STRUCTURAL CALCULATIONS

FOR

Poly Canyon Observation Deck
Senior Project
Spring 2018

Students: Emir Kuljancic & Sitora Vaxidova
Advisor: Kevin Dong

California Polytechnic State University
San Luis Obispo, California

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SAN LUIS OBISPO, CA

5 June 2018

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Advisor: Kevin Dong, SE

Project Overview

Poly Canyon Observation Platform is a proposed CM/ARCE interdisciplinary senior project with a goal of providing an observation point/rest stop for hikers and bikers. The platform has a shaded cover and seating area overlooking Poly Canyon for a rewarding experience after a long trek out to the lookout point.

The proposed location(see below) for the Poly Canyon Observation Platform is in the Poly Canyon below and to the right of the Blue Metal Stick Structure. This location will serve as a daytime/sunset observation point that overlooks Poly Canyon and adjacent structures.

The proposed structure will have timber framing and utilize cast in place concrete pier footings. The proposed dimensions for the observation deck are 12 feet by 12 feet. The open sides of the structure will include steps up to the deck and possibly an access ramp to meet ADA compliance requirements if required. A light framed shade structure is planned to be constructed out of 2x2 Redwood framing. The proposed connections heavily utilize Simpson Strong Tie connectors as well as some custom SST column bases and caps that connect multiple girders at different angles.

The following documents are included in the final permit package:

- Gravity Calculations (Dead/Live load)
- Lateral Calculations (Wind/Seismic load)
- Connection Design
- Framing plans, Elevations, Sections
- Typical Connection Details

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JOB _____
JOB NO. _____ DATE _____
CLIENT _____ BY _____ SHEET NO _____ OF ____

Project Description:
This project is an observation deck. It consists of a redwook deck construction. The roof is made up of red wood structural members supported by red wood posts. The deck is also supported by the red wood posts. These posts bear on circular concrete footings. The floor joists are made up of 2x6s supported by girders. The floor deck is made up of wooden planks which are nailed to the joists and girders. The deck, trellis and posts are coated with a fire proof sealant. The lateral system consists of 2x4 wood kickers.

Design Criteria:
Building Type:
Timber framed structure.
Type I - 2 hour fire rated, without sprinklers
Occupancy Category: A
Location: San Luis Obispo, CA
Design Code: 2015 IBC, ASCE 7-10, NDS 2015
Wind Criteria:
Risk Category I
Exposure C
See Lateral Design Calculations for detailed wind criteria. (100mph)
Seismic Criteria:
Class D
I=1.0
R =1.0

Foundation Criteria:
Allowable Bearing: 2000psf
Lateral Pressure: 150psf/ft.

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JOB POLY CANYON OBSERVATION DECK
JOB NO. _____ DATE 6-5-2018
CLIENT _____ BY EK SHEET NO T2 OF T2

REFERENCE

Roof Loads

Dead Loads

Description	Calculation	Load
2x2 Rafters @ 4" o.c.	35pcf x1.5"x1.5"x12"/(144"x4" o.c.)	1psf
People Hanging		200 lbs

Beam Dead Load 2psf
Girder Dead Load 4psf
Column Dead Load 5psf

Live Load 20psf (REDUCABLE)

Floor Loads

Dead Loads

Description	Calculation	Load
2x6 Decking		2psf
2x Floor Joists	35pcf x1.5"x5.5"x12"/(144"x24" o.c.)	1psf
Bench		10psf

Joist Dead Load 13psf
Girder Dead Load 15psf
Column Dead Load 16psf

Live Load

Deck Live Load 1.5x20psf 30psf (MINIMUM)

Live Load 50psf (DESIGN)

Building Weight: 2582 (lbs)

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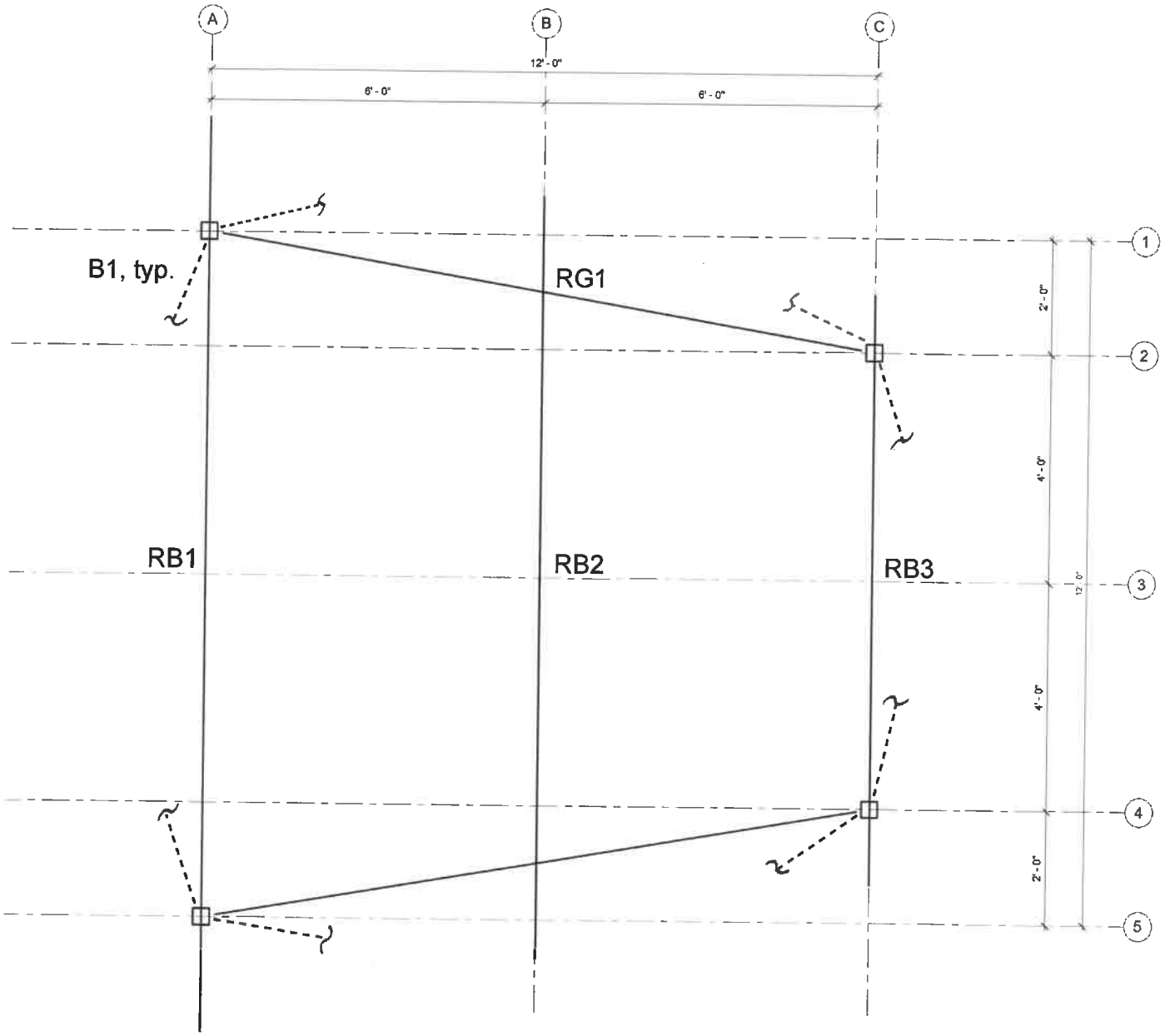
JOB	POLY CANYON OBSERVATION DECK		
JOB NO.		DATE	5/15/2018
CLIENT		BY EK	SHEET NO R1 OF R13

ROOF KEY PLAN



JOB
JOB NO. DATE
CLIENT BY EK SHEET NO 22 OF RB

REFERENCE

Roof Beam RB1 Risa Input:

Risa Input

Member Primary Data:

Label	I Joint	J Joint	Type	Design List
M1	A1	A2	No. 2 Red Wood	Rectangular
M2	A2	A3	No. 2 Red Wood	Rectangular
M3	A3	A4	No. 2 Red Wood	Rectangular

Joint Coordinate:

Label	x(ft)	y(ft)
A1	0	0
A2	2	0
A3	14	0
A4	16	0

Boundary Conditions:

Label	x-dir	y-dir
A1	Free	Free
A2	Reaction	Reaction
A3	Free	Reaction
A4	Free	Free

Basic Load Cases:

BLC	Description
1	Dead Load
3	Point Load 1
5	Point Load 2
6	Live Load All

Unfactored Live Load= **-60PLF**
Unfactored Dead Load= **-6PLF**
Unfactored Point Load= **-200 #**

Load Combinations:

Description	BLC	Factor	BLC	Factor
D+L	1	1	6	1
Skip Load 1	1	1	3	1
Skip Load 2	1	1	5	1

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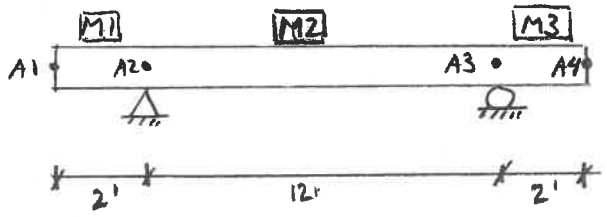
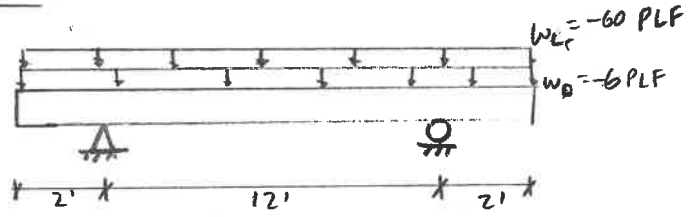
REFERENCE

ROOF BEAM CALCULATIONS (RB1, SEE KEY PLAN)

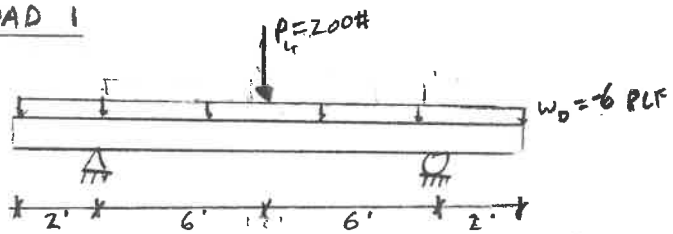


LOAD COMBONATIONS:

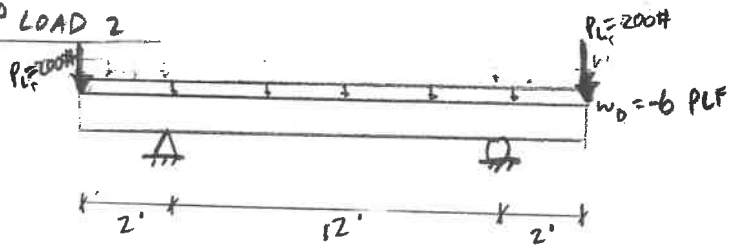
D+L



SKIP LOAD 1



SKIP LOAD 2



JOB
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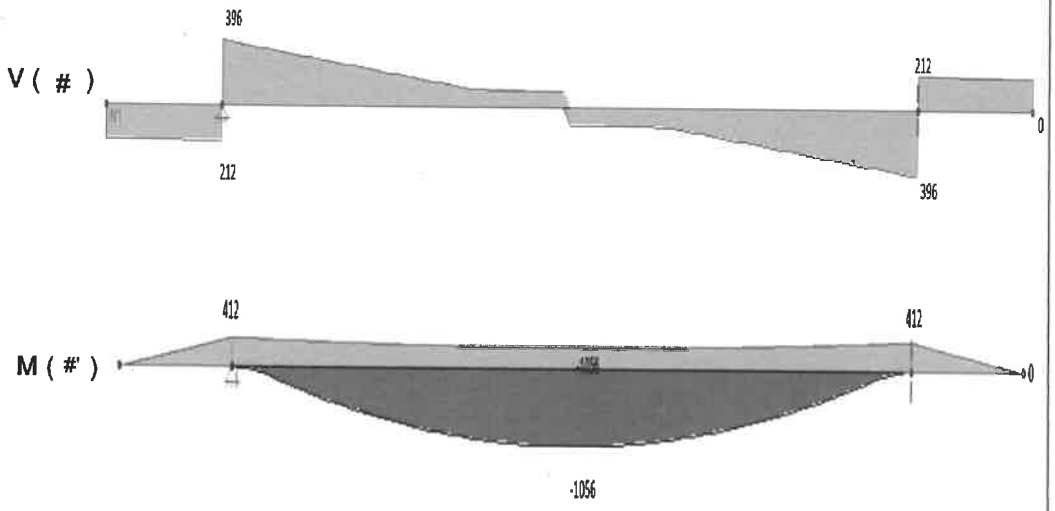
CLIENT BY SHEET NO 14 OF 13

REFERENCE

Roof Beam (RB1) Shear and Moment Output:



$M_u = -1056\ \#'$

$V_u = 396 + 212 = 608\#$

DESIGN FOR BENDING

No. 2 Redwood

$F_b = 925\ psi$ $\quad E = 1,200,000\ psi$

$F_v = 160\ psi$ $\quad E_{min} = 440,000\ psi$

$F_{c\perp} = 525\ psi$

Find S_{req}:

$$f_b = \frac{M}{S_{req}} \qquad S_{req} = \frac{1056\ \#' \cdot (12''/ft)}{925\ psi} = 13.7\ in^3$$

Try: No. 2 Redwood 3x8

$S = 21.90\ in^3 > 13.7\ in^3$ ✓ OK

$$f_b = \frac{M}{S} = \frac{1056\ \#' \cdot (12''/ft)}{21.90\ in^3} = 578.6\ psi$$

REFERENCE

$F_b' = F_b C_D C_M \overset{1.0}{C_t} C_L C_F \overset{1.0}{C_{fu}} \overset{1.0}{C_i} \overset{1.0}{C_r}$

- D+L LOAD COMBO GOVERNS ∴ $C_D = 1.0$
- $C_F = 1.$
- $F_b C_F = 925psi(1.1) = 1017.5psi \leq 1150psi$ ∴ $C_M = 1.0$

$C_D = 1.0$
$C_F = 1.2$
$C_M = 1.0$

FIND C_L:

$\frac{l_u}{d} = \frac{12' \times 12"/ft}{7.25"} = 19.9 \geq 7$ ∴ $l_e = 1.84 l_u$

$l_e = 1.84(12' \times 12"/ft) = 265.0"$

$R_b = \sqrt{\frac{l_e d}{b^2}} = \sqrt{\frac{265"(7.25")}{(2.5)^2}} = 17.5 \leq 50$ ✓OK

$F_{bE} = \frac{1.20 E'_{min}}{R_b^2}$

$E'_{min} = E_{min} C_M C_t C_i C_T = 440,000psi$

$F_{bE} = \frac{1.20(440,000psi)}{(17.5)^2} = 1724.1psi$

$F_b^* = 925(1.2) = 1110psi$ → NO C_L, C_V

$C_L = \frac{1 + (F_{bE}/F_b^*)}{1.9} - \sqrt{\left[\frac{1 + (F_{bE}/F_b^*)}{1.9}\right]^2 - \frac{F_{bE}/F_b^*}{0.95}}$

$F_{bE}/F_b^* = 1.55$

$C_L = \frac{1 + 1.55}{1.9} - \sqrt{\left[\frac{1 + 1.55}{1.9}\right]^2 - \frac{1.55}{0.95}} = 0.93$

$C_L = 0.87$

$F_b' = 925psi(1.2)(0.93) = 1032.5psi$

$F_b' \geq f_b$ $1032.5psi > 578.6psi$ ✓OK

ADEQUATE IN BENDING

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JOB
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CLIENT BY EK SHEET NO 16 OF P13

REFERENCE
NDS 2015
§3.4.2
SEE R4 FOR V_u

SHEAR CHECK

$$f_v = \frac{1.5\,V}{bd} \qquad V_u = 608\#$$

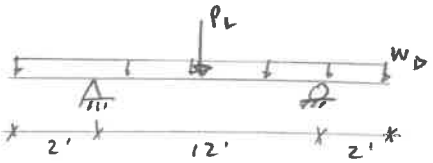
$$f_v = \frac{1.5(608\#)}{2.5"(7.25")} = 50.3psi$$

$$F'_v = F_v C_D' C_m' C_t' C_i' = 160psi$$

$F'_v > f_v$ $\quad 160psi > 50.3psi$ ✓OK

DEFLECTION CHECK

WORST CASE (200# HANGING LOAD)



ASSUME SIMPLY SUPPORTED BEAM WITH POINT LOAD @ MIDSPAN (CONSERVATIVE)

$$\Delta_D = \frac{5wL^4}{384EI} = \frac{5(6\#/ft)(12')^4(12"/ft)^3}{384(1{,}200{,}000)(79.39in^4)} = 0.35"$$

$$\Delta_L = \frac{PL^3}{48EI} = \frac{200\#(12'\times 12"/ft)^3}{48(1{,}200{,}000)(79.39in^4)} = 0.13"$$

Δ_{DTL}: SUPERIMPOSE ∴ $\Delta_{DTL} = 0.35" + 0.13" = 0.48"$

$$\Delta_{DTL\ allow} = \frac{l}{120} = \frac{12'\times 12"/ft}{120} = 1.2" > 0.48" \quad ✓OK$$

$$\Delta_{L\ allow} = \frac{l}{180} = \frac{12'\times 12"/ft}{180} = 0.8" > 0.13" \quad ✓OK$$

∴ ADEQUATE IN DEFLECTION

PROVIDE No.2 REDWOOD 3x8 ROOF BEAM, RB1

REFERENCE

Roof Beam RB2 Risa Input:

Risa Input

Member Primary Data:

Label	I Joint	J Joint	Type	Shape
M1	A1	A2	No. 2 Red Wood	Rectangular
M2	A2	A3	No. 2 Red Wood	Rectangular
M3	A3	A4	No. 2 Red Wood	Rectangular

* Nominal Dimensions

Joint Coordinate:

Label	x(ft)	y(ft)
A1	0	0
A2	1.66	0
A3	11.66	0
A4	13.33	0

Boundary Conditions:

Label	x-dir	y-dir
A1	Free	Free
A2	Reaction	Reaction
A3	Free	Reaction
A4	Free	Free

Basic Load Cases:

BLC	Description
1	Dead Load
2	Live Load
3	Hanging End
4	Hanging Midspan

Unfactored Live Load= **-120PLF**
Unfactored Dead Load= **-12PLF**
Hanging Point Load= **-200#**

Load Combinations:

Description	BLC	Factor	BLC	Factor
D+L	1	1	2	1
Hanging Ends	1	1	3	1
Hanging Midspan	1	1	4	1

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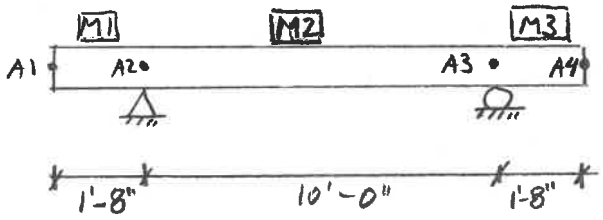
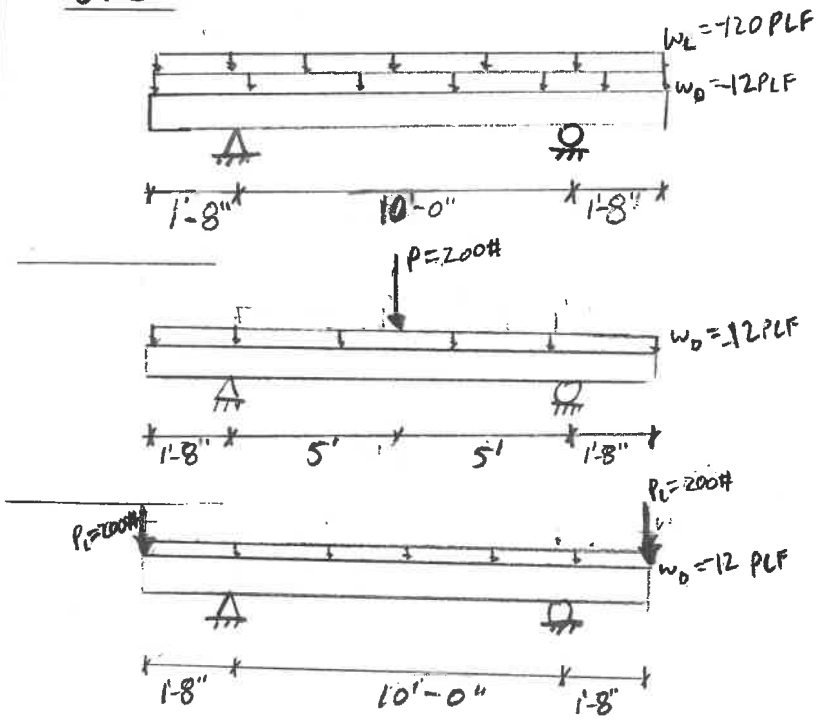
REFERENCE

ROOF BEAM CALCULATIONS (RB2) SEE KEY PLAN



LOAD COMBONATIONS:

D+L



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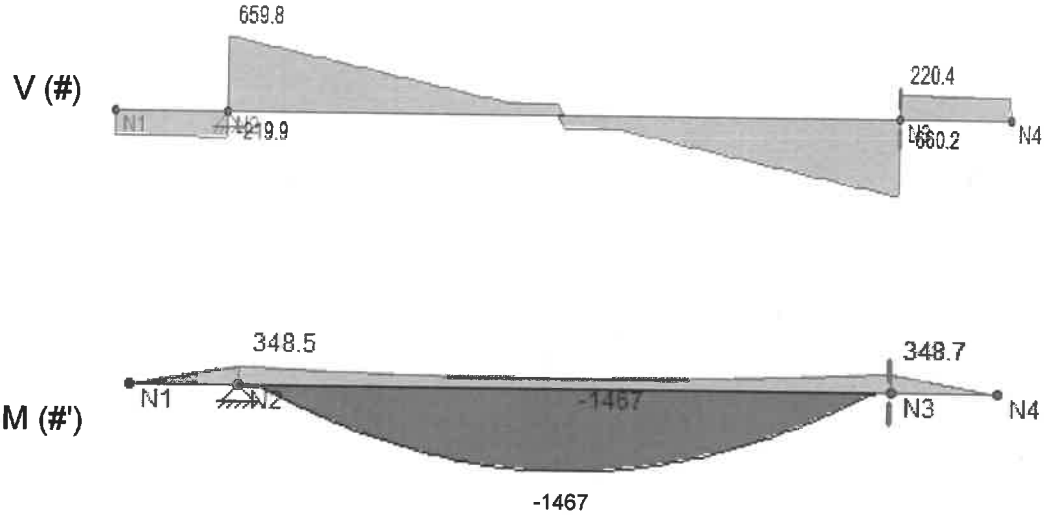
REFERENCE

Roof Beam RB2 Output:



$M_u = -1467\ \#'$
$V_u = 659.8 + 219.9 = 879.7\ \#$

DESIGN FOR BENDING

USE No. 2 REDWOOD

FIND S_{req}: $f_b = \frac{M}{S_{req}}$ $\quad S_{req} = \frac{1467\#'(12"/ft)}{925\,psi} = 19.03\,in^3$

TRY: 3x8 No. 2 REDWOOD

$S = 21.90\,in^3 \geq 19.03\,in^3$ ✓ OK

$f_b = \frac{M}{S} = \frac{1467\#'(12"/ft)}{21.90\,in^3} = 820.27\,psi$

$F_b' = F_b C_D^{1.25} C_M C_t C_L C_F C_{fu} C_i C_r$

- D + L_r GOVERNS $\therefore$ $C_D = 1.25$
- $C_F = 1.2$
- $F_b (C_F) = 925\,psi\,(1.2) = 1,100 \leq 1,150\,psi$ $\therefore$ $C_M = 1.0$

$C_D = 1.25$
$C_F = 1.2$
$C_M = 1.0$

REFERENCE

FIND C_L:

$\frac{l_u}{d} = \frac{10'(12"/ft)}{7.25"} = 16.6 \geq 7 \therefore l_e = 1.84 l_u$

$l_e = 1.84(10')(12"/ft) = 220.8"$

$R_B = \sqrt{\frac{l_e d}{b^2}} = \sqrt{\frac{220.8"(7.25")}{(2.5")^2}} = 16.00 \leq 50$ ✓OK

$F_{bE} = \frac{1.20 E'_{min}}{R_B^2}$

$E'_{min} = E_{min} C_M C_t C_i C_T = 440{,}000 psi$

$F_{bE} = \frac{1.20(440{,}000)}{(16.00)^2} = 2062.5 psi$

$F_b^* = 925 psi (1.2)(1.25) = 1387.5 psi$

$F_{bE}/F_b^* = 1.49$

$C_L = \frac{1+1.49}{1.9} - \sqrt{\left(\frac{1+1.49}{1.9}\right)^2 - \frac{1.49}{.95}} = 0.93$ $C_L = 0.93$

$F'_b = 925 psi (1.25)(0.93)(1.2) = 1290.4 psi$

$F'_b \geq f_b \quad 1290.4 psi \geq 797.3 psi$ ✓OK

∴ 2x8 IS ADEQUATE IN BENDING.

SHEAR CHECK

$f_v = \frac{1.5V}{bd} \qquad V_u = 747.6\#$

$f_v = \frac{1.5(879.7\#)}{1.5"(7.25")} = 121.4 psi$

$F'_v = F_v C_D^{1.25} C_M C_t C_i = 160(1.25) = 200 psi$

$F'_v \geq f_v \quad 200 psi \geq 121.4 psi$ ✓OK

∴ 3x8 ADEQUATE IN SHEAR

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JOB
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REFERENCE

DEFLECTION CHECK

- WORST CASE → 200# HANGING LOAD
- ASSUME SIMPLY SUPPORTED BEAM WITH POINT LOAD @ MIDSPAN (CONSERVATIVE)

$$\Delta_D = \frac{5wl^4}{384EI} = \frac{5(6\#/ft)(10')^4(12"/ft)^3}{384(1,200,000)(79.39in^4)} = 0.01"$$

$$\Delta_L = \frac{Pl^3}{48EI} = \frac{200\#(10'\times 12"/ft)^3}{48(79.39in^4)(1,200,000)} = 0.08"$$

Δ_{D+L}: SUPERIMPOSE $\therefore \Delta_{D+L} = 0.01" + 0.08" = 0.09"$

$$\Delta_{D+L\ allow} = \frac{l}{120} = \frac{10'(12"/ft)}{120} = 1.0" \geq 0.09" \checkmark OK$$

$$\Delta_{L\ allow} = \frac{l}{180} = \frac{10'(12"/ft)}{180} = 0.67" \geq 0.08" \checkmark OK$$

$\therefore$ 3x8 ADEQUATE IN DEFLECTION

PROVIDE 3X8 No.2 REDWOOD ROOF BEAM, RB2

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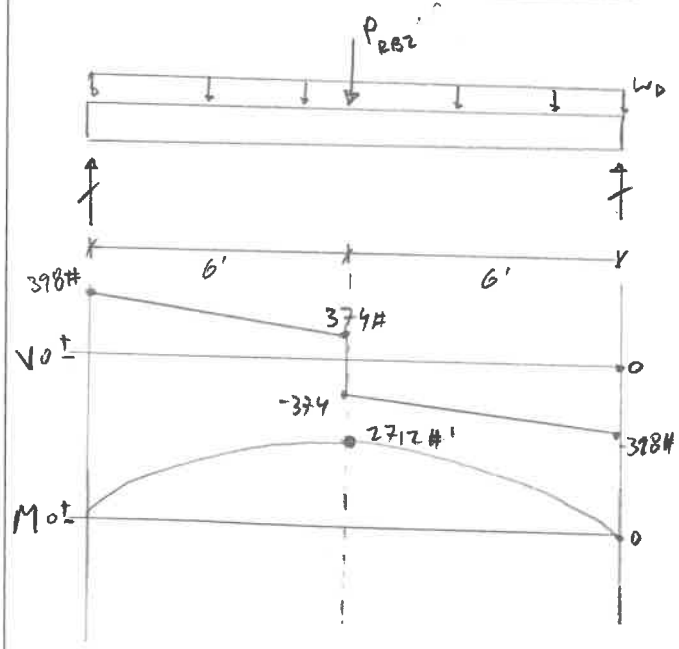
REFERENCE

ROOF GIRDER DESIGN, RG1



$w_D = 4 PLF$

$P_{RB2} = 879.7\#$

$V = \frac{wl}{2} + \frac{P}{2}$

$V_u = \frac{4(12')}{2} + \frac{879.7\#}{2} = 464\#$

$V_u = 464\#$

$M_u = 440\#(6) + 24(6)(\frac{1}{2})$

$M_u = 2712\#'$

$M_u = 2712\#'$

DESIGN FOR BENDING

FIND S_{req}: $f_b = \frac{M}{S_{req}}$ $\quad S_{req} = \frac{2712\#'(12"/ft)}{925 psi} = 35.1 in^3$

TRY 3x10 No.2 REDWOOD
$S = 35.65 in^3 \geq 35.1 in^3$ ✓OK

$f_b = \frac{M}{S} = \frac{2712\#'(12"/ft)}{35.65 in^3} = 915 psi$

$F_b' = F_b \overset{1.25}{C_D} C_M C_t C_L C_{fu} C_i C_r$

- D+Lr GOVERNS ∴ $C_D = 1.25$
- $C_F = 1.1$
- $F_b C_F = 925 psi (1.1) = 1017.5 psi \leq 1,150 psi$ ∴ $C_M = 1.0$

$C_D = 1.25$
$C_L = 1.1$
$C_M = 1.0$

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REFERENCE

FIND C_L:

$l_e = 1.11\, l_u = 1.11(6')(12''/ft) = 79.92''$

$R_B = \sqrt{\frac{l_e d}{b^2}} = \sqrt{\frac{79.92''(9.25'')}{(2.5'')^2}} = 10.9 \leq 50$ ✓OK

$F_{bE} = \frac{1.20\, E'_{min}}{R_B^2}$

$E'_{min} = E_{min} C_M' C_t' C_i' C_T' = 470{,}000 psi$

$F_{bE} = \frac{1.20(470{,}000 psi)}{(10.9)^2} = 4449.1 psi$

$F_b^* = 925 psi\,(1.25)(1.1) = 1271.9 psi$

$F_{bE}/F_b^* = 3.49$

$C_L = \frac{1+3.49}{1.9} - \sqrt{\left(\frac{1+3.49}{1.9}\right)^2 - \frac{3.49}{.95}} = 0.98$ $\quad C_L = 0.98$

$F'_b = 925 psi\,(1.25)(1.1)(0.98) = 1246.4 psi$

$F'_b \geq f_b \quad 1246.4 psi \geq 1017.5 psi$ ✓OK

∴ 3x10 ADEQUATE IN BENDING

SHEAR CHECK

$f_v = \frac{1.5V}{bd} \qquad V_u = 464\#$

$f_v = \frac{1.5(464\#)}{2.5''(9.25'')} = 30 psi$

$F'_v = F_v C_D^{1.25} C_M' C_t' C_i' = 160 psi\,(1.25) = 200 psi$

$F'_v \geq f_v \quad 200 psi \geq 30 psi$ ✓OK

∴ 3x10 ADEQUATE IN SHEAR

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DEFLECTION CHECK

$$\Delta_D = \frac{5wl^4}{384EI} = \frac{5(4\#/ft)(12')^4(12"/ft)^3}{384(1,200,000psi)(164.9in^4)} = 0.01"$$

$$\Delta_L = \frac{Pl^3}{48EI} = \frac{879.7\#(12'\times 12"/ft)^3}{48(1,200,000)(164.9in^4)} = 0.28"$$

$$\Delta_{DTL} = 0.01" + 0.28" = 0.29"$$

$$\Delta_{DTL\ allow} = \frac{l}{120} = \frac{12'(12"/ft)}{120} = 1.0" \geq 0.29" \checkmark OK$$

$$\Delta_{L\ allow} = \frac{l}{180} = \frac{12'(12"/ft)}{180} = 0.8" \geq 0.28" \checkmark OK$$

∴ 3x10 ADEQUATE IN DEFLECTION

PROVIDE 3X10 No. 2 REDWOOD ROOF GIRDER, RG1

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JOB
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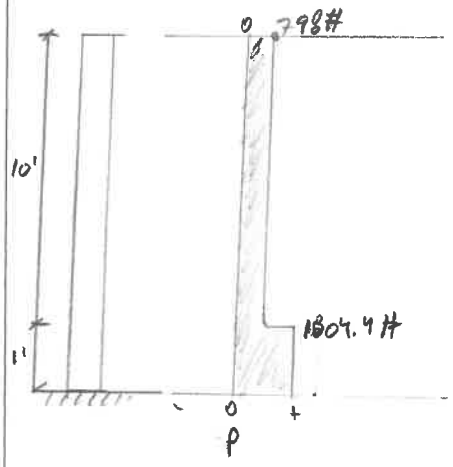
REFERENCE

P_{roof} & P_{floor} ARE REACTIONS OF RB1, RG1, FG1

TYPICAL COLUMN, C1

$P = P_{roof} + P_{floor} = 1006\# + 798.4\# = 1804.4\#$



USE No. 2 REDWOOD
$F_c = 950 psi$

FIND A_{req}:

$F_c = \frac{P}{A_{req}}$ $A_{req} = \frac{1804.4\#}{950 psi} = 1.90 in^2$

TRY: 4x4 No. 2 REDWOOD
$A = 12.25 in^2 \geq 1.90 in^2$

$f_c = \frac{P}{A} = \frac{1804.4\#}{12.25 in^2} = 131.87 psi$

$F'_c = F_c C_D C_M C_t' C_F C_i' C_p$

- $C_D = 1.25$ (L_r)
- $C_F = 1.15$
- $C_F F_c = 1.15(950 psi) = 1092.5 \nleq 750 psi \therefore C_M = 0.8$

$C_D = 1.25$
$C_F = 1.1$
$C_M = 0.8$

FIND C_p:

$K_e = 1.2$ $l_e = K_e l = 1.2(11')(12"/ft) = 158.4"$

$\frac{l_e}{d} = \frac{158.4"}{3.5"} = 45.3 \leq 50$ ✓OK

$F_c^* = 925 psi (1.25)(1.1)(0.8) = 1017.5 psi$
$E'_{min} = E_{min} C_M C_t' C_i' C_T' = 440{,}000 psi (0.8) = 352{,}000 psi$

$F_{cE} = \frac{0.822 E'_{min}}{(\frac{l_e}{d})^2} = \frac{0.822(352{,}000 psi)}{(45.3)^2} = 141.0 psi$

$F_{cE}/F_c^* = 0.13$

$C_p = \frac{1+.13}{2(.8)} - \sqrt{\left[\frac{1+.13}{2(.8)}\right]^2 - \frac{.13}{.8}} = 0.13$

$C_p = 0.13$

$F'_c = 925 psi (1.25)(1.1)(0.8)(0.13) = 138.3 psi$
$F'_c \geq f_c$ $138.3 psi \geq 131.87 psi$ ✓OK

PROVIDE 4x4 No. 2 REDWOOD TYPICAL COLUMN, C1

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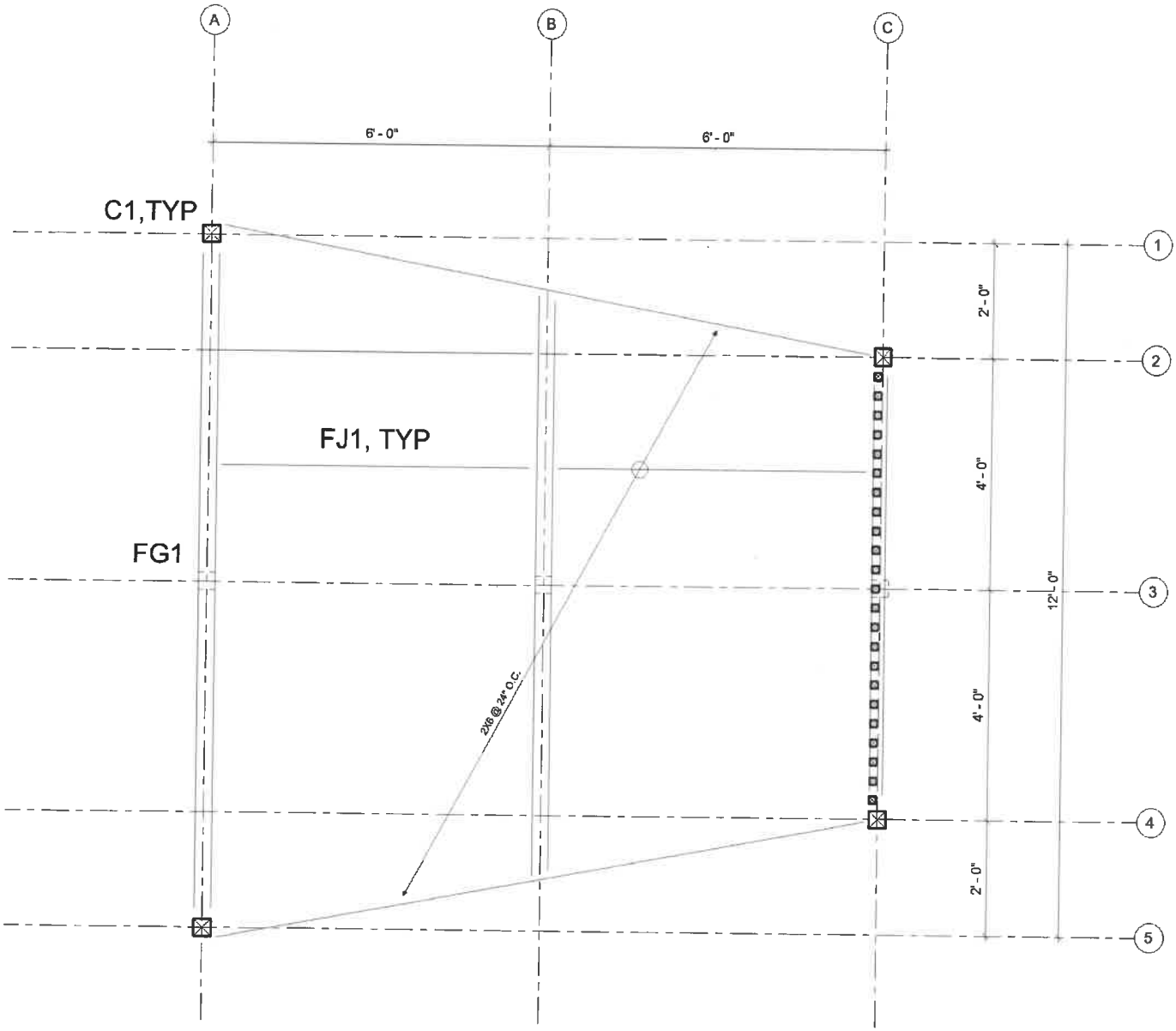
JOB NO. _____ DATE 5/15/2018
CLIENT _____ BY SV SHEET NO F1 OF F6

FLOOR KEY PLAN



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JOB NO. _____ DATE 4·9·18
CLIENT CAL POLY BY EV SHEET NO F2 OF F6

REFERENCE

IHITIAL TOLERANCES (FOR FLOOR MEMBERS)

NDS S. T4A — REDWOOD: NO. 2
F_b = 925 PSI
F_v = 160 PSI
E = 1,200,000 PSI
E_{min} = 440,000 PSI

NDS T4.3.1 — BENDING FACTORS:

NDST2.3.2 — C_D = 1.25 (CONSTR. LOAD)
NDSS P632 — C_M = 1.00 (MC < 19%)
NDST2.3.3 — C_t = 0.8 (100°F ≤ T ≤ 125°F)
NDSS P632 — C_{fu} = 1.0 (ABOUT STRONG AXIS)
NDST4.3.8 — C_i = 1.0 (NOT INCISED)
NDS 4.3.9 — C_r = 1.00 (NON REP. MEMBER)

NDS T4.3.1 — SHEAR FACTORS:

C_D = 1.25 (CONSTR. LOAD)
C_M = 1.00 (MC < 19%)
C_t = 0.8 (100°F ≤ T ≤ 125°F)
C_i = 1.00 (NOT INCISED)

NDS T4.3.1 — ELASTICITY FACTORS:

C_M = 1.00 (MC < 19%)
C_t = 0.80 (100°F ≤ T ≤ 125°F)
C_i = 1.00 (NOT INCISED)

FACTORED TOLERANCES:

F'_b* = 925 PSI (EXCLUDES C_L & C_F)
F'_v = 160 PSI
E' = 960,000 PSI
E'_{min} = 352,000 PSI

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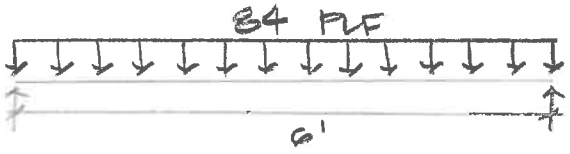
JOB POLY CANYON OBSERVATION DECK
JOB NO. TYP. JOIST DESIGN DATE 4.7.18
CLIENT CAL POLY BY SV SHEET NO F3 OF F6

REFERENCE

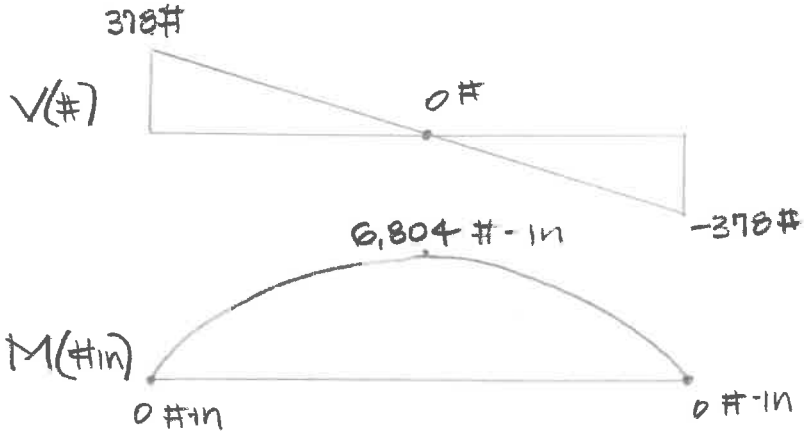
LOADS TO FLOOR JOISTS:

FJ1



ASD:
D = 13 PSF
L = 50 PSF

L = 6'
Wt = 24"
W = 63PSF (2') = 126 PLF → 126 PLF



NDS DESIGN AID 6. FI61

$V = \frac{we}{2} = \frac{126\,PLF(6')}{2} = 378\#$

$M = \frac{we^2}{8} = \frac{126\,PLF(6')^2}{8} = 567\,\#ft = 6804\,\#\text{-}in$

$\Delta_{all} = \frac{l}{360} = \frac{72"}{360} = 0.2"$

$\Delta_{act} = \frac{5we^4}{384EI} = \frac{5(126\,PLF)(6\times12)^4(\frac{1}{12})}{384(1.2\times10^6\,PSI)I} = \frac{3.06}{I}$

$0.2 = \frac{3.06\,in^5}{I}$ $I_{req} = 15.31\,in^4$.

$S_{req} = M/F_b = 6{,}804\#in/925\,PSI = 6.40\,in^3$

$A_{req} = 3V/2F'_v = 3(378\#)/2(160PSI) = 3.54\,in^2$

TRY 2×6 FOR ALL TYPICAL JOISTS @ 24" O.C.

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JOB NO. TYP. JOIST DESIGN DATE 4·9·18
CLIENT CAL POLY BY SV SHEET NO F4 OF F6

REFERENCE

CHECK 2×6 JOIST

$S = 7.563 in^3 \geq 6.40 in^3$ ✓
$I = 20.8 in^4 \geq 15.31 in^4$ ✓
$A = 8.25 in^2 \geq 3.54 in^2$ ✓

$F_{bau} = F_b (C_L)(C_f) = 1{,}202.5$ PSI

NDS 3.3-6

$$C_L = \frac{1 + F_{bE}/F_b^*}{1.9} - \sqrt{\left(\frac{1 + (F_{bE})(F_b^*)}{1.9}\right)^2 - \frac{F_{bE}/F_b^*}{.95}}$$

$= 1.0$

NDS 3.3.8

$$F_{bE} = \frac{1.20 E'_{min}}{R_b^2} = 9{,}090.9 \text{ PSI}$$

NDS 3.3-5

$$R_b = \sqrt{\frac{le\, d}{b^2}} = 6.82$$

NDS 4A

$C_F = 1.3$

$$F_{bact} = \frac{M}{S} = \frac{6{,}804 \#\text{-in}}{7.563\ in^2} = \underline{900 \text{ PSI}}$$

$$F_{vact} = \frac{3(V)}{2(A)} = \frac{3(378\#)}{2(8.25 in^2)} = \underline{69 \text{ PSI}}$$

$900 \text{ PSI} < 1{,}202.5 \text{ PSI}$ ✓

$69 \text{ PSI} < 160 \text{ PSI}$ ✓

$$\Delta_{act} = \frac{5 w L^4}{384 E I} = \frac{5(126 PLF)(6')^4}{384(960 ksi)(20.8 in^4)} = \underline{.184 in}$$

$.184 in < 0.2 in$ ✓

∴ USE 2×6 FOR ALL FLOOR JOIST AT 24" O.C

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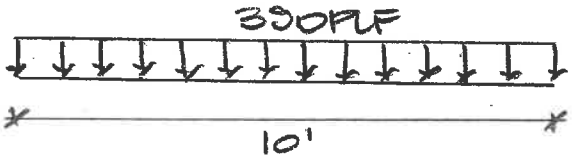
JOB NO. _____ DATE 5.27.18
CLIENT CAL POLY BY SV SHEET NO F5 OF F6

REFERENCE

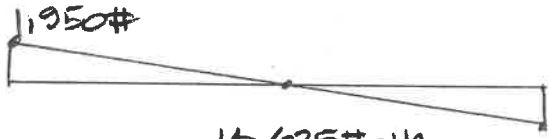
LOADS TO FLOOR GIRDER

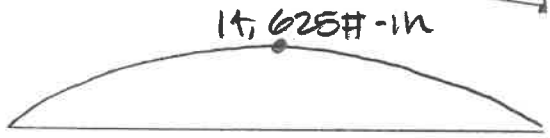
FG1



ASD:
D = 15 PSF
L = 50 PSF

t_w = 6'
L = 10'



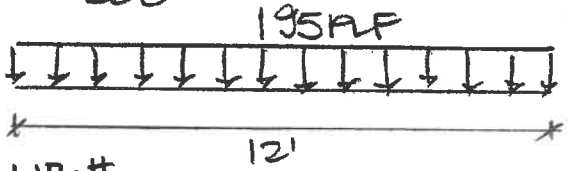


GOVERNS

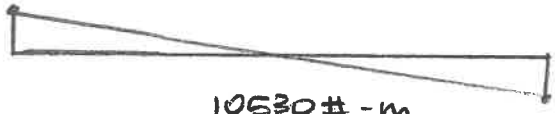
$V = \frac{wL}{2} = \frac{390PLF(10')}{2} = 1{,}950\#$

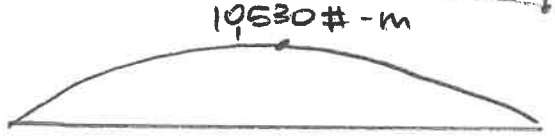
$M = \frac{wL^2}{8} = \frac{390PLF(10')^2}{8} = 14{,}625\#\text{-in}$

$\Delta_{all} = \frac{10'(12)}{360} = .333"$



t_w = 3'
L = 12'





$V = \frac{wL}{2} = \frac{195PLF(12')}{2} = 1170\#$

$M = \frac{wL^2}{8} = \frac{195PLF(12')^2}{8} = 10{,}530\#\text{-in}$

$\Delta_{all} = \frac{12'(12)}{360} = 0.4"$

CHOOSE MEMBER W/ GREATER MOMENT TO DESIGN. USE MEMBER SIZE FOR OTHER MEMBERS.

⇒ MIDDLE GIRDER W/ 10' SPAN & 6' TRIB WIDTH

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CLIENT CAL POLY BY SV SHEET NO F5 OF F6

REFERENCE

FOR 10' SPAN & 6' TRIB WIDTH

$$\Delta_{act} = \frac{5wL^4}{384EI} = \frac{5(390PLF)(10')^4(12")^4}{12(384)(1.2\times10^6PSI)I} = \frac{73.125}{I}$$

$0.333" = 73.125 in^5/I \quad I = 219.38 in^4$

$S_{req'd} = 14,625\#\text{-in}/925PSI = 15.81 in^3$

$A_{req'd} = 3(1,950\#)/2(160PSI) = 18.28 in^2$

TRY 3x12

$S = 52.73 in^3 \geq 15.81 in^3$ ✓
$A = 28.13 in^2 \geq 18.28 in^2$ ✓
$I = 296.6 in^4 \geq 219.38 in^4$ ✓

$F_{bau} = F_b(C_L)(C_f) = 925PSI$

$C_L = 1.0$

$F_{be} = \frac{1.2E'_{min}}{R_b^2} = 9,490.5PSI$

$R_b = \sqrt{\frac{l_e d}{b^2}} = 6.67$

$C_f = 1.0$

$F_{bact} = \frac{M}{S} = \frac{14,625\#in}{52.73in^3} = 277PSI$

$F_{vact} = \frac{3V}{2A} = \frac{3(1950\#)}{2(28.13in^2)} = 104PSI$

$\Delta_{act} = \frac{5wL^4}{384EI} = \frac{(5)390PLF(10')^4(12)^3}{384(1.6KSI)(296.6in^4)} = 0.308"$

277PSI < 925PSI ✓
104PSI < 160PSI ✓
0.308" < 0.333" ✓

∴ USE 3x12 FOR ALL FLOOR GIRDERS.

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JOB
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REFERENCE

SEISMIC ANALYSIS

$T_L = 8S$, $R = 1$, $I_e = 1.00$

ASCE 7-10
EQN 12.8-2
§T 12.2-1

$$C_S = \frac{S_{DS}}{\frac{R}{I_e}} = \frac{0.785_g}{\left(\frac{1}{1}\right)} = 0.785$$

$$T = C_t h_n^{\,x} = 0.02(11')^{0.75} = 0.125$$

$$T \le T_L \qquad 0.125 \le 8S$$

EQN 12.8-5

$$C_S = \frac{S_{D1}}{T\left(\frac{R}{I_e}\right)} = \frac{0.447}{.12\left(\frac{1}{1}\right)} = 3.725$$

$$C_S = 0.044\, S_{DS}\, I_e \ge 0.01$$
$$C_S = 0.044\,(0.785)1 \ge 0.01$$
$$0.0345 \ge 0.01 \quad \text{OK}$$

$R = 1$ IN N/S & E/W DIRECTIONS
$\therefore$ C_S IS SAME IN BOTH DIRECTIONS

$C_S = 0.785$

BASE SHEAR

SEE T FOR BLDG WEIGHT, W

$$V_b = C_S W$$

$W = 2520\#$

$$V_b = 0.785(2520\#) = 1978\# \approx 2.0^K$$

EQX:
$V_b = 2.0^K$

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REFERENCE

WIND ANALYSIS (BUILDING ENCLOSED)

ASCE 7-10 FIG. 26.5-1C
Risk category: I
V = 100 mph (45 m/s)
SURFACE ROUGHNESS: C
EXPOSURE: C

ASCE 7-10 §26.10
$K_{zt} = 1.0$
ASSUME BUILDING IS ENCLOSED (CONSERVATIVE)

$\frac{L}{B} = \frac{12'}{12'} = 1.0$

ASCE 7-10 §T 27.6-1
$h = 11' \therefore$ USE $h = 15'$
$p_o = 25.2$ psf
$p_h = 25.2$ psf
} WALL WIND LOADS

§T 27.6-2
$p_r = -23.7$ psf (WORST CASE)

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JOB
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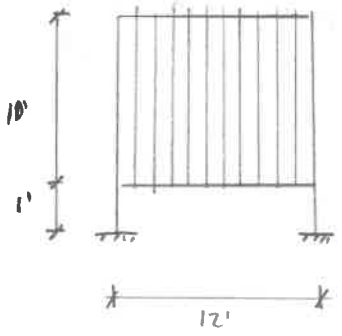
CLIENT BY EK SHEET NO L3 OF L11

REFERENCE

WIND ANALYSIS (BUILDING OPEN)

ASCE 7-10 §26.9

N/S FACING WALL:



N/S ELEVATION

$A_o \approx 11'(12') - \frac{1.5"(10')(12"/ft)(20)}{144}$

$A_o \approx 107.0 SF$

$A_g = 11'(12') = 132 SF$

$A_o \geq 0.8 A_g$

$A_o \geq 0.8(132 SF)$

$107 SF \geq 105.6 SF$ ✓OK

∴ BUILDING IS OPEN

§T1.5-1 • RISK CATEGORY: I

§26.5-1 • V = 100 mph (45 m/s)

§T26.6-1 • $K_d = 0.85$

§26.7 • EXPOSURE CATEGORY: C

§26.8 • K_{zt} ⟶ DOES NOT SATISFY ASCE 7-10 §26.8.1 #1

∴ $K_{zt} = 1$

§26.9 • $G = 0.85$

§26.11 • OPEN BUILDING ∴ $GC_{pi} = 0.00$

§T27.3-1 • K_z, K_h: $z = 11'$, EXPOSURE C, ∴ $K_z = 0.85$, $K_h = 0.85$

Eq. 27.3-1 • $q_z = 0.00256 K_z K_{zt} K_d V^2$

$q_{11'} = 0.00256(0.85)(1)(0.85)(100 mph)^2$

$q_{11'} = 18.5$

• $C_p = 0.8$ (OVERHANG)

Eq. 27.4-3 • $p = q_h G C_N$

$p = 18.5(0.85)(0.8)$

$p = 12.58 psf$

SEE L3 for P_o, P_h

$12.58 psf < 25.2 psf$ ∴ use $p_o = p_h = 25.2 psf$

$p_o = p_h = 25.2 psf$

$V_b = 12'(11')(25.2 psf) = 3326.4\# = 3.3^K$

$V_b = 3.3^K$

$3.3^K > 2^K$ ∴ WIND GOVERNS

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Lateral Analysis, Grid A

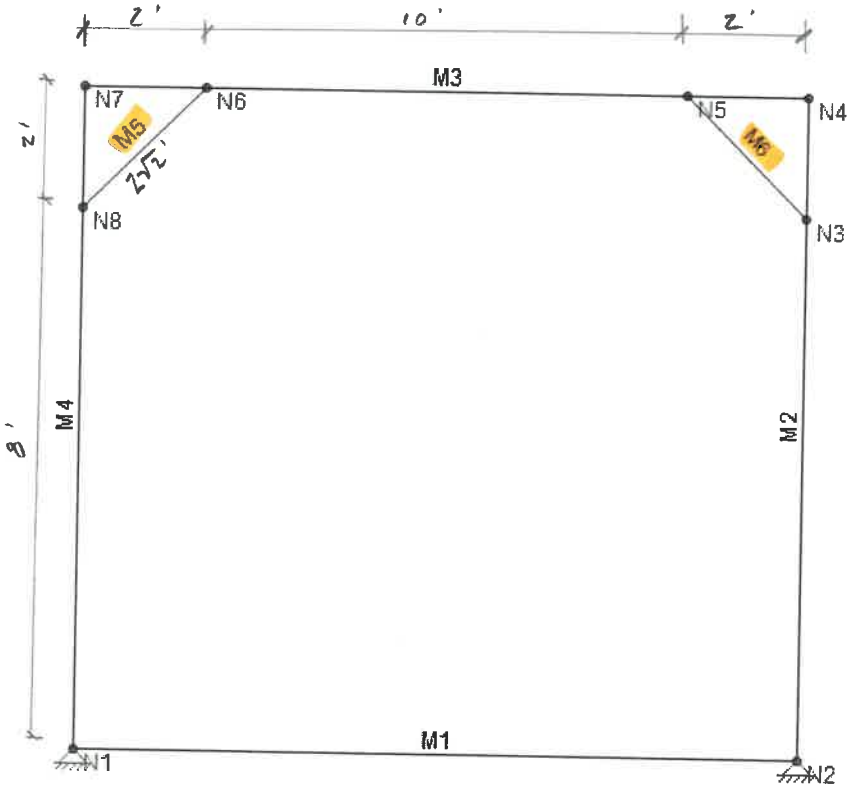
Risa Input

Member Primary Data:

Label	I Joint	J Joint	Design List
M1	N1	N2	Rectangular
M1A	N8	N8	Rectangular
M2	N4	N2	Rectangular
M3	N7	N4	Rectangular
M4	N1	N7	Rectangular
M5	N6	N8	Rectangular
M6	N3	N5	Rectangular

Joint Coordinate:

Label	x(ft)	y(ft)
N1	0	1
N2	12	1
N4	12	12
N3	12	10
N5	10	12
N6	2	12
N7	0	12
N8	0	10



Boundary Conditions:

Label	x-dir	y-dir
N1	Reaction	Reaction
N5	Reaction	Reaction
N10	Reaction	Reaction

Basic Load Cases:

BLC	Description
1	Floor Wind
2	Roof Live
3	Floor Live
4	Dead

Load Combinations:

Description	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor
D+0.6W	4	1	5	1	1	0.6		
D+0.75L+0.75Lr	4	1	5	1	1	0.45	2	0.75
0.6D+0.6W	4	0.6	5	0.6	1	0.6		

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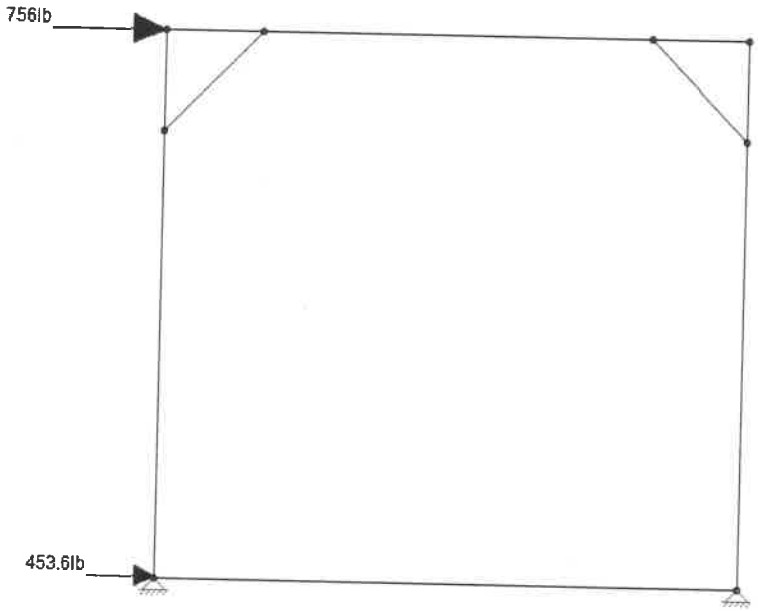
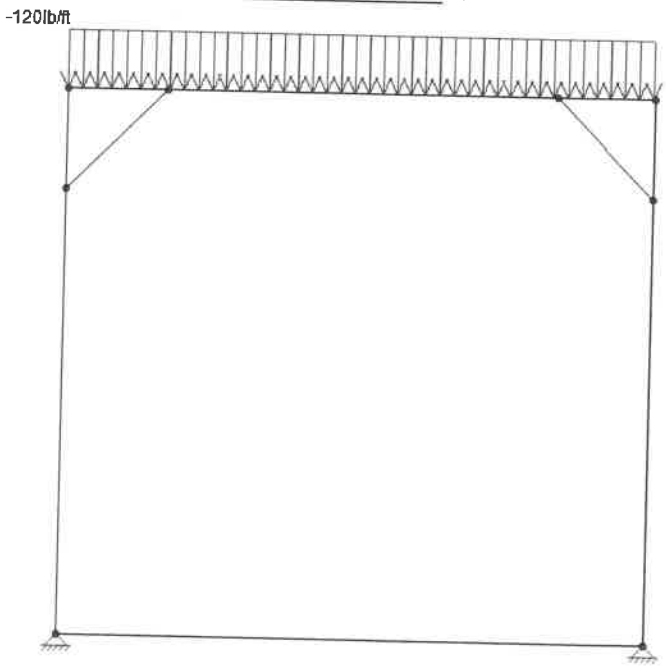
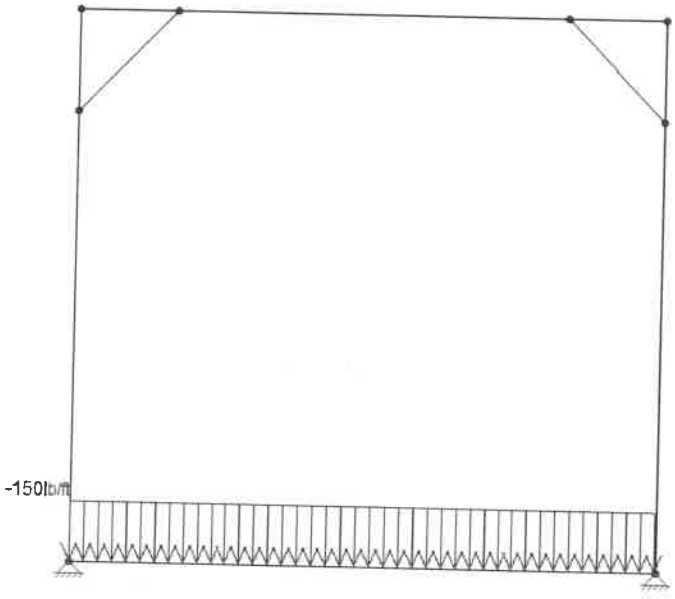
Wind Load



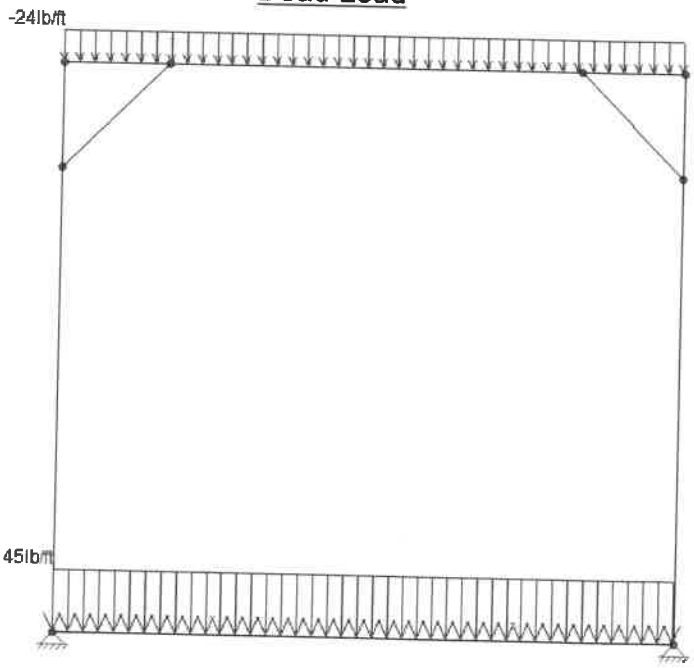
Roof Live Load



Floor Live Load



Dead Load



JOB
JOB NO. DATE
CLIENT BY EK SHEET NO 46 OF 111

REFERENCE

Risa Ouput (Grid A):

Member Forces (Axial):

Member		Force (lbs)
M1	max	0
M1	min	0
M2	max	869.804
M2	min	-308.74
M3	max	721.361
M3	min	-449.604
M4	max	498.196
M4	min	-161.339
M5	max	131.918
M5	min	-645.388
M6	max	1279.892
M6	min	885.244

* Negative values indicate member in tension

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REFERENCE

LATERAL DESIGN BRACE B1

$P_u = 1279.89\#$ (C)
$645.39\#$ (T)

CHECK COMPRESSION

USE NO. 2 REDWOOD
$F_c = 950\,psi$
FIND A_{req}: $F_c = \frac{P_u}{A_{req}}$ $A_{req} = \frac{1279.89\#}{950\,psi} = 1.35\,in^2$

TRY 2x4 No.2 REDWOOD
$A = 5.25\,in^2 \geq 1.35\,in^2$

$f_c = \frac{P}{A} = \frac{1279.89\#}{5.25\,in^2} = 243.8\,psi$

$F_c' = F_c C_D C_M C_t' C_F C_i' C_p$
- $C_D = 1.25$
- $C_F = 1.15$
- $C_F F_c = 1.15(950) = 1092.5psi \nleq 750psi$ $\therefore C_M = 0.8$

$C_D = 1.25$
$C_F = 1.15$
$C_M = 0.8$

FIND C_p:

$K_e = 1.0$ (pin-pin)
$l_e = K_e l = 1.0(2\sqrt{2})(12"/ft) = 33.9" \approx 34"$
$d = 3.5"$
$E'_{min} = E_{min} C_M^{0.8} C_t' C_i' C_T' = 440{,}000(0.8) = 352{,}000psi$
$F_{cE} = \frac{0.822(352{,}000psi)}{\left(\frac{34"}{3.5"}\right)^2} = 3066.15\,psi$
$F_c^* = 950(1.25)(1.15)(0.8) = 1092.5\,psi$
$\frac{F_{cE}}{F_c^*} = 2.81$

$C_p = \frac{1+2.81}{1.6} - \sqrt{\left(\frac{1+2.81}{1.6}\right)^2 - \frac{2.81}{0.8}} = 0.91$

$F_c' = 950psi(1.25)(1.15)(0.8)(0.91) = 994.2\,psi$
$F_c' \geq f_c$ $994.2psi \geq 243.8psi$ ✓OK

$\therefore$ ADEQUATE IN COMPRESSION

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CHECK TENSION

$$f_t = \frac{P}{A} = \frac{645.4\#}{5.25in^2} = 122.9psi$$

$$F_t' = F_t C_D^{1.25} C_M C_t C_F^{1.5} C_i$$

$C_D = 1.25$
$C_F = 1.5$
$C_M = 1.0$

$F_t' = 525psi\,(1.25)(1.5) = 984.4psi$

$F_t' \geq f_t \quad 984.4psi \geq 122.9psi$ ✓OK

∴ ADEQUATE IN TENSION

PROVIDE 2x4 NO.2 REDWOOD BRACE, BY

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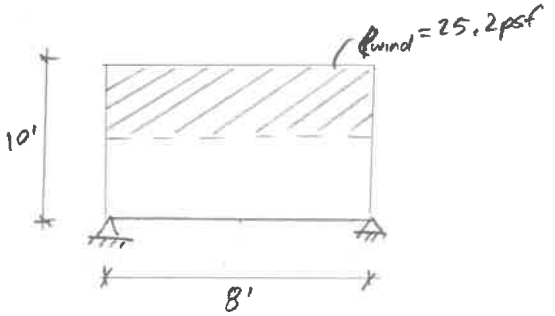
REFERENCE

CHORD @ ROOF (RB3) (3x8 No.2 REDWOOD)



N/S ELEVATION

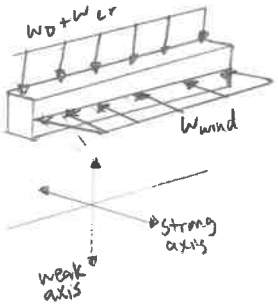
BIAXIAL BENDING

ASD LOAD COMBOS:

$D + 0.75(0.6W) + 0.75L_r$ GOVERNS

D = 2 psf
W = 0.75(0.6)(25.2psf) = 11.34psf
L_r = 0.75(20 psf) = 15psf

w_{wind} = 11.34psf(5') = 56.7plf
w_D = 2psf(3') = 6plf
w_{Lr} = 15psf(3') = 45plf



$$\left[\frac{f_c}{F_c'}\right]^2 + \frac{f_{b1}}{F_{b1}'\left[1 - \frac{f_c}{F_{cE1}}\right]} + \frac{f_{b2}}{F_{b2}'\left[1 - \frac{f_c}{F_{cE2}} - \left(\frac{f_{b1}}{F_{bE}}\right)^2\right]} \leq 1.0$$

f_c = 0 (both terms)

$$f_c = \frac{P}{A} = 0$$

$$\frac{f_{b1}}{F_{b1}'} + \frac{f_{b2}}{F_{b2}' - \left(\frac{f_{b1}}{F_{bE}}\right)^2} \leq 1.0$$

$$f_{b1} = \frac{(w_D + w_{Lr})l^2}{8} \cdot \frac{1}{S} = \frac{(6+45)(8')^2}{8} \cdot \frac{144in^2}{21.90in^3} = 2682.7psi$$

f_{b1} = 2682.7psi

$$f_{b2} = \frac{w_{wind}\, l^2}{8} \cdot \frac{1}{S} = \frac{56.7plf\,(8')^2}{8} \cdot \frac{144in^2}{21.90in^3} = 2982.6psi$$

f_{b2} = 2982.6psi

F_{bE} = 2043.4psi (FROM GRAVITY CALC)

REFERENCE

$F'_{b1} = F_b C_D C_M C_t' C_L C_F C_{fu}' C_i' C_r'$

$C_D = 1.25$ $C_F = 1.2$

$C_L = 0.93$

$C_M = 1.0$

$F'_{b1} = 925psi\,(1.25)(0.93)(1.2) = 1290psi$ → $F'_{b1} = 1290psi$

$F'_{b2} = F_b C_D C_M C_t' C_L C_F C_{fu} C_i' C_r'$

$C_D = 1.25$ $C_M = 0.8$

$C_M = 1.0$

$C_{fu} = 1.15$

$C_F = 1.2$

C_L: $\frac{l_{u2}}{d_2} = \frac{8'\times 12''/ft}{2.5''} = 38.4 \geq 7 \therefore l_{e2} = 1.63(96'') + 3(2.5'') = 163.98''$ → $l_{e2} = 163.98''$

$R_b = \sqrt{\frac{163.98''(2.5'')}{(7.25'')^2}} = 7.8 \leq 50$ ✓OK

$E'_{min} = E_{min} C_M^{0.8} C_t' C_i' C_T' = 440{,}000(0.8) = 352{,}000psi$ → $E'_{min} = 352{,}000psi$

$F_{bE_2} = \frac{1.20(352{,}000psi)}{(7.8'')^2} = 6942.8psi$

$F_b^* = 925(1.25)(0.8)(1.2) = 1110psi$

$F_{bE_2}/F_b^* = 6.25$

$C_L = \frac{1+6.25}{1.9} - \sqrt{\left(\frac{1+6.25}{1.9}\right)^2 - \frac{6.25}{0.95}} = 0.99$

$F'_{b2} = 925psi\,(1.25)(1.15)(1.2)(0.99)(0.8) = 1263.7psi$ → $F'_{b2} = 1263.7psi$

$$\frac{f_{b1}}{F'_{b1}} + \frac{f_{b2}}{F'_{b2}\left(1-\left(\frac{f_{b1}}{F_{bE}}\right)^2\right)} \leq 1.0$$

$$\frac{2682.7psi}{1290psi} + \frac{2968.7psi}{1263.7\left[1-\left(\frac{2682.7psi}{7093.4psi}\right)^2\right]} = -1.17 \leq 1.0$$ ✓OK

∴ 3x8 NO. 2 REDWOOD IS ADEQUATE IN BIAXIAL BENDING, RB3

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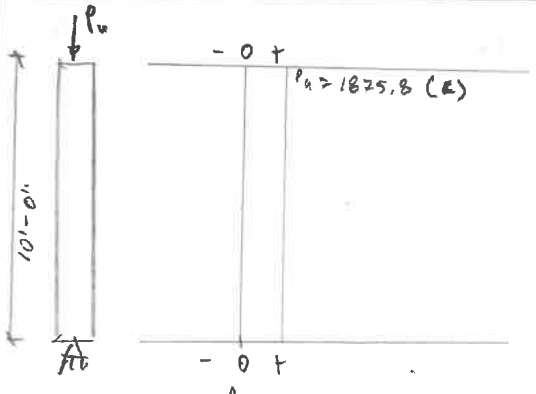
REFERENCE

TYP. COLUMN, C1 (OVERTURNING FORCES)

$P_{lateral}$ Forces FROM RISA OUTPUT GRID 'A'



$P_{grav} = 1006\#$

$P_{lat.\,E} = 869.8\#$

$P_{lat.\,T} = 161.4\#$

USE REDWOOD SELECT. STRUC. 4x4

$A = 12.25\,in^2$

CHECK COMPRESSION

$$F_c = \frac{P_u}{A} = \frac{1006 + 869.8}{12.25\,in^2} = 153.1\,psi$$

$F'_c = F_c C_D C_M C_t C_F C_i C_p$

- $C_D = 1.25$
- $C_F = 1.15$
- $C_F F_c = 1.15(1500\,psi) = 1725\,psi \not\leq 750\,psi \therefore C_M = 0.8$

$C_D = 1.25$
$C_F = 1.1$
$C_M = 0.8$

FIND C_p:

$K_e = 1.2$ $\quad l_e = K_e l = 1.2(10')(12"/ft) = 144"$

$$\frac{l_e}{d} = \frac{144"}{3.5"} = 41.1 \leq 50 \checkmark OK$$

$F_c^* = 1500\,psi(1.25)(1.1)(0.8) = 1650\,psi$

$E'_{min} = E_{min} C_M C_t C_i C_T = 1{,}400{,}000(0.5) = 1.12 \times 10^6\,psi$

$$F_{cE} = \frac{0.822(1.12 \times 10^6)}{(41.1)^2} = 545.0\,psi$$

$F_{cE}/F_c^* = 0.33$

$$C_p = \frac{1 + .33}{1.6} - \sqrt{\left(\frac{1.33}{1.6}\right)^2 - \frac{.33}{0.8}} = 0.30$$

$F'_c = 1650\,psi(0.3) = 495\,psi \geq 153.1\,psi$ ✓OK

PROVIDE SELECT STRUCTURAL REDWOOD 4x4 TYPICAL COLUMN, C1

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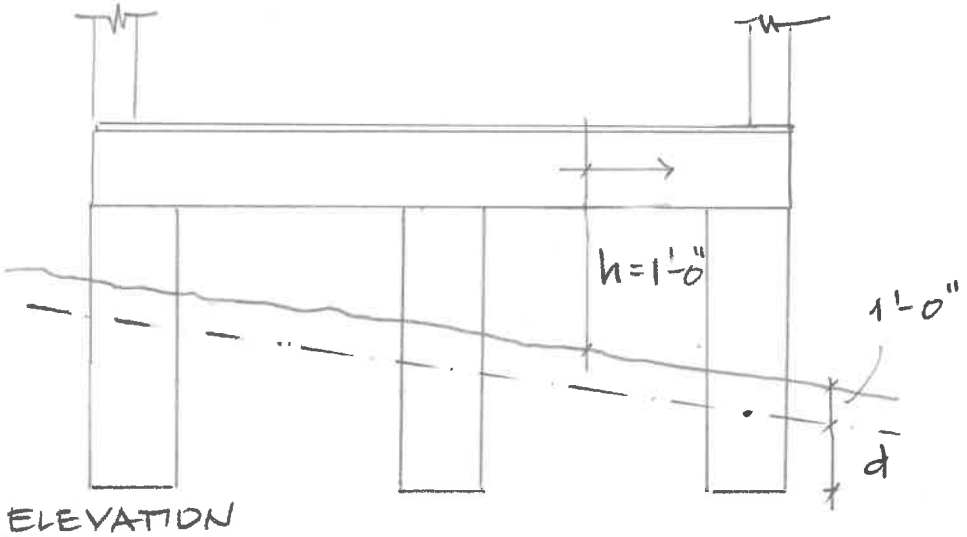
CLIENT CAL POLY BY SV SHEET NO F01 OF F01

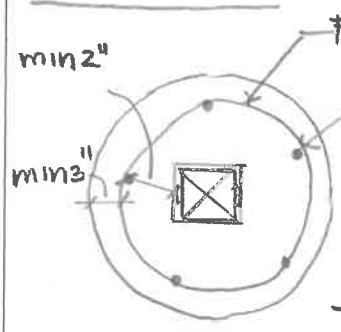
REFERENCE

FOUNDATION

*REFER TO ACI 316 FOR DETAILING
IBC 2015 FOR PROCEDURE



ELEVATION



#4 BAR DIAMETER = 0.5"
#3 BAR DIAMETER = 0.375"

$b = (3")(2) + (2")(2) + (.5")(2) + (.375")(2) + 3.5" + 1" = 16.25"$

USE $b = 18"$ FOR PIER FOOTING

PER IBC 15 SECTION 1807.3.2 :
NON CONSTRAINED =>

$$d = 0.5A\left(1 + \left(1 + (4.36h/A)\right)^{1/2}\right)$$

$A = 2.34P/S_1b$

$A = 2.34(0.5\ \text{KIPS})/(150\ \text{PSF}/A)(18") = 5.2\ SF$

$d = 0.5(5.2SF)\left(1 + \left(1 + (4.36(6"/5.2SF)\right)^{1/2}\right) =$

$= 5.697\ FT = 68.37\ in \approx 69\ in$

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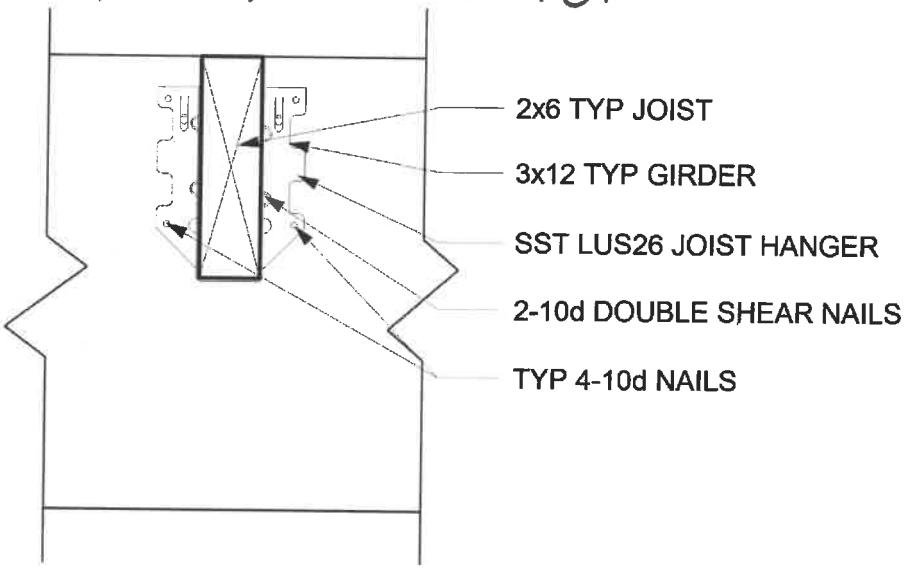
CLIENT CAL POLY BY SV SHEET NO M1 OF M3

REFERENCE

FLOOR JOIST TO GIRDER



LUS26 CAPACITY: 865#
DEMAND: 378#

865# > 378#

∴ USE LUS26 FOR ALL FLOOR JOIST TO GIRDER CONNECTIONS

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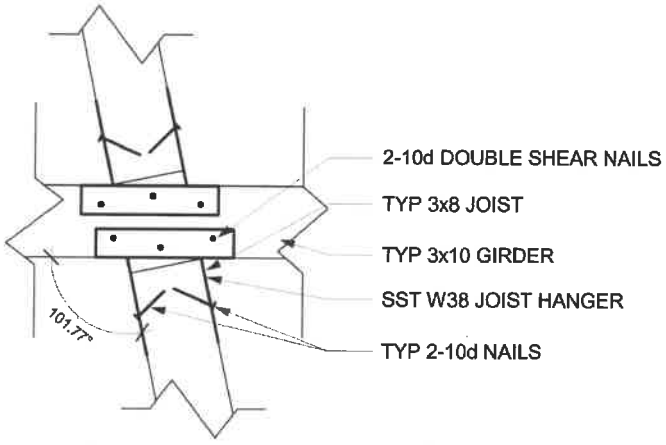
REFERENCE

ROOF BEAM RB2 TO GIRDER RG1



W38 HANGER CAPACITY: 2,900^{lk}
DEMAND: 439.9^{lk}

2,900^{lk} > 439.9^{lk} ✓

∴ USE W38 FOR ALL ROOF ANGLED CONNECTION INCLUDING RB2 OVERHANG

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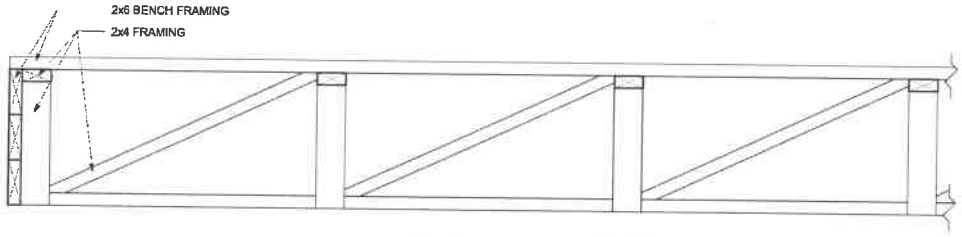
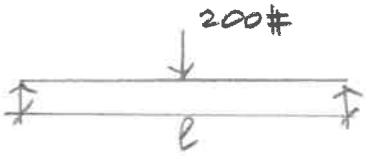
REFERENCE

BENCH DETAILING:



CHECKING 2x6 BENCH FRAMING FOR DEFLECTION TO DETERMINE BENCH SUPPORT SPACING:

FOR 2x6 $I_{xx} = 20.81 in^4$
$I_{yy} = 1.547 in^4$



$\Delta_{all} = \frac{\ell}{360}$ $\Delta_{act} = \frac{P\ell^3}{48EI}$

$\frac{\ell}{360} = \frac{200\#(\ell^3)}{48(900\ ksi)(1.547 in^4)}$

$990.081 in^3 = \ell^2$ $\ell = 31.47 in$

IN ORDER TO AVOID HAVING $\Delta_{all} \approx \Delta_{act}$ AND INSTEAD $\Delta_{all} >> \Delta_{act}$
USE $\ell = 24"$

∴ PLACE BENCH SUPPORT FRAMES FOR 2x6 BENCH MEMBERS AT 24" O.C.