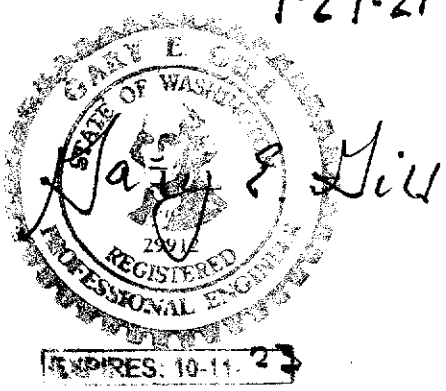
Bird McDonald Residence

4304 East Mercer Way
Mercer Island, WA 98040

STRUCTURAL CALCULATIONS

September 21, 2021

9-29-21



Prepared by

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Lateral

Design Criteria

Address: Paul McDonald & Carly Bird-Vogel4
304 E Mercer Way
Mercer Island, WA 98040

Seismic (2018 IBC)

Sds := 0.963 soil factors included
site class D

R = 6.5

Wind (ASCE 7-16)

Wind Speed = 110 mph Exposure B Kzt = 1.0
(exposure and Kzt from Google Earth)
V := 110

Roof Snow (ASCE 7-16)

Pg := 30 psf ws := Pg

Dead Loads

Roof

Ballast none
Roofing Membrane
sheathing 5/8" pw
purlins 11 7/8 560 TJ:I@16"
beams 6x12@12'
insul 10" BATT
ceiling 5/8 gyp
Mech/misc

rcob := 0
rf := 1
shtg := 1.9
rpurl := $\frac{4}{1.33}$
rbm := 1.3
rins := 1
rclg := 2.2
rspac := 1.6

wr := rcob + rf + shtg + rpurl + rbm + rins + rspac + rclg
wr = 12 psf

Main Floor

Flooring carpet/wood
Sheathing 1.125" pw
purlins 11 7/8 110 @16"
beams W10x39@23'
Ceiling 5/8 gyp
Topping none
Misc/Mech

lf := 3
lshtg := 4.3
lpurl := $\frac{2.5}{1.33}$
lbm := $\frac{39}{23}$
lclg := 2.2
ltpg := 0
lmisc := 1.9

w2 := lf + lpurl + lbm + lclg + lshtg + lmisc + ltpg
w2 = 15 psf w2l := 40

Lateral

Seismic

AreaURoof := 3362 sf WUroof := AreaURoof·(wr + 2) WUroof = 47093.3

Ct := .028 x := .8 hn := 22 Ta := $Ct \cdot hn^{x}$ Ta = 0.3

Rlong := 6.5 Cslong := $\frac{Sds}{Rlong \cdot 1.4}$ Cslong = 0.11 above min and below max

Cslongmax := $\frac{Sds}{Rlong \cdot Ta \cdot 1.4}$ Cslongmax = 0.3 Cslongmin := .044·Sds Cslongmin = 0.042

Ct := .02 x := .75 hn := 22 Ta := $Ct \cdot hn^{x}$ Ta = 0.2

Rtrans := 6.5 Cstrans := $\frac{Sds}{Rtrans \cdot 1.4}$ Cstrans = 0.11

Area2ndFloor := 2055

W2ndFloor := Area2ndFloor·(w2 + 4)

W2ndFloor = 38994.3

hr := 21.5 hrxWroof := hr·WUroof hrxWroof = 1012505.5

h2 := 10 h2xW2ndFloor := h2·W2ndFloor h2xW2ndFloor = 389943.5

SumhxW := hrxWroof + h2xW2ndFloor SumhxW = 1402449

Csr := $\frac{hrxWroof}{SumhxW}$ Csr = 0.7

Cs2 := $\frac{h2xW2ndFloor}{SumhxW}$ Cs2 = 0.3

Wtot := WUroof + W2ndFloor Wtot = 86087.6

Vsrlong := Wtot·Csr·Cslong Vsrlong = 6577.1

Vsrtrans := Wtot·Csr·Cstrans Vsrtrans = 6577.1

Vs2long := Wtot·Cs2·Cslong Vs2long = 2533

Vs2trans := Wtot·Cs2·Cstrans Vs2trans = 2533

Vsrtrans + Vs2trans = 9110.2 Vstrans := Vsrtrans + Vs2trans

Vsrlong + Vs2long = 9110.2 Vslong := Vsrlong + Vs2long

Lateral

Wind

Basic Wind Speed $BWS := 110$ mph Exposure B $Kzt = 1.0$

$Alpha := 7$ $Zg := 1200$ $Ht := 17$

$Kd := .85$ $Kz := 2.01 \cdot \left(\frac{Ht}{Zg}\right)^{\frac{2}{Alpha}}$ $Kz = 0.6$ $Kzt := 1.0$

$q := .00256 \cdot Kd \cdot Kz \cdot Kzt \cdot \frac{BWS^2}{1.4}$ $q = 11.2$

$Vwrlong := 24 \cdot \frac{11.5}{2} \cdot q$ $Vwrlong = 1545.9$

$Vwrtrans := 86 \cdot \frac{11.5}{2} \cdot q$ $Vwrtrans = 5539.5$

$Vw2long := 24 \cdot (11.5 + 5) \cdot q$ $Vw2trans := 86 \cdot (11.5 + 5) \cdot q$

$Vw2long = 4436.1$ $Vw2trans = 15895.9$

$Vwlong := Vwrlong + Vw2long$

$Vwlong = 5982$

$Vwtrans := Vwrtrans + Vw2trans$

$Vwtrans = 21435.4$

Wind Controls in Transverse direction and Seismic Controls in Longitudinal Direction

Shear Walls

Roof to 1st Floor

Check Redundancy (Number of Bays >= 2 therefore r = 1)

$L1 := 3 + 3 + 3 + 3$ $L1 = 12$ $NoBays := \frac{2 \cdot L1}{10}$ $NoBays = 2.4$ OK

$L2 := 20.33 + 9.07 + 12.5$ $L2 = 41.9$ $NoBays := \frac{2 \cdot L2}{9}$ $NoBays = 9.3$ OK

$LA := 8.66 + 4.57 + 3.07$ $LA = 16.3$ $NoBays := \frac{2 \cdot LA}{9}$ $NoBays = 3.6$ OK

$LB := 15.93 + 4.66$ $LB = 20.6$ $NoBays := \frac{2 \cdot LB}{9}$ $NoBays = 4.6$ OK

$LC := 11.33$ $LC = 11.3$ $NoBays := \frac{2 \cdot LC}{11}$ $NoBays = 2.1$ OK

$LD := 6 + 6.33 + 3.07$ $LD = 15.4$ $NoBays := \frac{2 \cdot LD}{11}$ $NoBays = 2.8$ OK

Distribute Shear to Shear Walls

Shear Wall S1

$V1 := Vsrlong \cdot \left(\frac{1}{2}\right)$ $V1 = 3288.6$ $v1 := \frac{V1}{L1}$ $v1 = 274$

$HD := v1 \cdot 10 - 9 \cdot 10 \cdot \frac{L1}{2}$ $HD = 2200.5$ Use: SW1 & HD1

Shear Wall S2

$V2 := Vsrlong \cdot \left(\frac{1}{2}\right)$ $V2 = 3288.6$ $v2 := \frac{V2}{L2}$ $v2 = 78.5$

$HD := v2 \cdot 10 - 9 \cdot 10 \cdot \frac{L2}{2}$ $HD = -1100.6$ Use: SW1 & HD2

Shear Wall SA

$VA := Vwrtrans \cdot \left(\frac{13}{86}\right)$ $VA = 837.4$ $vA := \frac{VA}{LA}$ $vA = 51.4$

$HD := vA \cdot 9 - 9 \cdot 10 \cdot \frac{LA}{2}$ $HD = -271.2$ Use: SW1 & HD1

Lateral

Shear Wall SB

$VB := Vwrtrans \cdot \left(\frac{30}{2 \cdot 86}\right)$ VB = 966.2 $vB := \frac{VB}{LB}$ vB = 46.9

$HD := vB \cdot 11 - 11 \cdot 10 \cdot \frac{LB}{2}$ HD = −616.3 Use: SW1 & HD1

Shear Wall SC

$VC := Vwrtrans \cdot \left(\frac{60.5}{2 \cdot 86}\right)$ VC = 1948.5 $vC := \frac{VC}{LC}$ vC = 172

$HD := vC \cdot 11 - 11 \cdot 10 \cdot \frac{LC}{2}$ HD = 1268.6 Use: SW1 & HD1

Shear Wall SD

$VD := Vwrtrans \cdot \frac{56}{2 \cdot 86}$ VD = 1803.6 $vD := \frac{VD}{LD}$ vD = 117.1

$HD := vD \cdot 11 - 11 \cdot 10 \cdot \frac{LD}{2}$ HD = 441.3 Use: SW1 & HD2

1st Floor to Basement

Check Redundancy (Number of Bays >= 2 therefore r = 1)

$L1 := 5.5 + 23.5 + 3 + 5.75 + 11$ L1 = 48.8 $NoBays := \frac{2 \cdot L1}{9}$ NoBays = 10.8 OK

L2 is a continous concrete wall. OK by inspection.

$LA := 2.75 + 2.75$ LA = 5.5 $NoBays := \frac{2 \cdot LA}{9}$ NoBays = 1.2 r=1.3

$LB := 11.25$ LB = 11.3 $NoBays := \frac{2 \cdot LB}{9}$ NoBays = 2.5 OK

$LC := 17.17$ LC = 17.2 $NoBays := \frac{2 \cdot LC}{9}$ NoBays = 3.8 OK

LD is a continous concrete wall. OK by inspection.

Distribute Shear to Shear Walls

Shear Wall S1

$V1 := Vslong \cdot \left(\frac{1}{2}\right)$ V1 = 4555.1 $v1 := \frac{V1}{L1}$ v1 = 93.4

$HD := v1 \cdot 9 - 9 \cdot 10 \cdot \frac{L1}{2}$ HD = −1352.8 Use: SW1 & HD2

Shear Wall SA

$VA := Vwtrans \cdot \left(\frac{13}{86}\right)$ VA = 3240.2 $vA := \frac{VA}{LA}$ vA = 589.1

Check Seismic with redundancy

$VAs := Vslong \cdot 1.3 \cdot \frac{13}{86}$ VAs = 1790.3 Wind Controls

$HD := vA \cdot 9 - 9 \cdot 10 \cdot \frac{LA}{2}$ HD = 5054.7 Use: SW3 & HD4

Shear Wall SB

$VB := Vwtrans \cdot \left(\frac{30}{2 \cdot 86}\right)$ VB = 3738.7 $vB := \frac{VB}{LB}$ vB = 332.3

$HD := vB \cdot 9 - 9 \cdot 10 \cdot \frac{LB}{2}$ HD = 2484.7 Use: SW2 & HD2

Shear Wall SC

$VC := Vwtrans \cdot \left(\frac{60.5}{2 \cdot 86}\right)$ VC = 7539.8 $vC := \frac{VC}{LC}$ vC = 439.1

$HD := vC \cdot 9 - 9 \cdot 10 \cdot \frac{LC}{2}$ HD = 3179.5 Use: SW2 & HD2

Entry Lateral

The cantilevered concrete wall on the north side of the entry vestibule will resist the seismic and wind forces for the wall itself as well as the roof of the entry

AreaRoof := 186 WtRoof := AreaRoof·(wr + 2) WtRoof = 2605.4

$WtWall := \frac{10}{12} \cdot 150 \cdot 10 \cdot 15$ WtWall = 18750

$Vs := \frac{(WtWall + WtRoof) \cdot Sds}{2.5}$ Vs = 8226.1

Vw := 10·15·q Vw = 1680.3 **Seismic Governs**

Footing

$Mot := \frac{WtWall \cdot 5 + WtRoof \cdot 10}{2.5 \cdot 1.4}$ Mot = 34229.7

FtgWidth := 4 FtgDepth := 1 WtFtg := 15·150·FtgWidth·FtgDepth

Lateral

$WtFtg = 9000$

$$Mr := (WtWall + WtFtg)\cdot\frac{FtgWidth}{2} \qquad Mr = 55500$$

$Mr = 55500$ $\qquad FOS := \frac{Mr}{Mot}$ $\qquad FOS = 1.6$ **Use**: 48"Wx12"D conc ftg

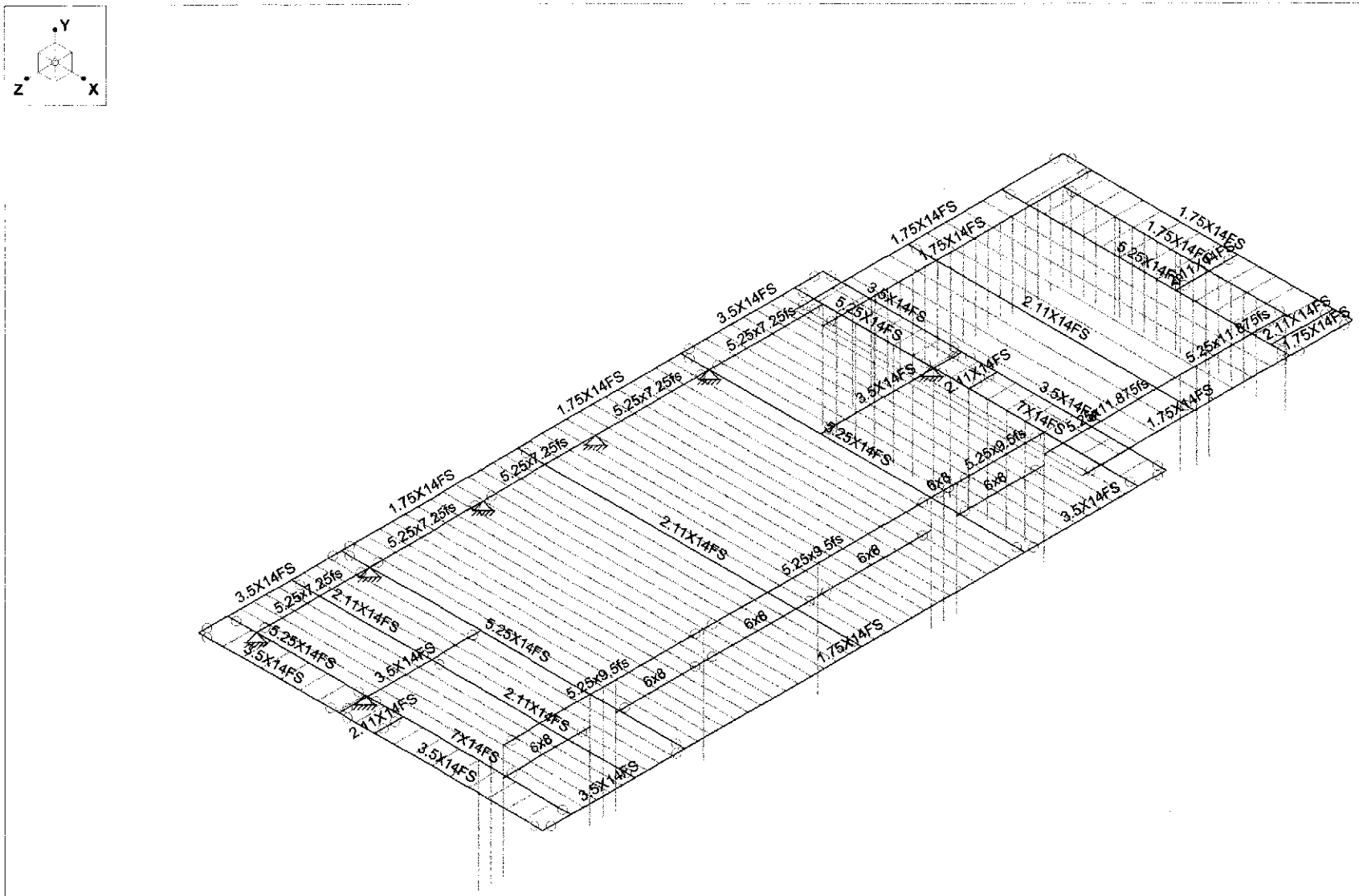
Pipe Piles

Total weight of footing and wall and roof will need to be resisted by the piles on each side of the footing

With 2" pipe piles: $Pall := 6000$

$$NoPiles := \frac{(WtWall + WtFtg + WtRoof)}{Pall}\cdot 2 \qquad NoPiles = 10.1$$

Use: 10-2" dia pipe piles at masonry wall.

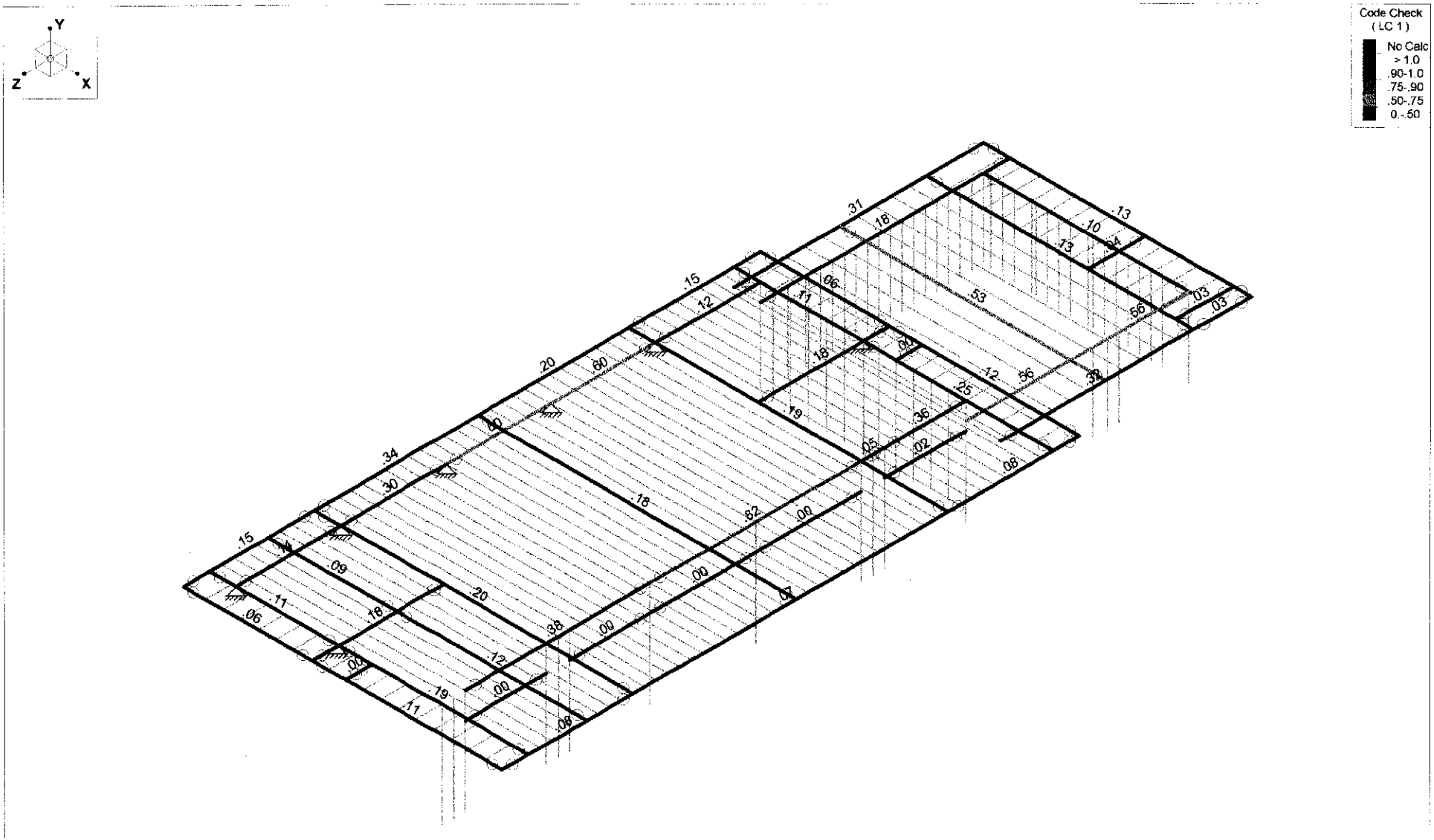


Member Sizes

Roof Framing - 1

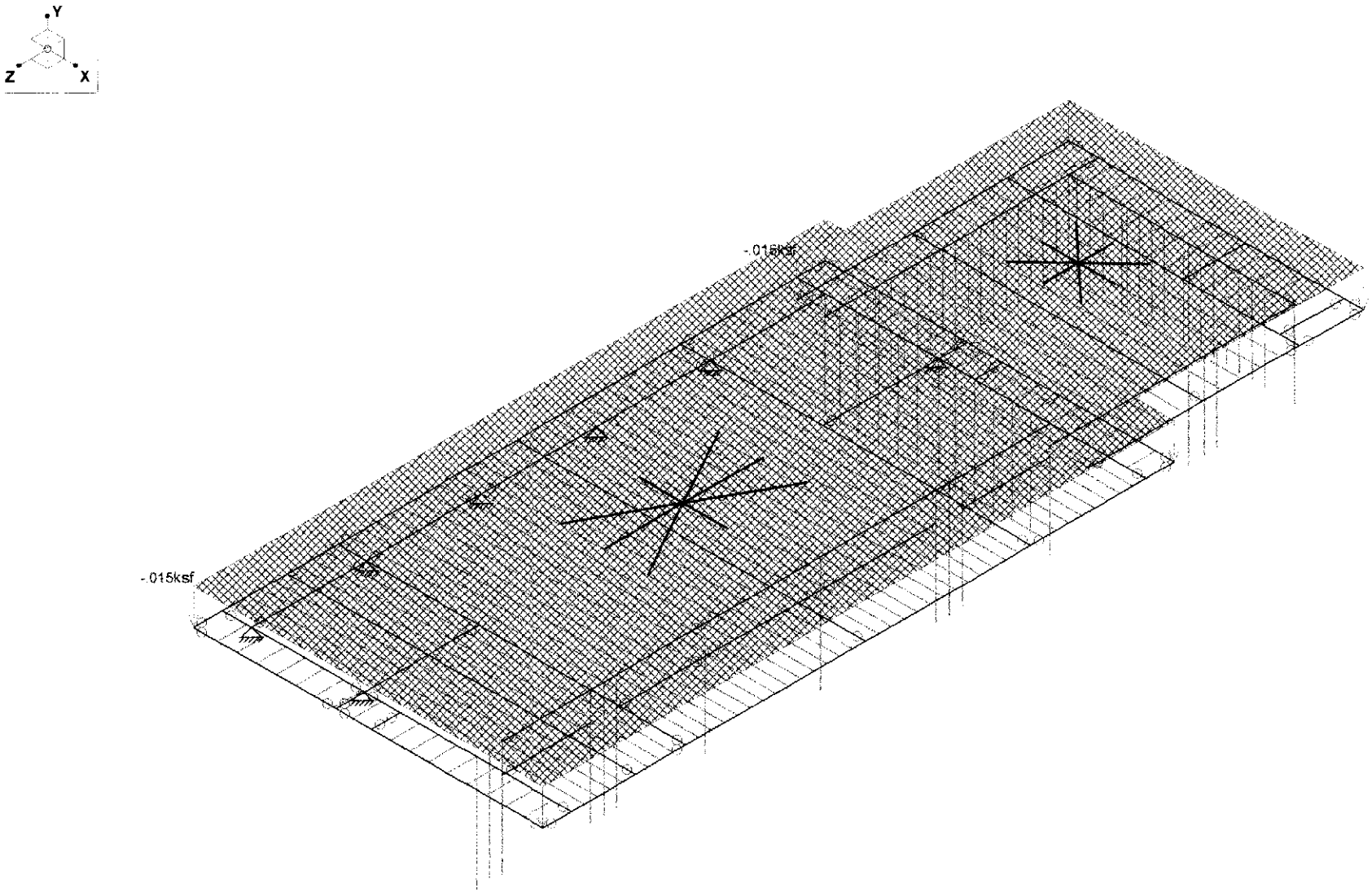
Sept 21, 2021 at 12:03 PM

bird mcdonald model.r3d



Member Code Checks Displayed
Results for LC 1, d+sn

	Stress Check Dead + Snow	Roof Framing - 2
		Sept 21, 2021 at 12:04 PM
		bird mcdonald model.r3d



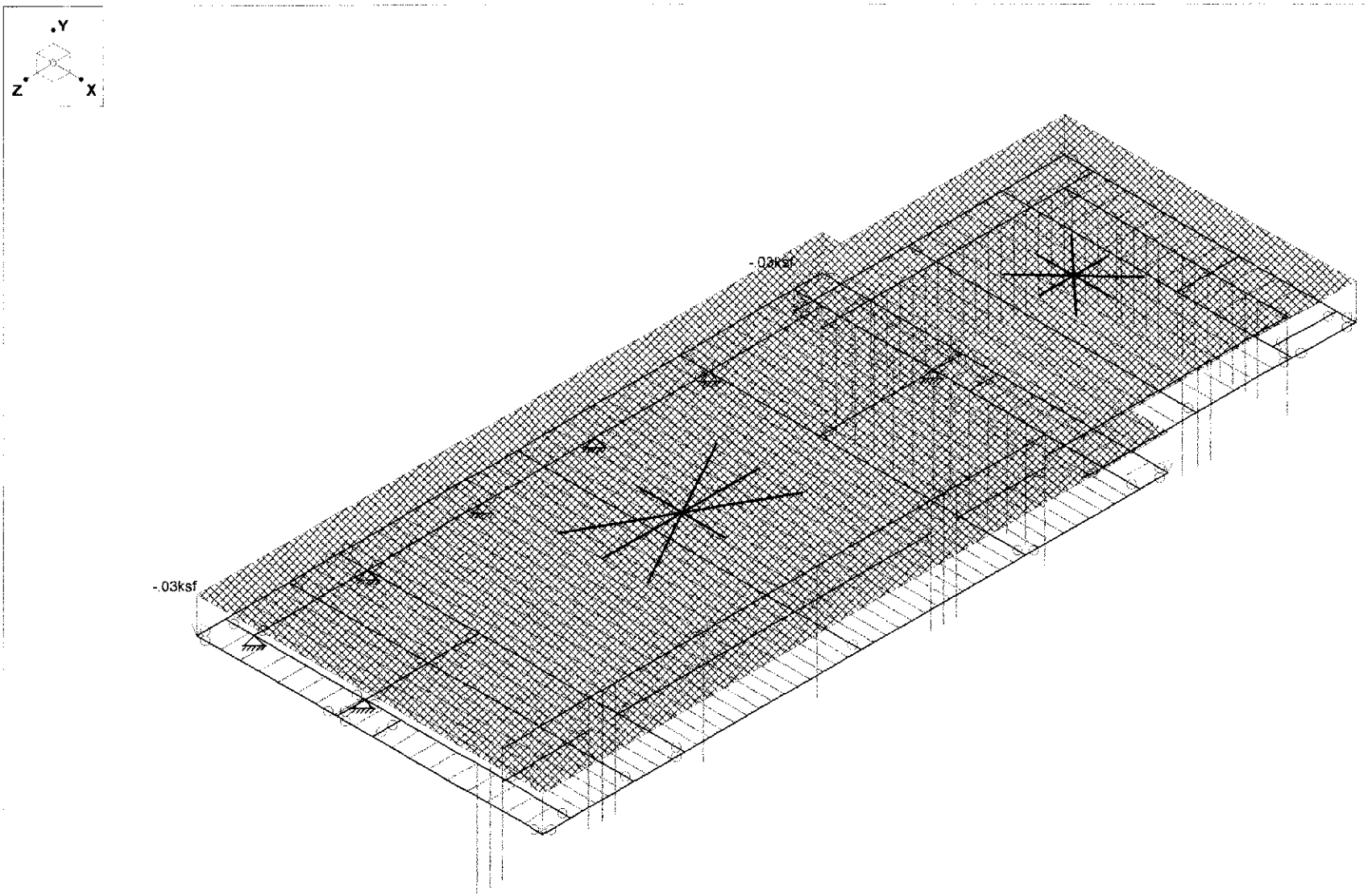
Loads: BLC 1, dead

Dead Load

Roof Framing - 3

Sept 21, 2021 at 12:05 PM

bird mcdonald model.r3d



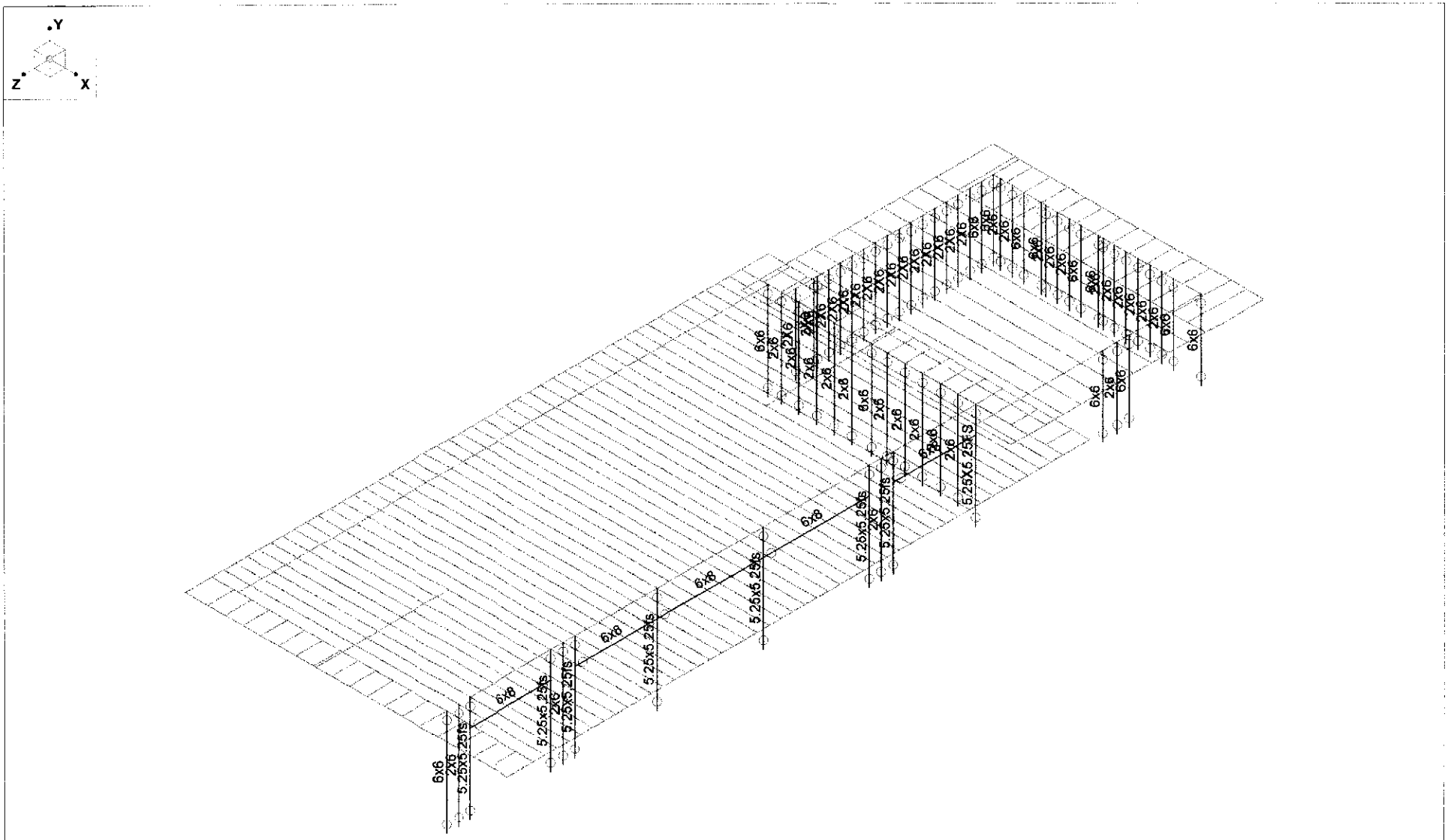
Loads: BLC 2, snow

Roof Framing - 4

Sept 21, 2021 at 12:05 PM

bird mcdonald model.r3d

Snow Load



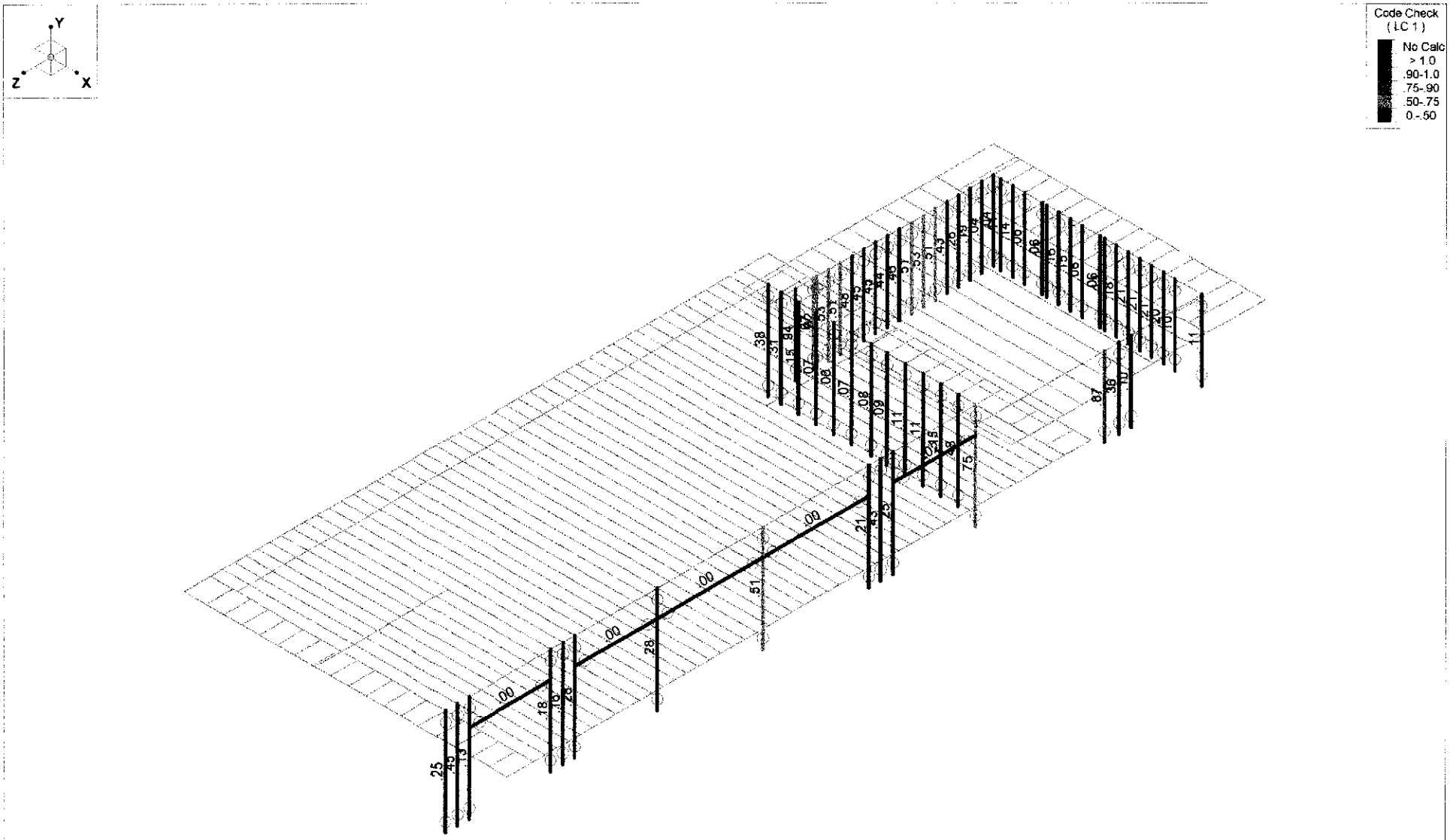
Loads: BLC 2, snow

Columns and Studs with Transom Beams

Roof Framing - 5

Sept 21, 2021 at 12:08 PM

bird mcdonald model.r3d



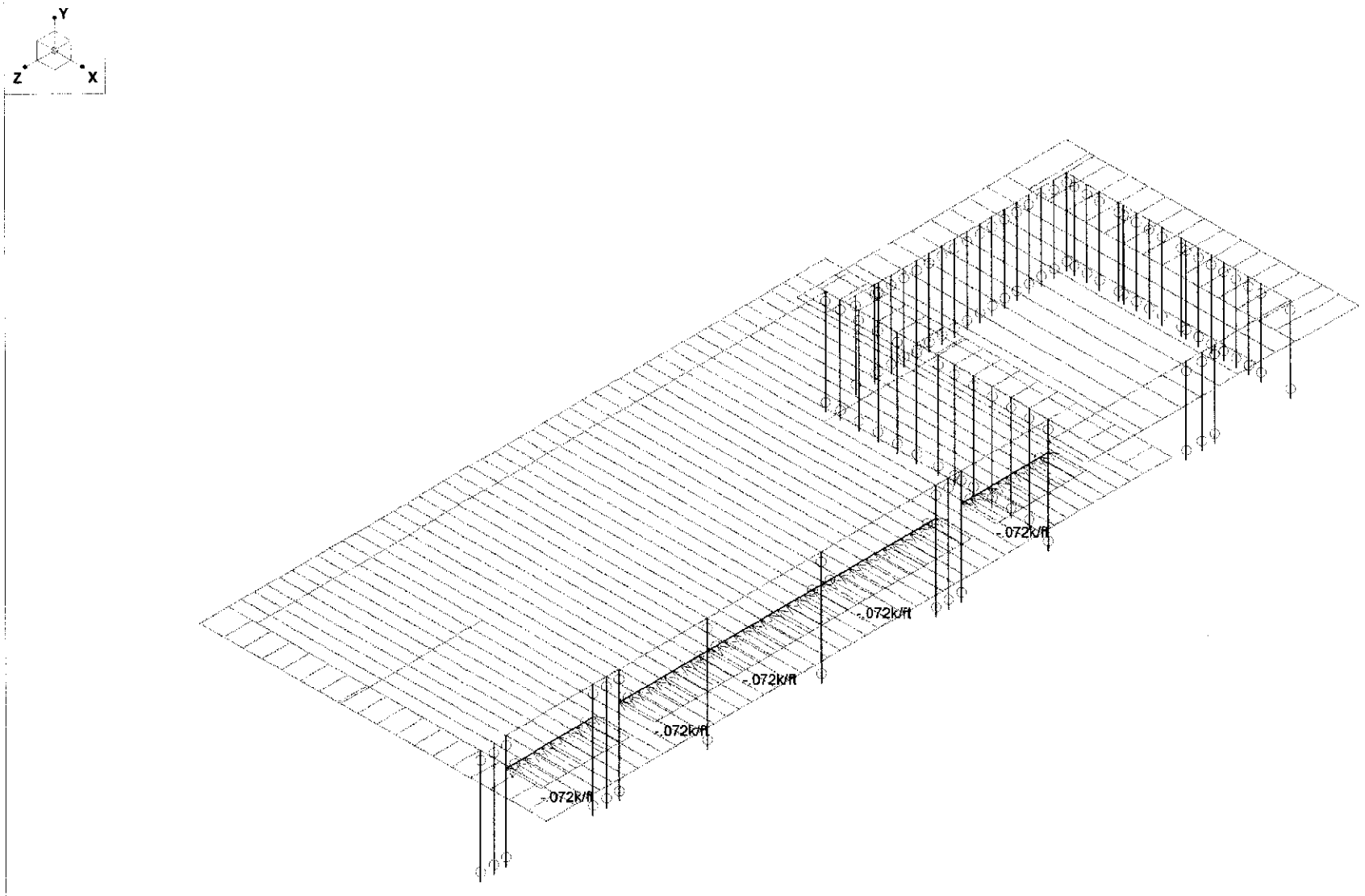
Member Code Checks Displayed
Loads: BLC 2, snow
Results for LC 1, d+sn

Column and Stud Stress Check Dead + Snow

Roof Framing - 6

Sept 21, 2021 at 12:09 PM

bird mcdonald model.r3d



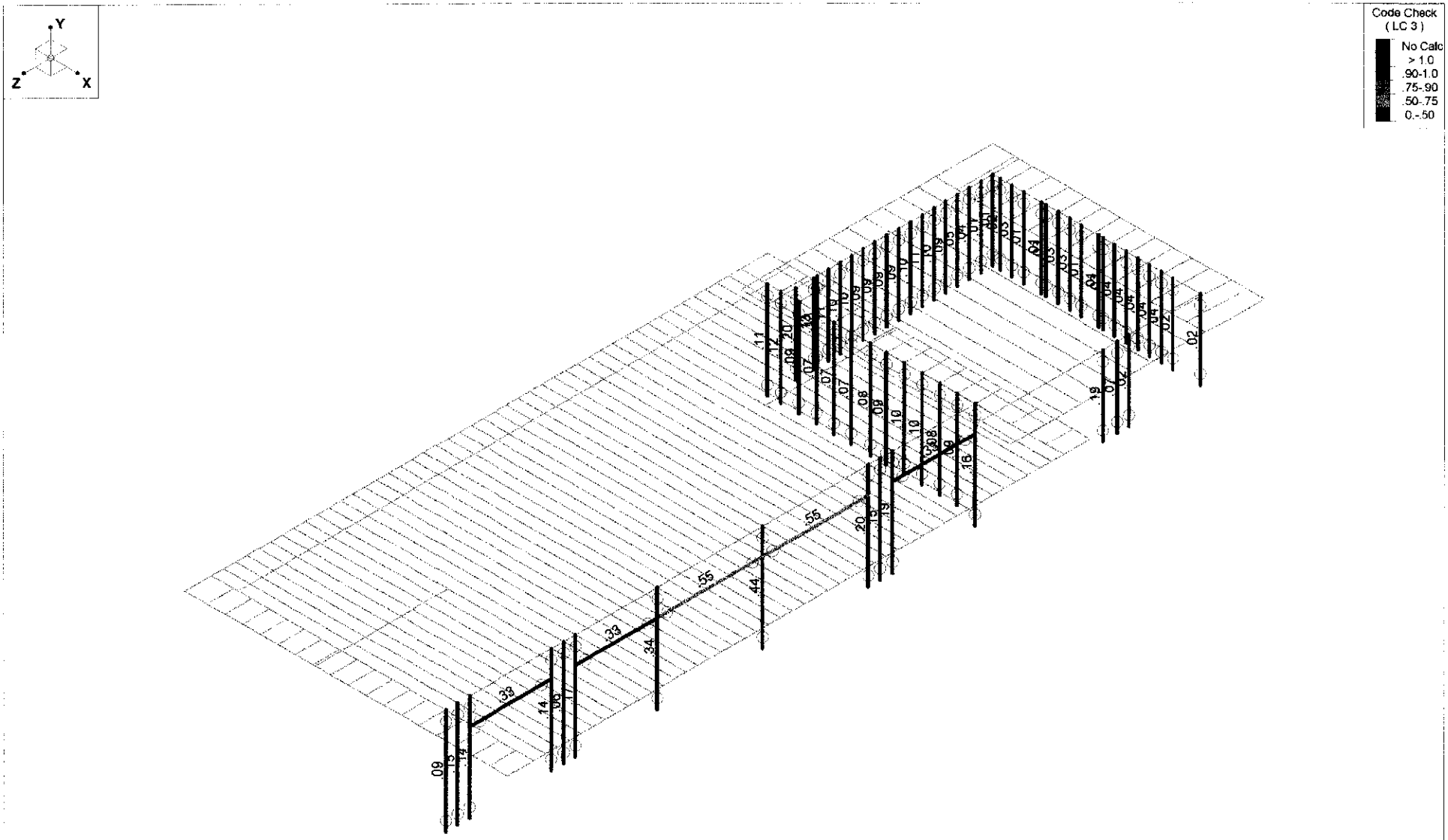
Loads: BLC 3,

Transom Beam Wind Loads

Roof Framing - 7

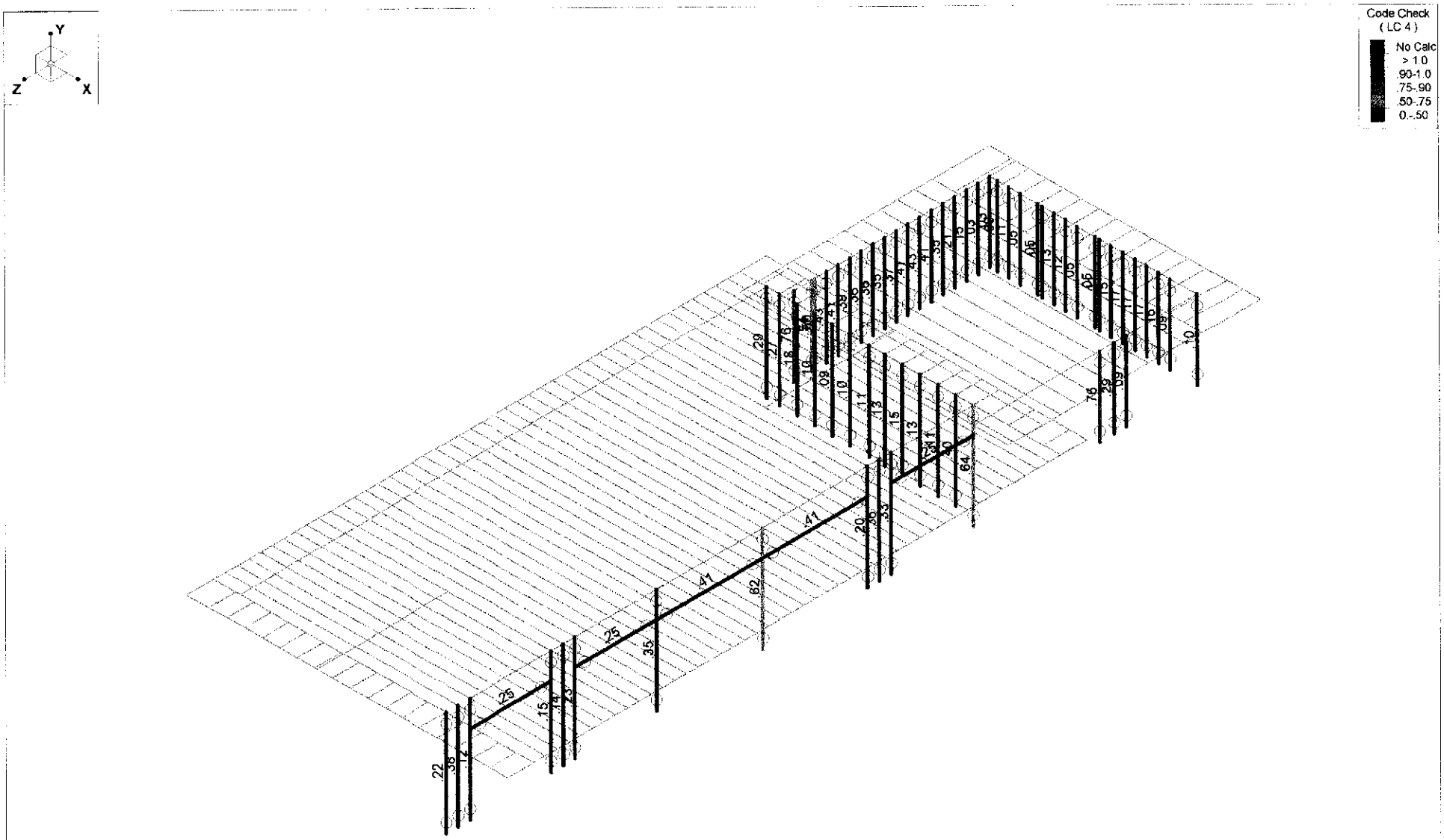
Sept 21, 2021 at 12:10 PM

bird mcdonald model.r3d



Member Code Checks Displayed
Results for LC 3, d+windx

	Stress Check for Dead + Windx	Roof Framing - 8 Sept 21, 2021 at 12:11 PM bird mcdonald model.r3d



Member Code Checks Displayed
Results for LC 4, d+.75snow+.75windx

Stress Check for Dead + .75 Snow + .75 Windx

Roof Framing - 9

Sept 21, 2021 at 12:12 PM

bird mcdonald model.r3d

RW1 (H=10'-0")

$A := 1$ $Tw := .66$ $B := 6$ $Tf := 1.33$ $H1 := .5$ $H := 10$

$ECP := .035$ $S := .008$ $Sur := .0 \cdot H$ $SoilWt := .13$

$Vecp := \frac{H^2}{2} \cdot ECP$ $Vecp = 1.75$ $Vs := S \cdot H^2$ $Vs = 0.8$ $Vsur := Sur \cdot H$ $Vsur = 0$

$$Mot := Vecp \cdot \left(\frac{H}{3} + H1 + Tf\right) + Vs \cdot \left(\frac{H}{2} + H1 + Tf\right) + Vsur \cdot \left(\frac{H}{2} + Tf + H1\right)$$

$Mot = 14.5$

$Wf := (A + Tw + B) \cdot Tf \cdot .15$ $Ww := (H + .5 + H1) \cdot Tw \cdot .15$ $Ws := A \cdot (H + H1) \cdot SoilWt$

$Wf = 1.528$ $Ww = 1.089$ $Ws = 1.365$

$W := Wf + Ww + Ws$ $W = 3.982$

$$Mr := Wf \cdot \frac{(A + Tw + B)}{2} + Ww \cdot \left(B + \frac{Tw}{2}\right) + Ws \cdot \left(B + Tw + \frac{A}{2}\right)$$ $Mr = 22.52$

$$FOS := \frac{Mr}{Mot}$$ $FOS = 1.553$

$$xb := \frac{Mr - Mot}{W}$$ $xb = 2.014$ $qmax := \frac{2 \cdot W}{3 \cdot xb}$ $qmax = 1.318$ **OK with sesimic**

Reinforcing

Wall

Bottom of Wall

$$Mu := 1.4 \cdot Vs \cdot \frac{H}{2} + 1.6Vecp \cdot \frac{H}{3} + 1.6Vsur \cdot \frac{H}{2}$$ $Mu = 14.933$

$d := 6$ $A := .75$ $Spac := 12$ $As := A \cdot \frac{12}{Spac}$

$$a := \frac{As \cdot 60}{12 \cdot .85 \cdot 2.5}$$ $a = 1.765$

$$PhiMc := As \cdot 60 \cdot .9 \cdot \frac{\left(d - \frac{a}{2}\right)}{12}$$ $PhiMc = 17.272$ **OK** Use: **#6&#5v @ 12"**

3 feet above bottom of Wall

$H3 := H - 3$

$V3ecp := \frac{H3^2}{2} \cdot ECP$ $V3ecp = 0.858$ $V3s := S \cdot H3^2$ $V3s = 0.392$ $V3sur := Sur \cdot H3$ $V3sur =$

$Mu := 1.4 \cdot V3s \cdot \frac{H3}{2} + 1.6V3ecp \cdot \frac{H3}{3} + 1.6V3sur \cdot \frac{H3}{2}$ $Mu = 5.122$

$d := 6$ $A := .31$ $Spac := 12$ $As := A \cdot \frac{12}{Spac}$

$a := \frac{As \cdot 60}{12 \cdot .85 \cdot 2.5}$ $a = 0.729$

$PhiMc := As \cdot 60 \cdot .9 \cdot \frac{\left(d - \frac{a}{2}\right)}{12}$ $PhiMc = 7.861$ **OK** Use: **#5v @ 12" ABV 3'-0"**

Footing

Bottom Bars

$Mbu := 1.55 \cdot W \cdot (B - xb)$ $Mbu = 24.603$

$d := 13$ $A := .44$ $Spac := 12$ $As := A \cdot \frac{12}{Spac}$

$a := \frac{As \cdot 60}{12 \cdot .85 \cdot 2.5}$ $a = 1.035$

$PhiMc := As \cdot 60 \cdot .9 \cdot \frac{\left(d - \frac{a}{2}\right)}{12}$ $PhiMc = 24.715$ **OK** Use: **#6b@12" Hooked**

RW1 (H=10'-0")

$A := 1$ $Tw := .66$ $B := 6$ $Tf := 1$ $H1 := .5$ $H := 10$

$ECP := .035$ $S := .008$ $Sur := 0$ o 12

$Vecp := \frac{H^2}{2} \cdot ECP$ $Vecp = 1.75$ $Vs := S \cdot H^2$ $Vs = 0.8$ $Vsur := Sur \cdot H$ $Vsur = 0$

$Mot := Vecp \cdot \left(\frac{H}{3} + H1 + Tf\right) + Vs \cdot \left(\frac{H}{2} + H1 + Tf\right) + Vsur \cdot \left(\frac{H}{2} + Tf + H1\right)$

$Mot = 13.658$

$Wf := (A + Tw + B) \cdot Tf \cdot .15$ $Ww := (H + .5 + H1) \cdot Tw \cdot .15$ $Ws := A \cdot (H + H1) \cdot .11$

$Wf = 1.149$ $Ww = 1.089$ $Ws = 1.155$

$W := Wf + Ww + Ws$ $W = 3.393$

$Mr := Wf \cdot \frac{(A + Tw + B)}{2} + Ww \cdot \left(B + \frac{Tw}{2}\right) + Ws \cdot \left(B + Tw + \frac{A}{2}\right)$ $Mr = 19.564$

$FOS := \frac{Mr}{Mot}$ $FOS = 1.432$

$xb := \frac{Mr - Mot}{W}$ $xb = 1.74$ $qmax := \frac{2 \cdot W}{3 \cdot xb}$ $qmax = 1.3$

$Sliding := \frac{Vecp + Vs}{W}$ $Sliding = 0.752$ $FOS := \frac{.45}{Sliding}$ $FOS = 0.599$

OK with sesimic

Reinforcing

$Mu := 1.6 \cdot \left(Vs \cdot \frac{H}{2} + Vecp \cdot \frac{H}{3} + Vsur \cdot \frac{H}{2}\right)$ $Mu = 15.733$

$d := 4$ $A := .31$ $Spac := 1$ $As := A \cdot Spac$

$a := \frac{As \cdot 60}{12 \cdot .85 \cdot 2.5}$ $a = 0.729$

$PhiMc := As \cdot 60 \cdot .9 \cdot \frac{\left(d - \frac{a}{2}\right)}{12}$ $PhiMc = 5.071$ **OK** **Use: #5v@12"**

Footing

$d := 9$ $A := .2$ $Spac := 12$ $As := A \cdot \frac{12}{Spac}$

$a := \frac{As \cdot 60}{12 \cdot .85 \cdot 2.5}$ $a = 0.471$

$PhiMc := As \cdot 60 \cdot .9 \cdot \frac{\left(d - \frac{a}{2}\right)}{12}$ $PhiMc = 7.888$ **OK** **Use: #4h@9"**

RW2 (H=4'-0")

$A := 1.0$ $Tw := .66$ $B := 1$ $Tf := 1$ $H1 := .5$ $H := 4$

$ECP := .035$ $S := .008$ $Sur := 0$

$Vecp := \frac{H^2}{2} \cdot ECP$ $Vecp = 0.28$ $Vs := S \cdot H^2$ $Vs = 0.128$ $Vsur := Sur \cdot H$ $Vsur = 0$

$Mot := Vecp \cdot \left(\frac{H}{3} + H1 + Tf\right) + Vs \cdot \left(\frac{H}{2} + H1 + Tf\right) + Vsur \cdot \left(\frac{H}{2} + Tf + H1\right)$

$Mot = 1.241$

$Wf := (A + Tw + B)\cdot Tf\cdot .15$ $Ww := (H + .5 + H1)\cdot Tw\cdot .15$ $Ws := A\cdot(H + H1)\cdot .11$

$Wf = 0.399$ $Ww = 0.495$ $Ws = 0.495$

$W := Wf + Ww + Ws$ $W = 1.389$

$Mr := Wf\cdot\frac{(A + Tw + B)}{2} + Ww\cdot\left(B + \frac{Tw}{2}\right) + Ws\cdot\left(B + Tw + \frac{A}{2}\right)$ $Mr = 2.258$

$FOS := \frac{Mr}{Mot}$ $FOS = 1.819$

$xb := \frac{Mr - Mot}{W}$ $xb = 0.732$ $qmax := \frac{2\cdot W}{3\cdot xb}$ $qmax = 1.265$

$Sliding := \frac{Vecp + Vs}{W}$ $Sliding = 0.294$ $FOS := \frac{.45}{Sliding}$ $FOS = 1.532$

OK with sesimic

Reinforcing

$Mu := 1.6\cdot\left(Vs\cdot\frac{H}{2} + Vecp\cdot\frac{H}{3} + Vsur\cdot\frac{H}{2}\right)$ $Mu = 1.007$

$d := 4$ $A := .31$ $Spac := 1$ $As := A\cdot Spac$

$a := \frac{As\cdot 60}{12\cdot .85\cdot 2.5}$ $a = 0.729$

$PhiMc := As\cdot 60\cdot .9\cdot\frac{\left(d - \frac{a}{2}\right)}{12}$ $PhiMc = 5.071$ **OK** Use: **#5v@12"**

RW1 (H=3'-0")

$A := 1$ $Tw := .66$ $B := .66$ $Tf := 1$ $H1 := .5$ $H := 3$

$ECP := .035$ $S := .008$ $Sur := 0$

$Vecp := \frac{H^2}{2}\cdot ECP$ $Vecp = 0.158$ $Vs := S\cdot H^2$ $Vs = 0.072$ $Vsur := Sur\cdot H$ $Vsur = 0$

$Mot := Vecp\cdot\left(\frac{H}{3} + H1 + Tf\right) + Vs\cdot\left(\frac{H}{2} + H1 + Tf\right) + Vsur\cdot\left(\frac{H}{2} + Tf + H1\right)$

$Mot = 0.61$

$Wf := (A + Tw + B)\cdot Tf\cdot .15$ $Ww := (H + .5 + H1)\cdot Tw\cdot .15$ $Ws := A\cdot(H + H1)\cdot .11$

$Wf = 0.348$ $Ww = 0.396$ $Ws = 0.385$

$W := Wf + Ww + Ws$ $W = 1.129$

$Mr := Wf\cdot\frac{(A + Tw + B)}{2} + Ww\cdot\left(B + \frac{Tw}{2}\right) + Ws\cdot\left(B + Tw + \frac{A}{2}\right)$ Mr = 1.496

$FOS := \frac{Mr}{Mot}$ FOS = 2.454

$xb := \frac{Mr - Mot}{W}$ xb = 0.785 $qmax := \frac{2\cdot W}{3\cdot xb}$ qmax = 0.958

$Sliding := \frac{Vecp + Vs}{W}$ Sliding = 0.203 OK

Reinforcing

$Mu := 1.6\cdot\left(Vs\cdot\frac{H}{2} + Vecp\cdot\frac{H}{3} + Vsur\cdot\frac{H}{2}\right)$ Mu = 0.425

d := 4 A := .31 Spac := 1 As := A·Spac

$a := \frac{As\cdot 60}{12\cdot.85\cdot 2.5}$ a = 0.729

$PhiMc := As\cdot 60\cdot.9\cdot\frac{\left(d - \frac{a}{2}\right)}{12}$ PhiMc = 5.071 **OK** Use: **#5v@12"**

RW2a (H=4'-0") With no toe

A := 0 Tw := .66 B := 2.5 Tf := 1 Hl := .5 H := 4

ECP := .035 S := .008 Sur := 0

$Vecp := \frac{H^2}{2}\cdot ECP$ Vecp = 0.28 $Vs := S\cdot H^2$ Vs = 0.128 Vsur := Sur·H Vsur = 0

$Mot := Vecp\cdot\left(\frac{H}{3} + Hl + Tf\right) + Vs\cdot\left(\frac{H}{2} + Hl + Tf\right) + Vsur\cdot\left(\frac{H}{2} + Tf + Hl\right)$

Mot = 1.241

Wf := (A + Tw + B)·Tf·.15 Ww := (H + .5 + Hl)·Tw·.15 Ws := A·(H + Hl)·.11

Wf = 0.474 Ww = 0.495 Ws = 0

W := Wf + Ww + Ws W = 0.969

$Mr := Wf\cdot\frac{(A + Tw + B)}{2} + Ww\cdot\left(B + \frac{Tw}{2}\right) + Ws\cdot\left(B + Tw + \frac{A}{2}\right)$ Mr = 2.15

$FOS := \frac{Mr}{Mot}$ FOS = 1.732

$xb := \frac{Mr - Mot}{W}$ xb = 0.937 $qmax := \frac{2\cdot W}{3\cdot xb}$ qmax = 0.689

$$Sliding := \frac{Vecp + Vs}{W} \qquad Sliding = 0.421 \qquad FOS := \frac{.45}{Sliding} \qquad FOS = 1.069$$

OK with sesimic

Reinforcing

$$Mu := 1.6 \cdot \left(Vs \cdot \frac{H}{2} + Vecp \cdot \frac{H}{3} + Vsur \cdot \frac{H}{2} \right) \qquad Mu = 1.007$$

$d := 4 \qquad A := .31 \qquad Spac := 1 \qquad As := A \cdot Spac$

$$a := \frac{As \cdot 60}{12 \cdot .85 \cdot 2.5} \qquad a = 0.729$$

$$PhiMc := As \cdot 60 \cdot .9 \cdot \frac{\left(d - \frac{a}{2} \right)}{12} \qquad PhiMc = 5.071$$

OK Use: **#5v@12"**

1st Floor Steel Beam

$Span := 22.5$ $trib := 12.5$ $Ir := \frac{5 \cdot trib \cdot .04 \cdot 144 \cdot Span^3 \cdot 480}{384 \cdot 29000}$ $Ir = 176.8$

$wd := 15$ $wl := 40$ $wt := (wd + wl) \cdot trib$ $wt = 687.5$

$Mt := wt \cdot \frac{Span^2}{8}$ $Mt = 43505.9$ $Sr := \frac{Mt \cdot 12}{36000 \cdot .6}$ $Sr = 24.2$ Use: W10x39

Deck Beams without Cantilever

$Span := 12$ $trib := 7$ $Ir := \frac{5 \cdot trib \cdot .04 \cdot 144 \cdot Span^3 \cdot 480}{384 \cdot 1600}$ $Ir = 272.2$

$wd := 10$ $wl := 60$ $wt := (wd + wl) \cdot trib$ $wt = 490$ $R := wt \cdot \frac{Span}{2}$

$Mt := wt \cdot \frac{Span^2}{8}$ $Mt = 8820$ $Sr := \frac{Mt \cdot 12}{.85 \cdot 2400}$ $Sr = 51.9$

$W := 5.5$ $D := 9.0$ $S := W \cdot \frac{D^2}{6}$ $S = 74.3$ $I := \frac{W \cdot D^3}{12}$ $I = 334.1$

Use: PT5.5x9 GLB

Interior Deck Beams with Cantilever

$wd := 00$ $wl := 40$ $wt := (wd + wl) \cdot trib$ $wt = 280$ $R := wt \cdot \frac{Span}{2}$

$Span := 12$ $Pt := 2 \cdot R$ $Ir := \frac{Pt \cdot 144 \cdot Span^2 \cdot 480}{48 \cdot 1600000}$ $Ir = 435.5$

$wd := 10$ $wl := 60$ $wt := (wd + wl) \cdot trib$ $wt = 490$ $Pt := Span \cdot wt$

$Mt := Pt \cdot \frac{Span}{4}$ $Mt = 17640$ $Sr := \frac{Mt \cdot 12}{.85 \cdot 2400}$ $Sr = 103.8$

$W := 5.5$ $D := 10.5$ $S := W \cdot \frac{D^2}{6}$ $S = 101.1$ $I := \frac{W \cdot D^3}{12}$ $I = 530.6$

Use: PT5.5x10.5 GLB

Connection at House

$Pt := 12 \cdot 6 \cdot (10 + 60)$ $Pt = 5040$ Use: HUCQ610-SDS HDG at Beams

With SDS25 $Vall := 340 \cdot 1.25$ $Vall = 425$

Use: PT4x10 ledger w/2-SDS25600 @ 12"

Exterior Deck Beams with Cantilever

$wd := 00$ $wl := 40$ $wt := (wd + wl)\cdot trib$ $wt = 280$ $R := wt\cdot\frac{Span}{2}$

$Span := 12$ $Pt := R$ $Ir := \frac{Pt\cdot 144\cdot Span^2\cdot 480}{48\cdot 1600000}$ $Ir = 217.7$

$wd := 10$ $wl := 60$ $wt := (wd + wl)\cdot trib$ $wt = 490$ $Pt := Span\cdot\frac{wt}{2}$

$Mt := Pt\cdot\frac{7.5}{Span}$ $Mt = 8575$ $Sr := \frac{Mt\cdot 12}{.85\cdot 1.6\cdot 850}$ $Sr = 89$

$W := 5.5$ $D := 9.5$ $S := W\cdot\frac{D^2}{6}$ $S = 82.7$ $I := \frac{W\cdot D^3}{12}$ $I = 393$

Use: PT6x10

Deck Guard Rail

Vertical

$H := 3.5$ $V := 200$ $M := V\cdot H$ $W := .5$ $D := 2.5$ $S := W\cdot\frac{D^2}{6}$

$fb := \frac{M\cdot 12}{S}$ $fb = 16128$ OK Use: PL2.5x.5 @ 48" max

Lag Screws

$T := M\cdot\frac{12}{8\cdot 2}$ $T = 525$ With 1/4" dia x 6" Lag Screws, vall = 199#/in penetration

$Penetration := 3 + \frac{11}{32}$ $Vall := 199\cdot Penetration\cdot 1.6$ $Vall = 1064.7$

Use: 6- 1/4" diameter x 6" FH Lag Screws

Entry Roof Rafters

$Span := 7$ $trib := 1.33$ $Ir := \frac{5\cdot trib\cdot .04\cdot 144\cdot Span^3\cdot 480}{384\cdot 1600}$ $Ir = 10.3$

$wd := 12$ $wl := 30$ $wt := (wd + wl)\cdot trib$ $wt = 55.9$ $R := wt\cdot\frac{Span}{2}$

$Mt := wt\cdot\frac{Span^2}{8}$ $Mt = 342.1$ $Sr := \frac{Mt\cdot 12}{.85\cdot 2400}$ $Sr = 2$

$W := 1.5$ $D := 5.5$ $S := W\cdot\frac{D^2}{6}$ $S = 7.6$ $I := \frac{W\cdot D^3}{12}$ $I = 20.8$

Use: 2x6 @ 16"

Entry Roof Beam

$Span := 7 \quad Cant := 8 \quad trib := 6$

$wd := 12 \quad wl := 30 \quad wt := (wd + wl)\cdot trib \quad wt = 252 \quad R := wt\cdot\frac{Span}{2}$

$Mt := wt\cdot\frac{Span^2}{8} \quad Mt = 1543.5 \quad Sr := \frac{Mt\cdot 12}{2400\cdot 1.15} \quad Sr = 6.7$

$Mtcant := \frac{wt\cdot Cant^2}{2} \quad Mtcant = 8064 \quad Sr := \frac{Mtcant\cdot 12}{2400\cdot 1.15} \quad Sr = 35.1$

$W := 5.5 \quad D := 10.5 \quad S := W\cdot\frac{D^2}{6} \quad S = 101.1 \quad I := \frac{W\cdot D^3}{12} \quad I = 530.6$

$Ds := \frac{trib\cdot .03\cdot Cant\cdot 1728}{24\cdot 1600\cdot I}\cdot\left(4Cant^2\cdot Span - Span^3 + 3\cdot Cant^3\right) \quad Ds = 0.4 \quad fac := \frac{Cant\cdot 12\cdot 2}{Ds}$

$fac = 526.7$

Use: 5.5x10.5 GLB

Clerestory Beam View Side

$Span := 11.5 \quad trib := 6$

$wd := 0 \quad ww := 12 \quad wt := (wd + ww)\cdot trib \quad wt = 72 \quad R := wt\cdot\frac{Span}{2}$

$Mt := wt\cdot\frac{Span^2}{8} \quad Mt = 1190.3 \quad Sr := \frac{Mt\cdot 12}{850\cdot 1.6} \quad Sr = 10.5$

$W := 7.5 \quad D := 5.5 \quad S := W\cdot\frac{D^2}{6} \quad S = 37.8 \quad I := \frac{W\cdot D^3}{12} \quad I = 104$

$Ds := \frac{5\cdot trib\cdot ww\cdot Span^4\cdot 1728}{384\cdot 1600000\cdot 1} \quad Ds = 0.2 \quad fac := \frac{Span\cdot 12}{Ds} \quad fac = 810.3$

Use: 5.25x7.5 PSL

Clerestory Column

See Risa Model

Clerestory Beam View Side

$Span := 11.5$ $trib := 5.25$

$wd := 0$ $ww := 12$ $wt := (wd + ww)\cdot trib$ $wt = 63$ $R := wt\cdot\frac{Span}{2}$

$Mt := wt\cdot\frac{Span^2}{8}$ $Mt = 1041.5$ $Sr := \frac{Mt\cdot 12}{850\cdot 1.6}$ $Sr = 9.2$

$W := 3$ $D := 5.5$ $S := W\cdot\frac{D^2}{6}$ $S = 15.1$ $I := \frac{W\cdot D^3}{12}$ $I = 41.6$

$Ds := \frac{5\cdot trib\cdot ww\cdot Span^4\cdot 1728}{384\cdot 1600000\cdot I}$ $Ds = 0.4$ $fac := \frac{Span\cdot 12}{Ds}$ $fac = 370.4$

Use: 5.25x7.5 PSL

Beam to Column Connection at Low to High Roof Transition

$Rbmbel := 5.7$ MGU5.5/10-SDS allowable load = 88% of listed load with one flange concealed

$Hgrall := 9.45\cdot.88$ $Hgrall = 8.3$ OK

Deck Post to Footing Connection

$Wdeck := 36\cdot 14\cdot 10$ $Wdeck = 5040$ $Sds := .963$ $Rdeck := 1.5$

$Vs := \frac{Wdeck\cdot Sds}{Rdeck}$ $Vs = 3235.7$ $NoCol := 4$ $VperCol := \frac{7}{12}\cdot\frac{Vs}{NoCol}$

$VperCol = 471.9$ $Hcol := 10$ $Mcol := VperCol\cdot Hcol$ $Mcol = 4718.7$

$Pd := \frac{7}{12}\cdot 14\cdot 12\cdot 10$ $Pd = 980$ $Pl := \frac{7}{12}\cdot 14\cdot 12\cdot 40$ $Pl = 3920$

$fb := \frac{Mcol\cdot 12}{5.5^2\cdot\frac{6}{6}}$ $fb = 1871.9$

Deck Column Design
(PT5.5x6 GLC 24f-v4)

Column Properties

$Wc := 5.5$

$Dc := 6$

$Ac := Dc \cdot Wc$ $Ac = 33$

$Sc := Wc \cdot \frac{Dc^2}{6}$ $Sc = 33$

$Ic := Wc \cdot \frac{Dc^3}{12}$ $Ic = 99$

$Ps := Pl$ $Ps = 3920$ lbs

$AvHt := 10$ $NoCol := 4$

$Mav := \frac{7Vs \cdot AvHt}{12NoCol}$ $Mav = 4718.7$

$K := 2.1$ $Le := K \cdot AvHt \cdot 12$ $Le = 252$

$d := Dc$ $Led := \frac{Le}{d}$ $Led = 42$ (must be less than 50)

$Kce := .3$ $c := .8$ $Fc := 1000 \cdot 1.6$

$E := 1800$ $Fce := Kce \cdot \frac{E \cdot 1000}{Led^2}$ $Fce = 306$

$$Cp := \frac{1 + \frac{Fce}{Fc}}{2 \cdot c} - \left[\left(\frac{1 + \frac{Fce}{Fc}}{2 \cdot c} \right)^2 - \frac{Fce}{Fc \cdot c} \right]^{.5} \qquad Cp = 0.183$$

$Fpc := Fc \cdot Cp$ $Fpc = 293$ psi

Dead+.75Live+.75Seismic

$fb := .75Mav \cdot \frac{12}{Sc}$ $fb = 1286.9$ psi

$fc := \frac{Pd + .75Ps}{Ac}$ $fc = 118.8$ psi

$Fb := 1.6 \cdot 2400$ $Fb = 3840$ psi

$$\frac{fc^2}{Fc^2} + \frac{fb}{Fb \cdot \left(1 - \frac{fc}{Fce}\right)} = 0.55 \quad \text{ok}$$

Dead+Live

$Kce := .3 \quad c := .8 \quad Fc := 1000$

$E := 1600 \quad Fce := Kce \cdot \frac{E \cdot 1000}{Led^2} \quad Fce = 272$

$$Cp := \frac{1 + \frac{Fce}{Fc}}{2 \cdot c} - \left[\left(\frac{1 + \frac{Fce}{Fc}}{2 \cdot c} \right)^2 - \frac{Fce}{Fc \cdot c} \right]^{.5} \quad Cp = 0.255$$

$fb := 0Mav \cdot \frac{12}{Sc} \quad fb = 0 \quad psi$

$fc := \frac{Pd + Ps}{Ac} \quad fc = 148.5 \quad psi$

$Fb := 1.15 \cdot 975 \quad Fb = 1121.3 \ psi$

$$\frac{fc^2}{Fc^2} + \frac{fb}{Fb \cdot \left(1 - \frac{fc}{Fce} \right)} = 0.022 \quad ok$$

Dead+Seismic

$Kce := .3 \quad c := .8 \quad Fc := 1000 \cdot 1.6$

$E := 1600 \quad Fce := Kce \cdot \frac{E \cdot 1000}{Led^2} \quad Fce = 272$

$$Cp := \frac{1 + \frac{Fce}{Fc}}{2 \cdot c} - \left[\left(\frac{1 + \frac{Fce}{Fc}}{2 \cdot c} \right)^2 - \frac{Fce}{Fc \cdot c} \right]^{.5} \quad Cp = 0.164$$

$fb := Mav \cdot \frac{12}{Sc} \quad fb = 1715.9 psi$

$fc := \frac{Pd}{Ac} \quad fc = 29.7 \ psi$

$Fb := 1.6 \cdot 2400 \quad Fb = 3840 \quad psi$

$$\frac{fc^2}{Fc^2} + \frac{fb}{Fb \cdot \left(1 - \frac{fc}{Fce} \right)} = 0.502 \quad ok$$

Deck Grade Beam

$Mu := Mav \cdot 1.6 \cdot \frac{1}{1000}$ $Mu = 7.5$ $d := 6$ $As := .31 \cdot 2$ $As = 0.6$

$a := \frac{As \cdot 60}{.85 \cdot 12 \cdot 2.5}$ $a = 1.5$ $PhiMc := .9 \cdot 60 \cdot As \cdot \left(d - \frac{a}{2} \right) \cdot \frac{1}{12}$ $PhiMc = 14.7$ OK

$Vs := \frac{Mu}{12}$ $Vs = 0.6$ $PhiVc := .85 \cdot 2 \cdot 2500^{.5} \cdot d \cdot 12$ $PhiVc = 6120$ OK

Use: 12"x12" Grade Beam w/ 2-#5 at mid depth