-#4 @ bond beam under joist bearing

$I_g := \frac{1 \cdot ft \cdot b_w^3}{12}$ $I_g = 443.322 \cdot in^4$

$\Delta max := 0.01 \cdot H_b$ $\Delta max = 2.24 \cdot in$

$\Delta_{center} := \frac{f_p \cdot X}{24 \cdot E_m \cdot I_g \cdot h_w} \cdot \left(h_w^4 - 2 \cdot h_w^2 \cdot X^2 + h_w \cdot X^3 - 2 \cdot a^2 \cdot h_w^2 + 2 \cdot a^2 \cdot X^2\right) \cdot 1ft$ $\Delta_{center} = 0 \cdot in$

$\Delta_{cant} := \frac{f_p \cdot a}{24 \cdot E_m \cdot I_g} \cdot \left(4 \cdot a^2 \cdot h_w - h_w^3 + 3 \cdot a^3\right) \cdot 1ft$ $\Delta_{cant} = -0.003 \cdot in$

$\Delta_{max} := \max(\Delta_{center}, |\Delta_{cant}|)$ $\Delta_{max} = 0.003 \cdot in$

Result := if($\Delta max \geq \Delta_{max}$, "OK", "Not OK") Result = "OK"

Wall Footing Design:

$w_f := 2ft$ $P_{serv} := [(w_m) \cdot H_b] + \left(TL_{serv} \cdot \frac{L_j}{2}\right)$ $P_{serv} = 1892.597 \cdot plf$ $L_f := 1ft$ $d_f := 12in$ $t_s := 2.67ft$

$f_y := 60ksi$ $f_c := 3ksi$ $W_c := 150pcf$ $W_s := 100pcf$ $e := 0ft$

$P := P_{serv} \cdot L_f$ $P = 1.893 \cdot k$

$$q_{max} := \begin{cases} \dfrac{P}{w_f \cdot L_f} & \text{if } e = 0 \\ \dfrac{P \cdot \left(1 + \dfrac{6 \cdot e}{L_f}\right)}{w_f \cdot L_f} & \text{if } e \le \dfrac{L_f}{6} \\ \dfrac{2 \cdot P}{3 \cdot w_f \cdot \left(\dfrac{L_f}{2} - e\right)} & \text{if } e > \dfrac{L_f}{6} \end{cases}$$

$q_{max} = 946.299 \cdot psf$

$$q_{min} := \begin{cases} \dfrac{P}{w_f \cdot L_f} & \text{if } e = 0 \\ \dfrac{P \cdot \left(1 - \dfrac{6 \cdot e}{L_f}\right)}{w_f \cdot L_f} & \text{if } e \le \dfrac{L_f}{6} \\ \dfrac{2 \cdot P}{3 \cdot w_f \cdot \left(\dfrac{L_f}{2} - e\right)} & \text{if } e > \dfrac{L_f}{6} \end{cases}$$

$q_{min} = 946.299 \cdot psf$

$$Result := \begin{cases} (\text{"Footing Is Okay"}) & \text{if } q_{max} < SBC \\ \text{"ReDesign Footing."} & \text{otherwise} \end{cases}$$

Result = "Footing Is Okay"

Limit the deflection to 1/2" in 25 feet

$\delta := 0.5 in$ $\quad L := 25 ft$ $\quad EI := 9.65 \cdot 10^{9} \cdot lbf \cdot in^{2}$

$E_c := 57000 \cdot \sqrt{\dfrac{f_c}{ksi}} \cdot ksi$ $\quad E_c = 98726.896 \cdot ksi$

$M := \dfrac{6 \cdot EI \cdot \delta}{L^{2}}$ $\quad M = 26.806 \cdot k \cdot ft$ $\quad Mu := 1.2 \cdot M$ $\quad Mu = 32.167 \cdot k \cdot ft$

Shear produced by the settlement:

$V := \dfrac{2 \cdot M}{L}$ $\quad V = 2.144 \cdot k$ $\quad Vu := 1.2 \cdot V$ $\quad Vu = 2.573 \cdot k$

$d := d_f - 3in + t_s$ $\quad d = 41.04 \cdot in$ effective depth

$b := 8in$ effective width

Neglecting compression reinforcement and assuming tension controlled section, required tension reinforcement area = ρ

$$\rho_{act} := \frac{0.85 \cdot f_c \cdot \left(1.0 - \sqrt{1.0 - \dfrac{2Mu}{0.765 \cdot b \cdot d^{2} \cdot f_c}}\right)}{f_y}$$

$\rho_{act} = 0.00053$ $\quad \beta 1 := 0.85$

$\rho t_{max} := 0.319 \cdot \beta 1 \cdot \frac{f_c}{f_y}$ $\rho t_{max} = 0.014$

check := if($\rho t_{max} > \rho_{act}$, "OK" , "NOT OK") check = "OK"

$\rho min := \frac{3 \cdot \sqrt{\frac{f_c}{psi}} \cdot psi}{f_y}$ $\rho min = 0.003$

check := if($\rho min > \rho_{act}$, "OK" , "NOT OK") check = "OK"

$\rho min2 := \frac{200 psi}{f_y}$ $\rho min2 = 0.003$

check := if($\rho min2 > \rho_{act}$, "OK" , "NOT OK") check = "OK"

Required reinforcement area:

$\rho_f := \begin{cases} \rho_{act} \cdot \frac{4}{3} & \text{if } \rho_{act} < \rho min2 \\ \rho min2 & \text{otherwise} \end{cases}$ $\rho_f = 0.0007$

$\rho := max(\rho_f, 0.0018)$ $\rho = 0.0018$

$Asreqd := \rho \cdot b \cdot d$ $Asreqd = 0.591 \cdot in^2$ $A_5 := .31 in^2$ $Asact := A_5 \cdot 2$ $Asact = 0.62 \cdot in^2$

check := if(Asact > Asreqd, "OK" , "Not OK") check = "OK" Use 2-#5 BTM.

Design shear strength: $\phi Vc := 0.75 \cdot 2 \cdot b \cdot d \cdot \sqrt{\frac{f_c}{psi}} \cdot psi$ $\phi Vc = 26.974 \cdot k$

Result := | ("no stirrups reqd") if $\phi Vc > 2 \cdot Vu$
| "stirrups reqd" otherwise

Result = "no stirrups reqd"

Use 1'-0" x 2'-0" strip footing w/ 2-#5 btm

Shear Wall A: $Ls_A = 38 ft$ $V3 = 13.18 \cdot k$ $b_w = 7.625 \cdot in$ $d_w := Ls_A - 8 in$ $d_w = 448 \cdot in$

$A_5 := .31 in^2$ $Av_{SWA} := 2 \cdot A_5$ $Av_{SWA} = 0.62 \cdot in^2$

$Mot := V3 \cdot h_w$ $Mot = 175.694 \, ft \cdot k$

$f_b := \frac{2 \cdot Mot}{j \cdot K \cdot b_w \cdot d_w^2}$ $f_b = 0.011 \cdot ksi$

check := if($F_b > f_b$, "OK" , "Not OK") check = "OK"

$f_s := \frac{Mot}{j \cdot d_w \cdot Av_{SWA}}$ $f_s = 8.401 \cdot ksi$

check := if($F_s > f_s$, "Flexural reinf is adequate" , "Flexural reinf is not adequate") check = "Flexural reinf is adequate"

Use 2-#5 Vertical Each End

$$Fv := \begin{cases} \left[\frac{1}{3}\left[4 - \left(\frac{Mot}{V3 \cdot d_w}\right)\right] \cdot \sqrt{\frac{f_m}{psi}} \cdot psi\right] & \text{if } \left|\frac{Mot}{V3 \cdot d_w}\right| < 1.0 \\ \sqrt{\frac{f_m}{psi}} \cdot psi & \text{if } \left|\frac{Mot}{V3 \cdot Ls_A}\right| \geq 1.0 \end{cases}$$

$Fv = 47.03 \cdot psi$

Where reinforcement is not provided to resist all for the calculated shear.

$$Fv_{max} := \begin{cases} \left(80psi - 45 \cdot \frac{Mot}{V3 \cdot d_w} \cdot psi\right) & \text{if } \left|\frac{Mot}{V3 \cdot d_w}\right| < 1.0 \\ (35psi) & \text{if } \left|\frac{Mot}{V3 \cdot d_w}\right| \geq 1.0 \end{cases}$$

$Fv_{max} = 63.933 \cdot psi$

$F_v := \min(Fv, Fv_{max})$ $\quad F_v = 47.03 \cdot psi$

$f_v := \frac{V3}{b_w \cdot d_w}$ $\quad f_v = 3.858 \cdot psi$

check := if($F_v \geq f_v$, "OK", "Not OK") $\quad$ check = "OK"

$s := \min\left(\frac{h_w}{2}, 48in\right)$ $\quad s = 48 \cdot in$

$A_{vh} := \frac{V3 \cdot s}{F_s \cdot d_w}$ $\quad A_{vh} = 0.059 \cdot in^2$ $\quad$ Area of reinforcement in the horizontal direction, shear reinforcement.

$A_{vv} := \frac{A_{vh}}{3}$ $\quad A_{vv} = 0.02 \cdot in^2$ $\quad$ Area of reinforcement in the vertical direction, perpendicular to the shear reinforcement.

$A_{hact} := 4A_4 \cdot \frac{12in}{4ft}$ $\quad A_{hact} = 0.2 \cdot in^2$

check := if($A_{vh} \leq A_{hact}$, "OK", "need more reinf") $\quad$ check = "OK"

Use 4-#4 horizontally in a grouted solid bond beam @ 4'-0" o.c.

$A_{vact} := A_5 \cdot \frac{12in}{40in}$ $\quad A_{vact} = 0.093 \cdot in^2$

check := if($A_{vv} \leq A_{vact}$, "OK", "need more reinf") $\quad$ check = "OK"

Use 1-#5 vertically in grouted solid cell @ 40" o.c.

$A_{st} := A_{hact} + A_{vact}$ $\quad A_{st} = 0.293 \cdot in^2$ per linear foot

$A_{sreq} := 0.002 \cdot b_w \cdot 12in$ $\quad A_{sreq} = 0.183 \cdot in^2$ per linear foot

check := if($A_{st} \geq A_{sreq}$, "OK", "Need more reinf") $\quad$ check = "OK" $\quad$ only req'd for SDC = D

$\gamma := 1.0$ for #3-#5 bars $\quad K_d := \min(2in, 48in, 5 \cdot d_{b5})$ $\quad K_d = 2 \cdot in$

$$l_d := \frac{0.13 \cdot d_{b5}^2 \cdot f_y \cdot \gamma}{K_d \cdot \sqrt{\frac{f_m}{psi}} \cdot psi}$$ $l_d = 39.335 \cdot in$ Required development length

check := if($l_d \geq 12in$, "OK", "use 12in") check = "OK"

splice := l_d splice = $39.335 \cdot in$ Use Splice length = 40in

Footing Design:

$MotA := V3 \cdot h_w$ $MotA = 175.694 \, ft \cdot k$

Try 1.0 ft Deep x 2.0 ft Wide x 29.33 ft Long Footing $d_A := 1 \cdot ft$ $w_A := 2.0 \cdot ft$ $l_A := Ls_A + 3ft$ $l_A = 41 \, ft$

$$P_{dl} := \left(DLr \cdot \frac{L_j}{2} \cdot Ls_A\right) + \left(w_m \cdot Ls_A \cdot h_w\right)$$ $P_{dl} = 39.389 \cdot k$

$Pftg := d_A \cdot w_A \cdot l_A \cdot W_c$ $Pftg = 12.3 \cdot k$

$Psoil := t_s \cdot w_A \cdot l_A \cdot W_s$ $Psoil = 21.894 \cdot k$

$Pt := P_{dl} + Pftg + Psoil$ $Pt = 73.583 \cdot k$

$$Mres := Pt \cdot \frac{l_A}{2}$$ $Mres = 1508.449 \, ft \cdot k$

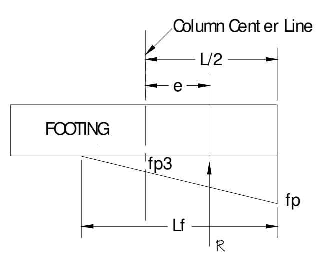
$$SF := \frac{Mres}{MotA}$$ $SF = 8.586$

Result := if($SF \geq 1.5$, "OK", "Redesign Footing") Result = "OK"

$$e := \frac{MotA}{Pt}$$ $e = 2.388 \, ft$

$$q_{max} := \begin{cases} \dfrac{Pt}{w_A \cdot l_A} & \text{if } e = 0 \\ \dfrac{Pt \cdot \left(1 + \dfrac{6 \cdot e}{l_A}\right)}{w_A \cdot l_A} & \text{if } e \leq \dfrac{l_A}{6} \\ \dfrac{2 \cdot Pt}{3 \cdot w_A \cdot \left(\dfrac{l_A}{2} - e\right)} & \text{if } e > \dfrac{l_A}{6} \end{cases}$$

$q_{max} = 1210.905 \cdot psf$



$$q_{min} := \begin{cases} \dfrac{Pt}{w_A \cdot l_A} & \text{if } e = 0 \\ \dfrac{Pt \cdot \left(1 - \dfrac{6 \cdot e}{l_A}\right)}{w_A \cdot l_A} & \text{if } e \le \dfrac{l_A}{6} \\ 0psf & \text{if } e > \dfrac{l_A}{6} \end{cases}$$

$q_{min} = 583.8 \cdot psf$

$$Result := \begin{cases} (\text{"Footing Is Okay"}) & \text{if } q_{max} < SBC \\ \text{"ReDesign Footing."} & \text{otherwise} \end{cases}$$

Result = "Footing Is Okay"

Shear Wall B:

$Ls_B = 29.33 \cdot ft$ $V1 = 12.893 \cdot k$ $d_w := Ls_B - 8in$ $d_w = 343.96 \cdot in$

$A_5 := .31in^2$ $Av_{SWB} := 2 \cdot A_5$ $Av_{SWB} = 0.62 \cdot in^2$

$Mot := V1 \cdot h_w$ $Mot = 171.867 \cdot ft \cdot k$

$$f_b := \frac{2 \cdot Mot}{j \cdot K \cdot b_w \cdot d_w^2}$$ $f_b = 0.017 \cdot ksi$

check := if($F_b > f_b$, "OK", "Not OK") check = "OK"

$$f_s := \frac{Mot}{j \cdot d_w \cdot Av_{SWB}}$$ $f_s = 10.704 \cdot ksi$

check := if($F_s > f_s$, "Flexural reinf is adequate", "Flexural reinf is not adequate") check = "Flexural reinf is adequate"

Use 2-#5 Vertical Each End

$$Fv := \begin{cases} \left[\dfrac{1}{3} \cdot \left[4 - \left(\dfrac{Mot}{V1 \cdot d_w}\right)\right]\right] \cdot \sqrt{\dfrac{f_m}{psi}} \cdot psi & \text{if } \left|\dfrac{Mot}{V1 \cdot d_w}\right| < 1.0 \\ \sqrt{\dfrac{f_m}{psi}} \cdot psi & \text{if } \left|\dfrac{Mot}{V1 \cdot Ls_B}\right| \ge 1.0 \end{cases}$$

$Fv = 45.636 \cdot psi$

Where reinforcement is not provided to resist all for the calculated shear.

$$Fv_{max} := \begin{cases} \left(80psi - 45 \cdot \dfrac{Mot}{V1 \cdot d_w} \cdot psi\right) & \text{if } \left|\dfrac{Mot}{V1 \cdot d_w}\right| < 1.0 \\ (35psi) & \text{if } \left|\dfrac{Mot}{V1 \cdot d_w}\right| \ge 1.0 \end{cases}$$

$Fv_{max} = 59.073 \cdot psi$

$F_v := \min(Fv, Fv_{max})$ $F_v = 45.636 \cdot psi$

$$f_v := \frac{V1}{b_w \cdot d_w}$$ $f_v = 4.916 \cdot psi$

check := if($F_v \ge f_v$, "OK", "Not OK") check = "OK"

$s := \min\left(\frac{h_w}{2}, 48in\right)$ $s = 48 \cdot in$

$A_{vh} := \frac{V1 \cdot s}{F_s \cdot d_w}$ $A_{vh} = 0.075 \cdot in^2$ Area of reinforcement in the horizontal direction, shear reinforcement.

$A_{vv} := \frac{A_{vh}}{3}$ $A_{vv} = 0.025 \cdot in^2$ Area of reinforcement in the vertical direction, perpendicular to the shear reinforcement.

$A_{hact} := 4A_4 \cdot \frac{12in}{4ft}$ $A_{hact} = 0.2 \cdot in^2$

check := if($A_{vh} \le A_{hact}$, "OK" , "need more reinf") check = "OK"

Use 4-#4 horizontally in a grouted solid bond beam @ 10'-0" o.c.

$A_{vact} := A_5 \cdot \frac{12in}{4in}$ $A_{vact} = 0.93 \cdot in^2$

check := if($A_{vv} \le A_{vact}$, "OK" , "need more reinf") check = "OK"

Use 1-#5 vertically in grouted solid cell @ 40" o.c.

$A_{st} := A_{hact} + A_{vact}$ $A_{st} = 1.13 \cdot in^2$ per linear foot

$A_{sreq} := 0.002 \cdot b_w \cdot 12in$ $A_{sreq} = 0.183 \cdot in^2$ per linear foot

check := if($A_{st} \ge A_{sreq}$, "OK" , "Need more reinf") check = "OK" only req'd for SDC = D

$\gamma := 1.0$ for #3-#5 bars $K_d := \min(2in, 48in, 5 \cdot d_{b5})$ $K_d = 2 \cdot in$

$l_d := \frac{0.13 \cdot d_{b5}^2 \cdot f_y \cdot \gamma}{K_d \cdot \sqrt{\frac{f_m}{psi}} \cdot psi}$ $l_d = 39.335 \cdot in$ Required development length

check := if($l_d \ge 12in$, "OK" , "use 12in") check = "OK"

splice := l_d splice = 39.335·in Use Splice length = 40in

Footing Design:

$MotB := V1 \cdot h_w$ $MotB = 171.867 \, ft \cdot k$

Try 1.0 ft Deep x 2.0 ft Wide x 31.67 ft Long Footing $d_B := 1 \cdot ft$ $w_B := 2.0 \cdot ft$ $l_B := Ls_B + 3ft$ $l_B = 32.33 ft$

$P_{dl} := \left(DLr \cdot \frac{S_j}{2} \cdot Ls_B\right) + (w_m \cdot Ls_B \cdot h_w)$ $P_{dl} = 19.353 \cdot k$

$Pftg := d_B \cdot w_B \cdot l_B \cdot W_c$ $Pftg = 9.699 \cdot k$

$Psoil := t_s \cdot w_B \cdot l_B \cdot W_s$ $Psoil = 17.264 \cdot k$

$Pt := P_{dl} + Pftg + Psoil$ $Pt = 46.317 \cdot k$

$Mres := Pt \cdot \frac{l_B}{2}$ $Mres = 748.708 \, ft \cdot k$

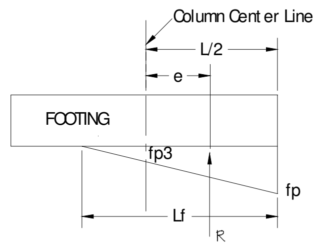
$SF := \frac{Mres}{MotB}$ $\quad SF = 4.356$

$Result := if(SF \geq 1.5, \text{"OK"}, \text{"Redesign Footing"})$ $\quad Result = \text{"OK"}$

$e := \frac{MotB}{Pt}$ $\quad e = 3.711 \, ft$

$$q_{max} := \begin{cases} \frac{Pt}{w_B \cdot l_B} & \text{if } e = 0 \\ \frac{Pt \cdot \left(1 + \frac{6 \cdot e}{l_B}\right)}{w_B \cdot l_B} & \text{if } e \leq \frac{l_B}{6} \\ \frac{2 \cdot Pt}{3 \cdot w_B \cdot \left(\frac{l_B}{2} - e\right)} & \text{if } e > \frac{l_B}{6} \end{cases}$$

$q_{max} = 1209.599 \cdot psf$



$$q_{min} := \begin{cases} \frac{Pt}{w_B \cdot l_B} & \text{if } e = 0 \\ \frac{Pt \cdot \left(1 - \frac{6 \cdot e}{l_B}\right)}{w_B \cdot l_B} & \text{if } e \leq \frac{l_B}{6} \\ 0psf & \text{if } e > \frac{l_B}{6} \end{cases}$$

$q_{min} = 223.021 \cdot psf$

$$Result := \begin{cases} (\text{"Footing Is Okay"}) & \text{if } q_{max} < SBC \\ \text{"ReDesign Footing."} & \text{otherwise} \end{cases}$$

$Result = \text{"Footing Is Okay"}$

Shear Wall C: $Ls_C = 40 ft$ $\quad V3 = 13.18 \cdot k$ $\quad d_w := Ls_C - 8in$ $\quad d_w = 472 \cdot in$

$A_5 := .31in^2$ $\quad Av_{SWC} := 2 \cdot A_5$ $\quad Av_{SWC} = 0.62 \cdot in^2$

$Mot := V3 \cdot h_w$ $\quad Mot = 175.694 \, ft \cdot k$

$fb := \frac{2 \cdot Mot}{j \cdot K \cdot b_w \cdot d_w^2}$ $\quad fb = 0.009 \cdot ksi$

$check := if(Fb > fb, \text{"OK"}, \text{"Not OK"})$ $\quad check = \text{"OK"}$

$fs := \frac{Mot}{j \cdot d_w \cdot Av_{SWC}}$ $\quad fs = 7.974 \cdot ksi$

$check := if(F_s > f_s, \text{"Flexural reinf is adequate"}, \text{"Flexural reinf is not adequate"})$ $\quad check = \text{"Flexural reinf is adequate"}$

Use 2-#5 Vertical Each End

$$F_v := \begin{cases} \left[\frac{1}{3}\left[4-\left(\frac{M_{ot}}{V3\cdot d_w}\right)\right]\right]\cdot\sqrt{\frac{f_m}{psi}}\cdot psi & \text{if } \left|\frac{M_{ot}}{V3\cdot d_w}\right| < 1.0 \\ \sqrt{\frac{f_m}{psi}}\cdot psi & \text{if } \left|\frac{M_{ot}}{V3\cdot Ls_C}\right| \geq 1.0 \end{cases}$$ $F_v = 47.265\cdot psi$

Where reinforcement is not provided to resist all for the calculated shear.

$$F_{vmax} := \begin{cases} \left(80psi - 45\cdot\frac{M_{ot}}{V3\cdot d_w}\cdot psi\right) & \text{if } \left|\frac{M_{ot}}{V3\cdot d_w}\right| < 1.0 \\ (35psi) & \text{if } \left|\frac{M_{ot}}{V3\cdot d_w}\right| \geq 1.0 \end{cases}$$ $F_{vmax} = 64.75\cdot psi$

$F_V := \min(F_v, F_{vmax})$ $F_V = 47.265\cdot psi$

$f_v := \frac{V3}{b_w\cdot d_w}$ $f_v = 3.662\cdot psi$

check := if$(F_V \geq f_v$, "OK", "Not OK"$)$ check = "OK"

$s := \min\left(\frac{h_w}{2}, 48in\right)$ $s = 48\cdot in$

$A_{vh} := \frac{V3\cdot s}{F_s\cdot d_w}$ $A_{vh} = 0.056\cdot in^2$ Area of reinforcement in the horizontal direction, shear reinforcement.

$A_{vv} := \frac{A_{vh}}{3}$ $A_{vv} = 0.019\cdot in^2$ Area of reinforcement in the vertical direction, perpendicular to the shear reinforcement.

$A_{hact} := 4A_4\cdot\frac{12in}{4ft}$ $A_{hact} = 0.2\cdot in^2$

check := if$(A_{vh} \leq A_{hact}$, "OK", "need more reinf"$)$ check = "OK"

Use 4-#4 horizontally in a grouted solid bond beam @ 4'-0" o.c.

$A_{vact} := A_5\cdot\frac{12in}{40in}$ $A_{vact} = 0.093\cdot in^2$

check := if$(A_{vv} \leq A_{vact}$, "OK", "need more reinf"$)$ check = "OK"

Use 1-#5 vertically in grouted solid cell @ 40" o.c.

$A_{st} := A_{hact} + A_{vact}$ $A_{st} = 0.293\cdot in^2$ per linear foot

$A_{sreq} := 0.002\cdot b_w\cdot 12in$ $A_{sreq} = 0.183\cdot in^2$ per linear foot

check := if$(A_{st} \geq A_{sreq}$, "OK", "Need more reinf"$)$ check = "OK" only req'd for SDC = D

$\gamma := 1.0$ for #3-#5 bars $K_d := \min(2in, 48in, 5\cdot d_{b5})$ $K_d = 2\cdot in$

$l_d := \frac{0.13\cdot d_{b5}^2\cdot f_y\cdot\gamma}{K_d\cdot\sqrt{\frac{f_m}{psi}}\cdot psi}$ $l_d = 39.335\cdot in$ Required development length check := if($l_d \geq 12in$, "OK", "use 12in")   check = "OK"

Footing Design:

$MotC := V3 \cdot h_w$ $MotC = 175.694 \, ft \cdot k$

Try 1.0 ft Deep x 2.0 ft Wide x 36.0 ft Long Footing $d_C := 1 \cdot ft$ $w_C := 2.0 \cdot ft$ $l_C := Ls_C + 3ft$ $l_C = 43 ft$

$P_{dl} := \left(DLr \cdot \frac{L_j}{2} \cdot Ls_C\right) + \left(w_m \cdot Ls_C \cdot h_w\right)$ $P_{dl} = 41.462 \cdot k$

$Pftg := d_C \cdot w_C \cdot l_C \cdot W_c$ $Pftg = 12.9 \cdot k$

$Psoil := t_s \cdot w_C \cdot l_C \cdot W_s$ $Psoil = 22.962 \cdot k$

$Pt := P_{dl} + Pftg + Psoil$ $Pt = 77.324 \cdot k$

$Mres := Pt \cdot \frac{l_C}{2}$ $Mres = 1662.466 \, ft \cdot k$

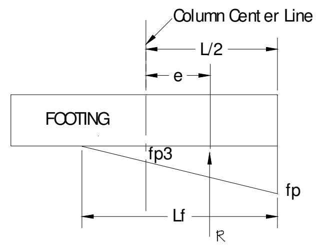
$SF := \frac{Mres}{MotC}$ $SF = 9.462$

Result := if(SF ≥ 1.5, "OK", "Redesign Footing")   Result = "OK"

$e := \frac{MotC}{Pt}$ $e = 2.272 ft$

$$q_{max} := \begin{cases} \frac{Pt}{w_C \cdot l_C} & \text{if } e = 0 \\ \frac{Pt \cdot \left(1 + \frac{6 \cdot e}{l_C}\right)}{w_C \cdot l_C} & \text{if } e \leq \frac{l_C}{6} \\ \frac{2 \cdot Pt}{3 \cdot w_C \cdot \left(\frac{l_C}{2} - e\right)} & \text{if } e > \frac{l_C}{6} \end{cases}$$

$q_{max} = 1184.18 \cdot psf$



$$q_{min} := \begin{cases} \frac{Pt}{w_C \cdot l_C} & \text{if } e = 0 \\ \frac{Pt \cdot \left(1 - \frac{6 \cdot e}{l_C}\right)}{w_C \cdot l_C} & \text{if } e \leq \frac{l_C}{6} \\ 0psf & \text{if } e > \frac{l_C}{6} \end{cases}$$

$q_{min} = 614.053 \cdot psf$

$Result := \begin{cases} (\text{"Footing Is Okay"}) & \text{if } q_{max} < SBC \\ \text{"ReDesign Footing."} & \text{otherwise} \end{cases}$ $Result = \text{"Footing Is Okay"}$

Shear Wall D: $Ls_D = 7.33 ft$ $V2 = 7.977 \cdot k$ $d_w := Ls_D - 8in$ $d_w = 79.96 \cdot in$

$A_5 := .31 in^2$ $Av_{SWD} := 2 \cdot A_5$ $Av_{SWD} = 0.62 \cdot in^2$

$Mot := V2 \cdot h_w$ $Mot = 106.328 ft \cdot k$

$f_b := \frac{2 \cdot Mot}{j \cdot K \cdot b_w \cdot d_w^2}$ $f_b = 0.2 \cdot ksi$

$check := if(F_b > f_b, \text{"OK"}, \text{"Not OK"})$ $check = \text{"OK"}$

$f_s := \frac{Mot}{j \cdot d_w \cdot Av_{SWD}}$ $f_s = 28.486 \cdot ksi$

$check := if(F_s > f_s, \text{"Flexural reinf is adequate"}, \text{"Flexural reinf is not adequate"})$ $check = \text{"Flexural reinf is not adequate"}$

Use 2-#5 Vertical Each End

$Fv := \begin{cases} \left[\frac{1}{3} \cdot \left[4 - \left(\frac{Mot}{V2 \cdot d_w}\right)\right] \cdot \sqrt{\frac{fm}{psi}} \cdot psi\right] & \text{if } \left|\frac{Mot}{V2 \cdot d_w}\right| < 1.0 \\ \sqrt{\frac{fm}{psi}} \cdot psi & \text{if } \left|\frac{Mot}{V2 \cdot Ls_D}\right| \ge 1.0 \end{cases}$ $Fv = 38.73 \cdot psi$

Where reinforcement is not provided to resist all for the calculated shear.

$Fv_{max} := \begin{cases} \left(80psi - 45 \cdot \frac{Mot}{V2 \cdot d_w} \cdot psi\right) & \text{if } \left|\frac{Mot}{V2 \cdot d_w}\right| < 1.0 \\ (35psi) & \text{if } \left|\frac{Mot}{V2 \cdot d_w}\right| \ge 1.0 \end{cases}$ $Fv_{max} = 35 \cdot psi$

$F_v := min(Fv, Fv_{max})$ $F_v = 35 \cdot psi$

$f_v := \frac{V2}{b_w \cdot d_w}$ $f_v = 13.083 \cdot psi$

$check := if(F_v \ge f_v, \text{"OK"}, \text{"Not OK"})$ $check = \text{"OK"}$

$s := min\left(\frac{h_w}{2}, 48in\right)$ $s = 48 \cdot in$

$A_{vh} := \frac{V2 \cdot s}{F_s \cdot d_w}$ $A_{vh} = 0.2 \cdot in^2$ Area of reinforcement in the horizontal direction, shear reinforcement.

$A_{vv} := \frac{A_{vh}}{3}$ $A_{vv} = 0.067 \cdot in^2$ Area of reinforcement in the vertical direction, perpendicular to the shear reinforcement.

$A_{hact} := 4A_4 \cdot \frac{12in}{4ft}$ $\qquad A_{hact} = 0.2 \cdot in^2$

check := if($A_{vh} \le A_{hact}$, "OK", "need more reinf") $\qquad$ check = "OK"

Use 4-#4 horizontally in a grouted solid bond beam @ 4'-0" o.c.

$A_{vact} := A_5 \cdot \frac{12in}{40in}$ $\qquad A_{vact} = 0.093 \cdot in^2$

check := if($A_{vv} \le A_{vact}$, "OK", "need more reinf") $\qquad$ check = "OK"

Use 1-#5 vertically in grouted solid cell @ 40" o.c.

$A_{st} := A_{hact} + A_{vact}$ $\qquad A_{st} = 0.293 \cdot in^2$ per linear foot

$A_{sreq} := 0.002 \cdot b_w \cdot 12in$ $\qquad A_{sreq} = 0.183 \cdot in^2$ per linear foot

check := if($A_{st} \ge A_{sreq}$, "OK", "Need more reinf") $\qquad$ check = "OK" $\qquad$ only req'd for SDC = D

$\gamma := 1.0$ for #3-#5 bars $\qquad K_d := \min(2in, 48in, 5 \cdot d_{b5})$ $\qquad K_d = 2 \cdot in$

$$l_d := \frac{0.13 \cdot d_{b5}^2 \cdot f_y \cdot \gamma}{K_d \cdot \sqrt{\frac{f_m}{psi}} \cdot psi}$$ $\qquad l_d = 39.335 \cdot in$ $\qquad$ Required development length

check := if($l_d \ge 12in$, "OK", "use 12in") $\qquad$ check = "OK"

Footing Design:

$MotD := V2 \cdot h_w$ $\qquad MotD = 106.328 \, ft \cdot k$

Try 1.0 ft Deep x 2.0 ft Wide x 10.33 ft Long Footing $\qquad d_D := 1ft \qquad w_D := 4.83 \cdot ft \qquad l_D := 11.66ft \qquad l_D = 11.66ft$

$$P_{dl} := \left(DLr \cdot \frac{S_j}{2} \cdot Ls_D\right) + (w_m \cdot Ls_D \cdot h_w)$$ $\qquad P_{dl} = 4.837 \cdot k$

$Pftg := d_D \cdot w_D \cdot l_D \cdot W_c$ $\qquad Pftg = 8.448 \cdot k$

$Psoil := t_s \cdot w_D \cdot l_D \cdot W_s$ $\qquad Psoil = 15.037 \cdot k$

$Pt := P_{dl} + Pftg + Psoil$ $\qquad Pt = 28.321 \cdot k$

$Mres := Pt \cdot \frac{l_D}{2}$ $\qquad Mres = 165.113 \, ft \cdot k$

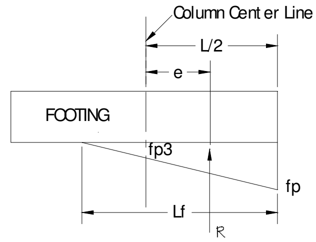
$SF := \frac{Mres}{MotD}$ $\qquad SF = 1.553$

Result := if(SF ≥ 1.5, "OK", "Redesign Footing") $\qquad$ Result = "OK"

$e := \frac{MotD}{Pt}$ $\qquad e = 3.754ft$

$$q_{max} := \begin{cases} \dfrac{Pt}{w_D \cdot l_D} & \text{if } e = 0 \\ \dfrac{Pt \cdot \left(1 + \dfrac{6 \cdot e}{l_D}\right)}{w_D \cdot l_D} & \text{if } e \le \dfrac{l_D}{6} \\ \dfrac{2 \cdot Pt}{3 \cdot w_D \cdot \left(\dfrac{l_D}{2} - e\right)} & \text{if } e > \dfrac{l_D}{6} \end{cases}$$

$q_{max} = 1883.312 \cdot psf$



$$q_{min} := \begin{cases} \dfrac{Pt}{w_D \cdot l_D} & \text{if } e = 0 \\ \dfrac{Pt \cdot \left(1 - \dfrac{6 \cdot e}{l_D}\right)}{w_D \cdot l_D} & \text{if } e \le \dfrac{l_D}{6} \\ 0psf & \text{if } e > \dfrac{l_D}{6} \end{cases}$$

$q_{min} = 0 \cdot psf$

$$Result := \begin{cases} (\text{"Footing Is Okay"}) & \text{if } q_{max} < SBC \\ \text{"ReDesign Footing."} & \text{otherwise} \end{cases}$$

Result = "Footing Is Okay"

Design of Ledger @ Rear Wall:

$P_{seis} := V1$ $\quad P_{vert} := \dfrac{S_j}{2} \cdot \left[TL + \left(1.6 \cdot P_{dL}\right)\right] \cdot L_j$ $\quad P := \sqrt{P_{seis}^{\ 2} + P_{vert}^{\ 2}}$ $\quad P = 19.878 \cdot k$

Provide L4x4x1/4 $\quad F_y := 36ksi$ $\quad F_u := 58ksi$ $\quad \phi_y := 1.0$ $\quad \phi_r := 0.75$

$A_g := 1.94in^2$

$R_{ny} := 0.60 \cdot F_y \cdot A_g$ $\quad R_{ny} = 41.904 \cdot k$

$R_{nr} := 0.6 \cdot F_u \cdot A_g$ $\quad R_{nr} = 67.512 \cdot k$

$Check := if\left(\phi_y \cdot R_{ny} \ge P, \text{"OK"}, \text{"Not OK"}\right)$ $\quad$ Check = "OK"

$Check := if\left(\phi_r \cdot R_{nr} \ge P, \text{"OK"}, \text{"Not OK"}\right)$ $\quad$ Check = "OK"

Therefore:
L4x4x1/4

Using 1/2"ϕ Titen HD Anchor

$Cap := 1385lbf$

$Nb := \dfrac{P}{Cap}$ $\quad Nb = 14.353$ $\quad$ no. of bolts $\quad$ say $\quad Nb := 15$

$Sb := \dfrac{L_j}{Nb}$ $\quad Sb = 34.936 \cdot in$ $\quad$ bolt spacing $\quad$ say $\quad Sb := 32in$

Therefore: Use 1-1/2"ϕ Titen HD Anchor @ 32" o.c.

Design of Angle @ Side Wall:

$P := V3$ $\quad P = 13.18 \cdot k$

Provide L4x4x1/4

$R_{ny} := 0.60 \cdot F_y \cdot A_g$ $\quad R_{ny} = 41.904 \cdot k$

$R_{nr} := 0.6 \cdot F_u \cdot A_g$ $\quad R_{nr} = 67.512 \cdot k$

$Check := if(\phi_y \cdot R_{ny} \geq P, \text{"OK"}, \text{"Not OK"})$ $\quad Check = \text{"OK"}$

$Check := if(\phi_r \cdot R_{nr} \geq P, \text{"OK"}, \text{"Not OK"})$ $\quad Check = \text{"OK"}$

Therefore: L4x4x1/4

Using 1/2"ϕ Titen HD Anchor

$Nb := \frac{P}{Cap}$ $\quad Nb = 9.517$ $\quad$ no. of bolts $\quad$ say $\quad Nb := 10$

$Sb := \frac{LL}{Nb}$ $\quad Sb = 85.5 \cdot in$ $\quad$ bolt spacing $\quad$ say $\quad Sb := 48 in$

Therefore: Use 1-1/2"ϕ Titen HD Anchor @ 48" o.c.

BRACED FRAME DESIGN:

$F_y := 46 ksi$ $\quad F_u := 58 ksi$ $\quad V := V1 + V2$ $\quad V = 20.87 \cdot k$ $\quad \Omega_{o2} = 2$ $\quad P_u := \Omega_{o2} \cdot \frac{V}{1.3}$ $\quad P_u = 32.107 \cdot k$

Using HSS4x4x1/4: $\quad A_g := 3.37 in^2$ $\quad \phi_{ty} := 0.9$ $\quad \phi_{tf} := 0.75$ $\quad c_1 := 4 in$ $\quad c_2 := 4 in$ $\quad t_f := 0.233 in$

$a := 5.67 ft$ $\quad H_b := 14.42 ft$ $\quad b := \frac{H_b}{2}$ $\quad b = 7.21 ft$ $\quad c := \sqrt{a^2 + b^2}$ $\quad c = 9.172 ft$ $\quad h_{m1} := 6.67 ft$

$\theta := asin\left(\frac{b}{c}\right)$ $\quad \theta = 51.818 \cdot deg$ $\quad \theta_2 := \frac{180 deg - 2 \cdot \theta}{2}$ $\quad \theta_2 = 38.182 \cdot deg$ $\quad 2 \cdot \theta_2 = 76.364 \cdot deg$

Seismic Load $\quad vs_{Lut} := \frac{V_{st}}{Lu_L}$ $\quad vs_{Lut} = 361.915 \cdot plf$ $\quad V_s := vs_{Lut} \cdot \left(\frac{LL + LL_e}{2}\right)$ $\quad V_s = 20.87 \cdot k$

Wind Load $\quad vw_{Lut} := \frac{V_{Wn}}{Lu_L}$ $\quad vw_{Lut} = 274.596 \cdot plf$ $\quad V_w := vw_{Lut} \cdot \left(\frac{LL + LL_e}{2}\right)$ $\quad V_w = 15.835 \cdot k$

Distributed Load

$DL_d := DLr \cdot S_j$ $\quad DL_d = 120 \cdot plf$

$LL_d := LLr \cdot S_j$ $\quad LL_d = 111.6 \cdot plf$ $\quad E := \frac{V_{st}}{Lu_L \cdot Lu_t}$ $\quad E = 8.043 \cdot psf$

$PF_d := P_f \cdot S_j$ $\quad PF_d = 60 \cdot plf$

$1.2 \cdot DLr + 1.6 LLr + P_f \cdot .5 = 58.76 \cdot psf$

$1.2 DLr + 1.6 LLr + 0.8 \cdot P_w = 70.551 \cdot psf$

$1.2 DLr + 1.6 \cdot P_w + LLr + 0.5 \cdot P_f = 81.181 \cdot psf$ $\quad$ governs

$1.2 DLr + E + LLr + 0.2 \cdot P_f = 52.643 \cdot psf$

Reactions from RISA Model:

$R_{n1} := 36.759 k$ $\quad R_{n4} := 36.046 k$ $\quad R_{diag} := 23.998 k$

Max deflection from Risa:

$\Delta_{Risa} := 0.236 in$ $\quad \Delta := \Delta_{Risa} \cdot Cd2$ $\quad \Delta = 0.767 \cdot in$

$\Delta_{allow} := 0.01 \cdot h_w$ $\Delta_{allow} = 1.6 \cdot in$

check := if($\Delta \le \Delta_{allow}$, "OK", "NOT OK") check = "OK"

Therefore: Use HSS4x4x1/4 for Braced Frame

Welded Connection:

$F_{exx} = 70 \cdot ksi$ fillet := $\frac{3}{16} in$ Table J2.4 D := fillet $\phi_w := 0.75$ $H_{bd} := 6.5 in$

$L_e := \frac{2 \cdot H_{bd} - 1.2 \cdot t_f}{\sin(\theta)}$ $L_e = 16.183 \cdot in$

$R_n := 0.6 \cdot F_{exx} \cdot \frac{\sqrt{2}}{2} \cdot D \cdot L_e$ $R_n = 90.112 \cdot k$ $\phi Rn := \phi_w \cdot R_n$ $\phi Rn = 67.584 \cdot k$ Design Shear Strength

check := if($R_{diag} \le \phi Rn$, "OK", "not OK") check = "OK"

check := if($|R_{n1}| \le \phi Rn$, "OK", "not OK") check = "OK"

$P_{ult} := \max(R_{diag}, R_{n1}, R_{n4})$ $P_{ult} = 36.759 \cdot k$

Use 3/16" fillet weld HSS to HSS connection

Base Plate & Anchor Bolts:

$d_c := 4in$ $b_f := 4in$ $N := 12in$ $B := 12in$ $F_y := 36ksi$ $F_c := 3ksi$

$\phi cPn := 0.85 \cdot F_c \cdot B \cdot N$ $\phi cPn = 367.2 \cdot k$

$m := \frac{N - 0.95 \cdot d_c}{2}$ $m = 4.1 \cdot in$

$n := \frac{B - 0.8 \cdot b_f}{2}$ $n = 4.4 \cdot in$

$np := \frac{\sqrt{d_c \cdot b_f}}{4}$ $np = 1 \cdot in$

$X := \left[\frac{4 \cdot d_c \cdot b_f}{(d_c + b_f)^2}\right] \cdot \frac{P_{ult}}{\phi cPn}$ $X = 0.1$

$\lambda plate := \frac{2 \cdot \sqrt{X}}{1 + \sqrt{1 - X}}$ $\lambda plate = 0.325$

check := if($\lambda plate \le 1.0$, "OK", "plate is heavily loaded and simple cantilever method is appropriate") check = "OK"

$\lambda n := \lambda plate \cdot np$ $\lambda n = 0.325 \cdot in$

$l := \max(m, n, \lambda n)$ $l = 4.4 \cdot in$

$t_{p1} := l \cdot \sqrt{\frac{2 \cdot P_{ult}}{0.9 \cdot F_y \cdot B \cdot N}}$ $t_{p1} = 0.552 \cdot in$

Try 3/4"x12"x12" column base plate B

$M_{ot} := \frac{V \cdot b_f}{4}$ $\qquad M_{ot} = 1.739 \cdot k \cdot ft$

$e := \frac{M_{ot}}{P_{ult}}$ $\qquad e = 0.568 \cdot in$

$c := \frac{N}{2}$ $\qquad c = 6 \cdot in$ $\qquad I := \frac{B \cdot N^3}{12}$ $\qquad I = 1728 \cdot in^4$

$\frac{N}{6} = 2 \cdot in$ $\qquad$ if e is less than or equal to N/6, then there is small eccentricity and compressive bearing stress bears on full plate

$f_{p1} := \frac{P_{ult}}{B \cdot N} + \frac{M_{ot} \cdot c}{I}$ $\qquad f_{p1} = 327.736 \cdot psi$ $\qquad f_{p2} := \frac{P_{ult}}{B \cdot N} - \frac{M_{ot} \cdot c}{I}$ $\qquad f_{p2} = 182.806 \cdot psi$

$F_p := 0.85 \cdot 0.6 \cdot F_c \cdot \sqrt{1}$ $\qquad F_p = 1530 \cdot psi$

check := if$\left(F_p \le 1.7 \cdot 0.6 \cdot F_c, \text{"OK"}, \text{"Not OK"}\right)$ $\qquad$ check = "OK"

check := if$\left(f_{p1} \le F_p, \text{"OK"}, \text{"Not OK"}\right)$ $\qquad$ check = "OK"

$L_{crit} := \frac{N - 0.95 \cdot d_c}{2}$ $\qquad L_{crit} = 4.1 \cdot in$

$f_{crit} := f_{p2} + \frac{(f_{p1} - f_{p2}) \cdot (N - L_{crit})}{N}$ $\qquad f_{crit} = 278.218 \cdot psi$

$M_{plu} := \frac{f_{crit} \cdot L_{crit}^2}{2} + \frac{(f_{p1} - f_{crit}) \cdot L_{crit}^2 \cdot 0.67}{2}$ $\qquad M_{plu} = 2.617 \cdot \frac{k \cdot in}{in}$

$t_{p2} := \sqrt{\frac{4 \cdot M_{plu}}{0.9 \cdot F_y}}$ $\qquad t_{p2} = 0.568 \cdot in$ $\qquad$ Use 12"x12"x3/4" for Base Plate B

$T := \frac{M_{ot}}{N - 2in \cdot 2}$ $\qquad T = 2.609 \cdot k$

Use 4 Bolt Connection, 2 Bolts/SIde

Using1" ϕ F1554 Anchor Bolts $\qquad d_b := 1in$ $\qquad \phi_T := 0.75$ $\qquad F_u := 60ksi$

$A_g := 0.601in^2$ $\qquad l_{bolt} := 2in$ $\qquad$ center of bolt to column edge

<u>bolt check:</u>

$P_{brace} := \frac{V \cdot H_b}{a}$ $\qquad P_{brace} = 53.076 \cdot k$ $\qquad T_{act} := \frac{P_{brace}}{4}$ $\qquad T_{act} = 13.269 \cdot k$

$t_{p3} := 2.11\sqrt{\frac{2 \cdot T_{act} \cdot l_{bolt}}{B \cdot F_y}}$ $t_{p3} = 0.74 \cdot in$ $t_p := max(t_{p1}, t_{p2}, t_{p3})$ $t_p = 0.74 \cdot in$

Use 3/4"x 12"x12"Base Plate

Check Bolts using ACI 318 Appendix D using Simspon Strongtie Anchor Selector Software

Note for building in Seismic Design Categories C & D that have a brittle failure mode have a large capacity reduction factor. Bolts should be checked for Seismic in these cases even if Wind controls other aspects of design.

Wind Load Factored for Anchor Selector

$V_{wu} := \frac{V_w}{.6}$ $V_{wu} = 26390.964\,lbf$

$T_{wu} := \frac{(V_{wu} \cdot h_w)}{5ft}$ $T_{wu} = 70358.31\,lbf$

Seismic Load Factored for Anchor Selector

$V_{su} := \frac{V_s}{.7}$ $V_{su} = 29814.039\,lbf$

$T_{su} := \frac{(V_{su} \cdot h_w)}{5ft}$ $T_{su} = 79484.228\,lbf$

Anchor Calculations

Anchor Selector (Version 4.10.0.0)

Job Name : MCD Proto

Date/Time : 12/5/2012 5:52:04 PM

Calculation Summary - ACI 318 Appendix D For Cracked Concrete per ACI 318-08

Anchor

Anchor	Steel	# of Anchors	Embedment Depth (in)	Category
1" Heavy Hex Bolt	F1554 GR. 36	4	18	N/A

Concrete

Concrete	Cracked	f'_c(psi)	$\Psi_{c,V}$
Normal weight	Yes	3000.0	1.40

Condition	Thickness (in)	Suppl. Edge Reinforcement
B tension and shear	36	No

Anchor Layout Dimensions

c_{x1} (in)	c_{x2} (in)	c_{y1} (in)	c_{y2} (in)	b_{x1} (in)	b_{x2} (in)	b_{y1} (in)	b_{y2} (in)	s_{x1} (in)	s_{y1} (in)
26	26	60	60	2	2	2	2	8	8

Factored Loads

N_{ua} (lb)	V_{uax} (lb)	V_{uay} (lb)	M_{ux} (lb*ft)	M_{uy} (lb*ft)
59400	0	22300	0	0

e_x(in)	e_y(in)	Mod/high seismic	Apply entire shear @ front row
0	0	No	No

Individual Anchor Tension Loads

N_{ua1} (lb)	N_{ua2} (lb)	N_{ua3} (lb)	N_{ua4} (lb)
14850.00	14850.00	14850.00	14850.00

e'_{Nx}(in)	e'_{Ny}(in)
0.00	0.00

Individual Anchor Shear Loads

V_{ua1} (lb)	V_{ua2} (lb)	V_{ua3} (lb)	V_{ua4} (lb)
5575.00	5575.00	5575.00	5575.00

e'_{Vx}(in)	e'_{Vy}(in)
0.00	0.00

Tension Strengths

Steel (Φ = 0.75)

N_{sa}(lb)	ΦN_{sa}(lb)	N_{ua}(lb)	$N_{ua}/\Phi N_{sa}$
35150	26362.50	14850.00	0.5633

Concrete Breakout (Φ = 0.70)

N_{cbg}(lb)	ΦN_{cbg}(lb)	ΣN_{ua}(lb)	$\Sigma N_{ua}/\Phi N_{cbg}$
131823.40	92276.38	59400.00	0.6437

Pullout (Φ = 0.70)

N_{pn}(lb)	ΦN_{pn}(lb)	N_{ua}(lb)	$N_{ua}/\Phi N_{pn}$
36024.00	25216.80	14850.00	0.5889

Side-Face Blowout does not apply

Shear Strengths

Steel (Φ = 0.65)

V_{sa}(lb)	ΦV_{sa} (lb)	V_{ua}(lb)	$V_{ua} / \Phi V_{sa}$
21090	13708.50	5575.00	0.4067

Concrete Breakout (case 1) (Φ = 0.70)

V_{cbgx}(lb)	ΦV_{cbgx}(lb)	ΣV_{uax}(lb)	$\Sigma V_{uax} / \Phi V_{cbgx}$
114258.24	79980.77	0.00	0.0000

V_{cbgy}(lb)	ΦV_{cbgy}(lb)	ΣV_{uay}(lb)	$\Sigma V_{uay} / \Phi V_{cbgy}$	$\Sigma V_{ua} / \Phi V_{cbg}$
73072.13	51150.49	11150.00	0.2180	0.2180

Concrete Breakout (case 2) (Φ = 0.70)

V_{cbgx}(lb)	ΦV_{cbgx}(lb)	ΣV_{uax}(lb)	$\Sigma V_{uax} / \Phi V_{cbgx}$
146144.26	102300.98	0.00	0.0000

V_{cbgy}(lb)	ΦV_{cbgy}(lb)	ΣV_{uay}(lb)	$\Sigma V_{uay} / \Phi V_{cbgy}$	$\Sigma V_{ua} / \Phi V_{cbg}$
73072.13	51150.49	22300.00	0.4360	0.4360

Concrete Breakout (case 3) (Φ = 0.70)

c_{x1} edge

V_{cbgy}(lb)	ΦV_{cbgy}(lb)	ΣV_{uay}(lb)	$\Sigma V_{uay} / \Phi V_{cbgy}$
228516.47	159961.53	11150.00	0.0697

c_{y1} edge

V_{cbgx}(lb)	ΦV_{cbgx}(lb)	ΣV_{uax}(lb)	$\Sigma V_{uax} / \Phi V_{cbgx}$
159430.10	111601.07	0.00	0.0000

c_{x2} edge

V_{cbgy}(lb)	ΦV_{cbgy}(lb)	ΣV_{uay}(lb)	$\Sigma V_{uay} / \Phi V_{cbgy}$
228516.47	159961.53	11150.00	0.0697

c_{y2} edge

V_{cbgx}(lb)	ΦV_{cbgx}(lb)	ΣV_{uax}(lb)	$\Sigma V_{uax} / \Phi V_{cbgx}$	$\Sigma V_{ua} / \Phi V_{cbg}$
159430.10	111601.07	0.00	0.0000	0.0697

Pryout (Φ = 0.70)

V_{cpg}(lb)	ΦV_{cpg}(lb)	ΣV_{uax}(lb)	$\Sigma V_{uax} / \Phi V_{cpg}$
263646.81	184552.77	0	0.0000

V_{cpg}(lb)	ΦV_{cpg}(lb)	ΣV_{uay}(lb)	$\Sigma V_{uay} / \Phi V_{cpg}$	$\Sigma V_{ua} / \Phi V_{cpg}$
263646.81	184552.77	22300	0.1208	0.1208

Interaction check

T.Max(0.64) + V.Max(0.44) = 1.08 <= 1.2 [Sec D.7.3]

Interaction check: PASS

Use 1" diameter F1554 GR. 36 Heavy Hex Bolt anchor(s) with 18 in. embedment

Wind OK

Anchor Calculations

Anchor Selector (Version 4.10.0.0)

Job Name : MCD Proto

Date/Time : 12/5/2012 6:02:00 PM

Calculation Summary - ACI 318 Appendix D For Cracked Concrete per ACI 318-08

Anchor

Anchor	Steel	# of Anchors	Embedment Depth (in)	Category
1" Heavy Hex Bolt	F1554 GR. 36	4	18	N/A

Concrete

Concrete	Cracked	f'_c(psi)	$\Psi_{c,V}$
Normal weight	Yes	3000.0	1.40

Condition	Thickness (in)	Suppl. Edge Reinforcement
B tension and shear	36	No

Anchor Layout Dimensions

c_{x1} (in)	c_{x2} (in)	c_{y1} (in)	c_{y2} (in)	b_{x1} (in)	b_{x2} (in)	b_{y1} (in)	b_{y2} (in)	s_{x1} (in)	s_{y1} (in)
26	26	60	60	2	2	2	2	8	8

Factored Loads

N_{ua} (lb)	V_{uax} (lb)	V_{uay} (lb)	M_{ux} (lb*ft)	M_{uy} (lb*ft)
22100	0	8283	0	0

e_x(in)	e_y(in)	Mod/high seismic	Apply entire shear @ front row
0	0	Yes	No

Individual Anchor Tension Loads

N_{ua1} (lb)	N_{ua2} (lb)	N_{ua3} (lb)	N_{ua4} (lb)
5525.00	5525.00	5525.00	5525.00

e'_{Nx}(in)	e'_{Ny}(in)
0.00	0.00

Individual Anchor Shear Loads

V_{ua1} (lb)	V_{ua2} (lb)	V_{ua3} (lb)	V_{ua4} (lb)
2070.75	2070.75	2070.75	2070.75

e'_{Vx}(in)	e'_{Vy}(in)
0.00	0.00

Tension Strengths

Steel ($\Phi = 0.75$)

N_{sa}(lb)	ΦN_{sa}(lb)	N_{ua}(lb)	$N_{ua} / \Phi N_{sa}$
35150	26362.50	5525.00	0.2096

Concrete Breakout ($\Phi = 0.70$, $\Phi_{seis} = 0.75$)

N_{cbg}(lb)	ΦN_{cbg}(lb)	ΣN_{ua}(lb)	$\Sigma N_{ua} / \Phi N_{cbg}$
131823.40	69207.29	22100.00	0.3193

Pullout ($\Phi = 0.70$, $\Phi_{seis} = 0.75$)

N_{pn}(lb)	ΦN_{pn}(lb)	N_{ua}(lb)	$N_{ua} / \Phi N_{pn}$
36024.00	18912.60	5525.00	0.2921

Side-Face Blowout does not apply

Shear Strengths

Steel (Φ = 0.65)

V_{eq}(lb)	ΦV_{eq}(lb)	V_{ua}(lb)	$V_{ua}/\Phi V_{eq}$
21090	13708.50	2070.75	0.1511

Concrete Breakout (case 1) (Φ = 0.70 , Φ_{seis} = 0.75)

V_{cbgx}(lb)	ΦV_{cbgx}(lb)	ΣV_{uax}(lb)	$\Sigma V_{uax}/\Phi V_{cbgx}$
114258.24	59985.57	0.00	0.0000

V_{cbgy}(lb)	ΦV_{cbgy}(lb)	ΣV_{uay}(lb)	$\Sigma V_{uay}/\Phi V_{cbgy}$	$\Sigma V_{ua}/\Phi V_{cbg}$
73072.13	38362.87	4141.50	0.1080	0.1080

Concrete Breakout (case 2) (Φ = 0.70 , Φ_{seis} = 0.75)

V_{cbgx}(lb)	ΦV_{cbgx}(lb)	ΣV_{uax}(lb)	$\Sigma V_{uax}/\Phi V_{cbgx}$
146144.26	76725.73	0.00	0.0000

V_{cbgy}(lb)	ΦV_{cbgy}(lb)	ΣV_{uay}(lb)	$\Sigma V_{uay}/\Phi V_{cbgy}$	$\Sigma V_{ua}/\Phi V_{cbg}$
73072.13	38362.87	8283.00	0.2159	0.2159

Concrete Breakout (case 3) (Φ = 0.70 , Φ_{seis} = 0.75)

c_{x1} edge

V_{cbgy}(lb)	ΦV_{cbgy}(lb)	ΣV_{uay}(lb)	$\Sigma V_{uay}/\Phi V_{cbgy}$
228516.47	119971.15	4141.50	0.0345

c_{y1} edge

V_{cbgx}(lb)	ΦV_{cbgx}(lb)	ΣV_{uax}(lb)	$\Sigma V_{uax}/\Phi V_{cbgx}$
159430.10	83700.80	0.00	0.0000

c_{x2} edge

V_{cbgy}(lb)	ΦV_{cbgy}(lb)	ΣV_{uay}(lb)	$\Sigma V_{uay}/\Phi V_{cbgy}$
228516.47	119971.15	4141.50	0.0345

c_{y2} edge

V_{cbgx}(lb)	ΦV_{cbgx}(lb)	ΣV_{uax}(lb)	$\Sigma V_{uax}/\Phi V_{cbgx}$	$\Sigma V_{ua}/\Phi V_{cbg}$
159430.10	83700.80	0.00	0.0000	0.0345

Pryout (Φ = 0.70 , Φ_{seis} = 0.75)

V_{cpg}(lb)	ΦV_{cpg}(lb)	ΣV_{uax}(lb)	$\Sigma V_{uax}/\Phi V_{cpg}$
263646.81	138414.57	0	0.0000

V_{cpg}(lb)	ΦV_{cpg}(lb)	ΣV_{uay}(lb)	$\Sigma V_{uay}/\Phi V_{cpg}$	$\Sigma V_{ua}/\Phi V_{cpg}$
263646.81	138414.57	8283	0.0598	0.0598

Interaction check

Note: Ratios in the equation below have been divided by 0.5 factor for brittle failure.
T.Max(0.64) + V.Max(0.43) = 1.07 <= 1.2 [Sec D.7.3]

Interaction check: PASS

Use 1" diameter F1554 GR. 36 Heavy Hex Bolt anchor(s) with 18 in. embedment

Seismic Okay

Footing Design For Braced Frame:

$t_s := 16in$ $\quad$ $SBC = 2000 \cdot psf$ $\quad$ $\lambda_{conc} := 1.0$ $\quad$ $F_y := 60ksi$ $\quad$ $f_c := 3000psi$

Assume 6'0"x18'0"x3.0' footing: $\quad b := 6 \cdot ft$ $\quad d := 18ft$ $\quad tf := 3ft$

$Af := b \cdot d$ $\quad$ $Af = 108 ft^2$ $\quad$ $MmaxF := V H_b$ $\quad$ $MmaxF = 300.943 \cdot k \cdot ft$

$DLf := W_c \cdot Af \cdot tf$ $\quad$ $DLf = 48.6 \cdot k$ $\quad$ $DLs := W_s \cdot Af \cdot t_s$ $\quad$ $DLs = 14.4 \cdot k$

$DL_f := DLf + DLs$ $\quad$ $DL_f = 63 \cdot k$

$e := \frac{MmaxF}{DL_f}$ $\quad$ $e = 4.777 ft$

$$q_{max} := \begin{cases} \frac{DL_f}{b \cdot d} & \text{if } e = 0 \\ \frac{DL_f \cdot \left(1 + \frac{6 \cdot e}{d}\right)}{b \cdot d} & \text{if } e \le \frac{d}{6} \\ \frac{2 \cdot DL_f}{3 \cdot b \cdot \left(\frac{d}{2} - e\right)} & \text{if } e > \frac{d}{6} \end{cases}$$

$q_{max} = 1657.539 \cdot psf$

$$q_{min} := \begin{cases} \frac{DL_f}{b \cdot d} & \text{if } e = 0 \\ \frac{DL_f \cdot \left(1 - \frac{6 \cdot e}{d}\right)}{b \cdot d} & \text{if } e \le \frac{d}{6} \\ 0psf & \text{if } e > \frac{d}{6} \end{cases}$$

$q_{min} = 0 \cdot psf$

$Result := \begin{cases} (\text{"Footing Is Okay"}) & \text{if } q_{max} < SBC \\ \text{"ReDesign Footing."} & \text{otherwise} \end{cases}$ $Result = \text{"Footing Is Okay"}$

$MresF := (DLf + DLs)\cdot\frac{d}{2}$ $MresF = 567\cdot k\cdot ft$

$FS := \frac{MresF}{MmaxF}$ $FS = 1.884$

$check := if(FS \geq 1.5, \text{"OK"}, \text{"Not OK"})$ $check = \text{"OK"}$

Use 6'-0" x 18'-0" x 3'-0" footing

$fc := if\left(\sqrt{\frac{f_c}{ksi}}\cdot ksi \leq 100psi, \sqrt{\frac{f_c}{ksi}}\cdot ksi, 100psi\right)$ $fc = 100\cdot psi$

$V_c := 2\cdot\lambda_{conc}\cdot fc\cdot b\cdot tf$ $V_c = 518.4\cdot k$ Nominal shear strength provided by concrete

$space := \frac{tf}{2}$ $space = 18\cdot in$ maximum spacing for shear reinforcement

Try #4 @ 12" o.c. $s := 12in$ $A_4 := .20in^2$ $A_v := A_4\cdot\frac{12in}{s}$ $A_v = 0.2\cdot in^2$ $\phi_c := 0.9$

$V_{smax} := 4\cdot f_c\cdot b\cdot tf$ $V_{smax} = 31104\cdot k$

$V_s := \frac{A_v\cdot F_y\cdot tf}{s}$ $V_s = 36\cdot k$

$V_n := V_c + V_s$ $V_n = 554.4\cdot k$

$V_u := V$ $V_u = 20.87\cdot k$

$\phi V_n := \phi_c\cdot V_n$ $\phi V_n = 498.96\cdot k$

$check := if(\phi V_n \geq V_u, \text{"OK"}, \text{"Not OK"})$ $check = \text{"OK"}$

Use #6 @ 12" o.c. S.W.T&B

$d_{effect} := tf - 3in$ $d_{effect} = 33\cdot in$

Neglecting compression reinforcement and assuming tension controlled section, required tension reinforcement area = ρ

$$\rho_{act} := \frac{0.85\cdot f_c\cdot\left(1.0 - \sqrt{1.0 - \frac{2MresF}{0.765\cdot b\cdot d_{effect}^2\cdot f_c}}\right)}{F_y}$$ $\rho_{act} = 0.00164$ $\beta 1 := 0.85$

$\rho t_{max} := \frac{0.319\cdot\beta 1\cdot f_c}{F_y}$ $\rho t_{max} = 0.014$

$check := if(\rho t_{max} > \rho_{act}, \text{"Tension controlled"}, \text{"Compression controlled"})$ $check = \text{"Tension controlled"}$

$\rho min := \frac{3\cdot\sqrt{\frac{f_c}{psi}}\cdot psi}{F_y}$ $\rho min = 0.003$

$check := if(\rho_{min} > \rho_{act}, \text{"Use min"}, \text{"Use "})$ $check = \text{"Use min"}$

$\rho_{min2} := \frac{200psi}{F_y}$ $\rho_{min2} = 0.003$

$check := if(\rho_{min2} > \rho_{act}, \text{"use min"}, \text{"Use"})$ $check = \text{"use min"}$

$\rho_f := \begin{cases} \rho_{act} \cdot \frac{4}{3} & \text{if } \rho_{act} < \rho_{min2} \\ \rho_{min2} & \text{otherwise} \end{cases}$ $\rho_f = 0.0022$

$\rho := max(\rho_f, 0.0018)$ $\rho = 0.00218$

Required reinforcement area: $A_7 := 0.60in^2$ $A_8 := 0.79in^2$ $A_9 := 1.0in^2$

$A_{sreqd} := \rho \cdot b \cdot d_{effect}$ $A_{sreqd} = 5.191 \cdot in^2$ $N_b := \frac{A_{sreqd}}{A_7}$ $N_b = 8.652$

Use 9-#7 L.W.T&B

Drag Strut @ Braced Frame:

$Spand := L_j - 6.67ft$ $V_h := V \cdot \Omega_{o2}$ $wh1 := \frac{V_h}{Spand}$ $wh1 = 1128.099 \cdot plf$ $V4 = 20.87 \cdot k$ $F_y := 36ksi$

Welded Connection: $F_{exx} = 70 \cdot ksi$ $\phi_w := 0.75$ $\phi_b := 0.9$ $l_{wc} := 3.5in$ length of weld plate to column. $l_{wj} := 4.5in$ length of weld plate to joist

using plate 1/2"x6"x6" $A_{g1} := l_{wc} \cdot 0.5in$ $A_{g1} = 1.75 \cdot in^2$ $fillet := \frac{4}{16}in$ $D := fillet$

$A_{plate} := 0.5in \cdot 6in$

$R_{nw} := F_y \cdot A_{g1}$ $R_{nw} = 63 \cdot k$ $\phi R_{nw} := \phi_w \cdot R_{nw}$ $\phi R_{nw} = 47.25 \cdot k$ Design Strength of weld to col.

$R_{nl} := F_y \cdot A_{plate}$ $R_{nl} = 108 \cdot k$ $\phi R_{nl} := \phi_b \cdot R_{nl}$ $\phi R_{nl} = 97.2 \cdot k$ Design Strength of plate

$R_{nj} := 0.6 \cdot F_{exx} \cdot \frac{\sqrt{2}}{2} \cdot D \cdot (l_{wj} \cdot 2)$ $R_{nj} = 66.822 \cdot k$ $\phi R_{nj} := \phi_w \cdot R_{nj}$ $\phi R_{nj} = 50.116 \cdot k$ Design Strength of weld to joist

$\phi R_n := min(\phi R_{nw}, \phi R_{nl}, \phi R_{nj})$ $\phi R_n = 47.25 \cdot k$

$check := if(\phi R_n \geq V_h, \text{"OK"}, \text{"Not OK"})$ $check = \text{"OK"}$

Weld drag strut to Plate 1/2"x6"x6" with fillet weld and plate to column with complete joint pen. weld

Angle @ Braced Frame:

$R_{jmax} = 9.346 \cdot k$

Welded Connection: $F_{exx} = 70 \cdot ksi$

using angle L6 x 6 x 1/2 x 9" $A_g := 6in \cdot 0.5in$ $A_g = 3 \cdot in^2$ $F_y := 36ksi$ $fillet := \frac{1}{4}in$ Table J2.4

$D := fillet$ $l_w := 5in$ $\phi_w := 0.75$ $\phi_b := 0.9$

$R_{nw} := 0.6 \cdot F_{exx} \cdot \frac{\sqrt{2}}{2} \cdot D \cdot (l_w \cdot 2)$ $R_{nw} = 74.246 \cdot k$ $\phi R_{nw} := \phi_w \cdot R_{nw}$ $\phi R_{nw} = 55.685 \cdot k$ Design Strength of weld

$R_{nl} := F_y \cdot A_g$ $R_{nl} = 108 \cdot k$ $\phi R_{nl} := \phi_b \cdot R_{nl}$ $\phi R_{nl} = 97.2 \cdot k$ Design Strength of angle

$\phi R_n := \min(\phi R_{nw}, \phi R_{nl})$ $\phi R_n = 55.685 \cdot k$

check := if($\phi R_n \geq Rj_{max}$, "OK" , "Not OK") check = "OK"

Weld drag strut to L6x6x1/2x9" with 1/4" fillet weld on each side, and angle to frame 1/4"' weld each side