DANIEL C. SMITH, PE
Consulting Engineers

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Custom Shelter on Mercer Island

11/11/2019

File Name: 12258 Shelter on Mercer Island CAL1.xls CAL

Calculation Note

"Engineers make conservative assumptions based on education and years of experience on their expertise. The engineer and I both agree on the assumptions on the loading of the beam and that the PCB-2 was clearly resisting the worst case loading condition. Stress calculations indicate that the wood beam was structurally adequate.

Building Code	2015 Washington Building Code
Building Category	II
Occupancy Type	Assembly A-5
ASCE	ASCE 7-10

Building Data

Shelter Width	20	ft
Shelter Length	40	ft
Post Spacing	10	st
CTB Width	5	
CTB Length	16	
CTB S;an	16	
CTB Weight	346	
Shelter Mean Roof Height	15	ft
Roof Slope	6	/12
Footing depth	4.6	ft
Footing Diameter	3	ft
Soil Bearing	2000	psf

DANIEL C. SMITH STATE OF WASHINGTON 44613 REGISTERED PROFESSIONAL ENGINEER
11-25-2019
For Sheets 1/22 through 22 of 22

Design Loads

Roof Dead Load (incl 4 psf for CTB and convert to horiz proj)	RDL	18	psf
Roof Live Load	RLL	30	psf

Wind Design Data

Basic Wind Speed			110	mph
Wind Exposure Category			C	
Wind Importance Factor			1.0	
Tributary Area			800	sf
Kh			0.85	
Kd			0.85	
Kzt			1.00	
Internal Pressure Coefficient			0.0	psf
qh =			22.4	psf
	Load Case A		Load Case B	
Cnw (page 67 of ASCE 7-10)	1.20		0.20	
Cnl (page 67 of ASCE 7-10)	-0.10		-0.85	
Vertical projection of roof along long side			150	sf
Vertical projection of roof along short side			50	sf
Wind Base Shears	Vxx 1.1	Vyy	3.4	kips

Snow Load Design Data

Ground Snow Load		20	psf
Snow Exposure Factor		1.0	
Snow Importance Factor		1.0	
Snow Thermal Factor		1.2	
Flat Roof Snow Load		24	psf
Roof Slope Factor		1.0	
Sloped Roof Snow Load	RSL	24	psf

Seismic Design Data

Seismic Importance Factor		1.00	
Short Period Spectral Response Acceleration	Ss	1.408	
1-Second Period Spectral Response Acceleration	S1	0.488	
Seismic Site Class		D	
Design Short Period Spectral Response Acceleration	Sds	0.939	
Design 1-Second Period Spectral Response Acceleration	Sd1	0.541	
Seismic Design Category		D	
Basic Seimic Resisting System		Cantilevered Column System	
Basic Seismic Force Resisting System		Timber Frames	
Response Modification Factor		1.5	
Seismic Response Coefficient		0.63	
Seismic Base Shear (Strength Design)		9.0	kips
Seismic Base Shear (Allowable Stress Design)		6.3	kips

Curved Tapered Beam Analysis

By inspection, PCB-2 will control the design of the two beam types. Also, by inspection, roof dead load + 30 psf roof live load will govern over snow, wind or seismic for the beam design.

Input

PCB-2

Southern Pine

Span	L	16.0	ft	LDF	1.25	
Spacing	S	10.0	ft	Fb	2400	psi
Roof Slope (x/12)	P	6.0		Fv	200	psi
Dead Load	DL	18.0	psf	E	1800000	psi
Live Load	LL	30.0	psf			
Allowable Deflection	D	0.800	in (L/240)			
Width	B	5.000	in			
Vertical End Depth	De	7.688	in			
Vert Centerline Depth	Dc	30.375	in			
Centerline Str Depth	Dcs	16.000	in			
Radius	R	16.000	ft			
Lam Thickness	LT	1.375	in			

Intermediate Calculations

Roof Slope	phiT	0.464	radians
Curvature Factor	Cc	0.897	
Effective Length for Shear	Le	14.7	ft

Iterative Procedure to Calculate slope at bottom of Beam

1. Enter an assumed value of phiB,
2. Compare with the calculated value of phiB,
3. Enter a closer approximation of phiB
4. Repeat until phiB (assumed) = phiB (calculated)

Assumed value for phiB 26.300 degrees

Assumed	Compare these --->	phiB	0.459	radians
Calculated	Two values ----->		0.459	radians

Curved Beam Geometry

Horizontal distance from tangent to tangent	Lc	14.18	ft
Horizontal distance from end to tangent	Lt	0.91	ft
Overall height of beam	Ha	4.64	ft
Height from bottom of beam to bottom of curve @ CL	Hs	2.11	ft
Vertical depth at tangent	Dt	7.75	in
Radius @ mid-depth at beam centerline	Rm	17.27	ft
Effective depth of beam for deflection	Deb	11.85	in

Shear and Moment Calculations

Uniform load on beam	W	480	plf
Shear at end of beam	Rv	3840	lbs
Moment at tangent	Mt	3299	ft-lbs
Moment at beam centerline	Mc	15360	ft-lbs

Stress Factors

Radial stress factor	Kr	0.146
Bending stress factor	Ktheta	2.426
Radial stress reduction factor	Cr	0.740

Stress and Deflection Calculations

ENGR CHECK

Shear — OK

Area at end of beam for shear stress		38	in^2
Actual shear stress	1.5*Rv*(Le/L)/A	138	psi
Allowable shear stress	LDF*Fv	250	psi

Bending at Tangent — OK

Tangent depth perpendicular to lams		6.9	in
Section modulus		40	in^3
Actual bending stress	Mt*12/S	984	psi
Allowable bending stress	LDF*Cf*Cc*Fb	2826	psi

Bending at Centerline, Structural Depth — OK

Structural depth at beam centerline		16.0	in
Section modulus		213	in^3
Actual bending stress	Mc*12/S	864	psi
Allowable bending stress	LDF*Cf*Cc*Fb	2608	psi

Bending at Centerline, Full Depth **OK**

Vertical centerline depth			30.4	in
Section modulus			769	in^3
Actual bending stress	Ktheta*Mc*12/S		582	psi
Allowable bending stress	LDF*Cf*Cc*Fb		2429	psi

Radial Stress at Centerline **OK**

Bending stress			240	psi
Actual radial stress		Kr*Cr*fb	26	psi
Allowbable radial tension		LDF*Fv/3	83	psi

Vertical Deflection at Centerline **OK**

Effective moment of inertia	B*Deb^3/12		694	in^4
Actual deflection at centerline	5WL^4/(384EI)		1	in
Allowable deflection at centerline			1	in

Horizontal Deflection at Support

Height at mid-depth of centerline		H	3.4	ft
Horizontal deflection at each end	(2*H/L)*DEFLcl		0.2	in

P1, P2, P3

Actual Width	3.000	in
Actual Depth	6.875	in
Area	18	in^2
Section Modulus	16	in^3
Moment of Inertia	59	in^4
Spacing	4.0	ft
Span	10.0	ft
Total Load	0.192	klf
End Reaction	1.0	kips
Shear	0.9	kips
Moment	2.4	ft-kips
Deflection	0.41	in

Dead Load	18	psf
Live Load	30	psf
LDF	1.25	
Fv	0.300	ksi
Fb	2.400	ksi
E	1800	ksi
Eave Cut	1.50	in
Neutral Axis	3.08	in
Vol Factor	1.00	

W(klf)

vvvvvvvvvvvv vvvvvvvvvvvvvvvvvvvvvvvvvvv

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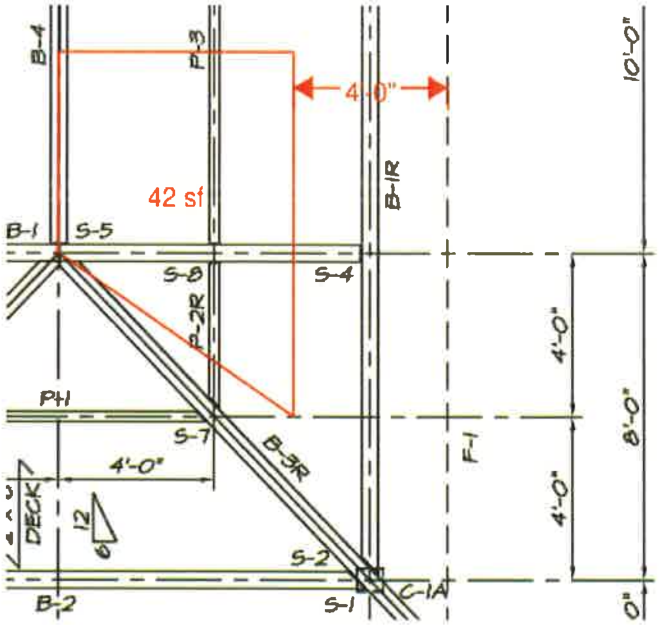
	Actual	Allowable	Status
Shear Stress	0.069	0.375	OK
Bending Stress	1.848	3.000	OK
Total Deflection Ratio	296	240	OK

B1

Tributary area for point load into B1	42	sf
Tributary width for distributed load into B1	4.0	ft



Actual Width	5.000	in
Actual Depth	13.750	in
Area	63	in^2
Section Modulus	111	in^3
Moment of Inertia	830	in^4
Span	18.0	ft
Spacing	4.0	ft
P	2.0	kips
a	8.0	ft
b	10.0	ft
Uniform Load	0.192	klf
Ryl	2.9	kips
Ryr	2.6	kips
Shear	2.6	kips
Ma	10.0	ft
Moment	16.7	ft-k
Deflection	0.58	in

Dead Load	18	psf
Live Load	30	psf
LDF	1.25	
Fv	0.300	ksi
Fb	2.400	ksi
E	1800	ksi
Eave Cut	2.50	in
Neutral Axis	6.27	in
Vol Factor	1.00	

| a | P b |
a<b V W(klf)
vvvvvvvvvvv vvvvvvvvvvvvvvvvvvvvvvvvvv
^ ^

	Actual	Allowable	Status
Shear Stress	0.063	0.375	OK
Bending Stress	1.802	3.000	OK
Deflection Ratio	372	240	OK

B2

Actual Width	5.000	in
Actual Depth	13.750	in
Area	63	in^2
Section Modulus	111	in^3
Moment of Inertia	830	in^4
Spacing	6.0	ft
Span	16.0	ft
Total Load	0.288	klf
End Reaction	2.3	kips
Shear	2.0	kips
Moment	9.2	ft-kips
Deflection	0.28	in

Dead Load	18	psf
Live Load	30	psf
LDF	1.25	
Fv	0.300	ksi
Fb	2.400	ksi
E	1800	ksi
Eave Cut	2.50	in
Neutral Axis	6.27	in
Vol Factor	1.00	

W(klf)

vvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvv

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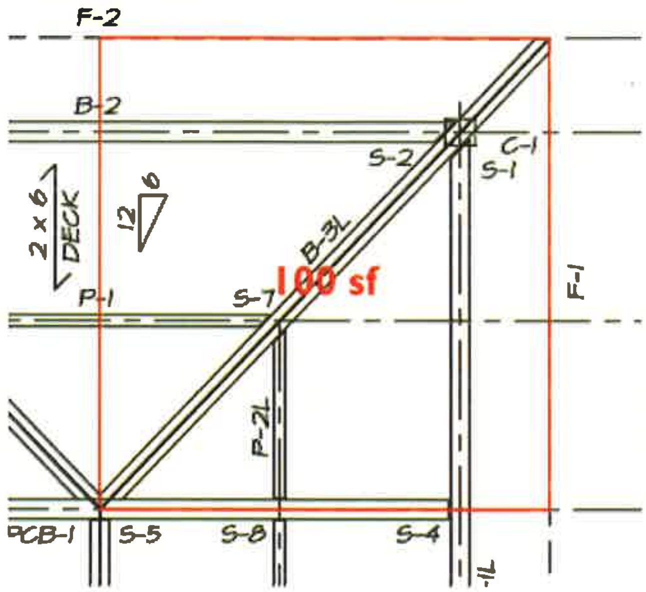
	Actual	Allowable	Status
Shear Stress	0.047	0.375	OK
Bending Stress	0.996	3.000	OK
Total Deflection Ratio	675	240	OK

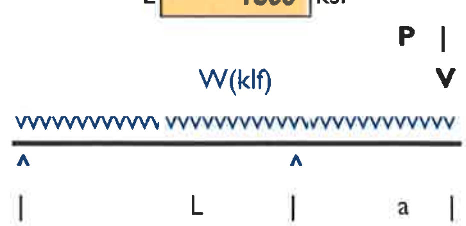
B3

Calculations below will show that this beam is very conservatively designed so the total load on the beam will be approximated as a uniform load.



Total square feet supported by beam	100	sf
Beam span + cantilever	14.1	ft
Equivalent uniform load	7.1	ft

Actual Width	5.000	in	Pitch	4	/12
Actual Depth	11.000	in	Dead Load	18.0	psf
Area	53.0	in^2	Live Load	30.0	psf
Section Modulus	87.2	in^3	P	0.0	kips
Moment of Inertia	496.8	in^4	a	2.8	ft
Total Load	0.339	klf	Eave Cut	0.81	in
Span	11.3	ft	Neutral Axis	5.30	in
Spacing	7.1	ft	Vol Factor	1.00	
Ryl	1.8	kips	LDF	1.25	
Ryr	3.0	kips	Fv	0.300	ksi
Ma	5.3	ft	Fb	2.400	ksi
Moment @ Ma	4.8	ft-k	E	1800	ksi
Moment @ Ryr	1.4	ft-k			
Vmax	2.0	kips			
Mmax	4.8	ft-k			
Defl @ L/2	0.13	in			
Defl @ O'hang	-0.09	in			



Design Check	Actual	Allowable	Status
Shear Stress	0.058	0.375	OK
Bending Stress	0.657	3.000	OK
Deflection	1015	240	OK

B4

Actual Width	5.000	in	Dead Load	18	psf
Actual Depth	6.875	in	Live Load	30	psf
Area	31	in^2	LDF	1.25	
Section Modulus	28	in^3	Fv	0.300	ksi
Moment of Inertia	104	in^4	Fb	2.400	ksi
Spacing	4.0	ft	E	1800	ksi
Span	10.0	ft	Eave Cut	1.25	in
Total Load	0.192	klf	Neutral Axis	3.14	in
End Reaction	1.0	kips	Vol Factor	1.00	
Shear	0.9	kips			
Moment	2.4	ft-kips			
Deflection	0.23	in			

W(klf)

	Actual	Allowable	Status
Shear Stress	0.041	0.375	OK
Bending Stress	1.038	3.000	OK
Total Deflection Ratio	519	240	OK

C1, C2

Loading combnation that controls is dead load + seismic load on C2. Seismic force will be in a direction to create weak axis bending. Check for dry conditions of use.

Axial Load on C2		2.4	kips
Lateral load at top of C2 (seismic base shear / 6)		1.1	kips
Column length above base		10.2	ft
Moment at base of column		10.7	ft-k
Width		6.750	in
Depth		8.250	in
Span		10.2	ft
LDF		1.60	
Fc		1.650	ksi
Fb in strong axis		1.600	ksi
Fb in weak axis		1.800	ksi
E		1700	ksi
Pmax		2.4	kips
Mmax in strong axis		0.0	ft-kips
Mmax in weak axis		10.7	ft-kips

Compression

Compression stress		0.044	ksi
Coefficient that depends upon coefficient of variation	KcE	0.418	
Coefficient for solid sawn, glulam or round piles	c	0.90	
Buckling length coefficient	Ke	2.1	
Length divided by width or depth, depending on which controls	le/d	38.1	
Allow Fc stress multiplied by all adjustment factors except Cp	F*c	2.640	ksi
Buckling strength of column	Fce	0.490	ksi
Column stability factor	Cp	0.182	
Compression portion of unity check		0.091	

Strong Axis Bending

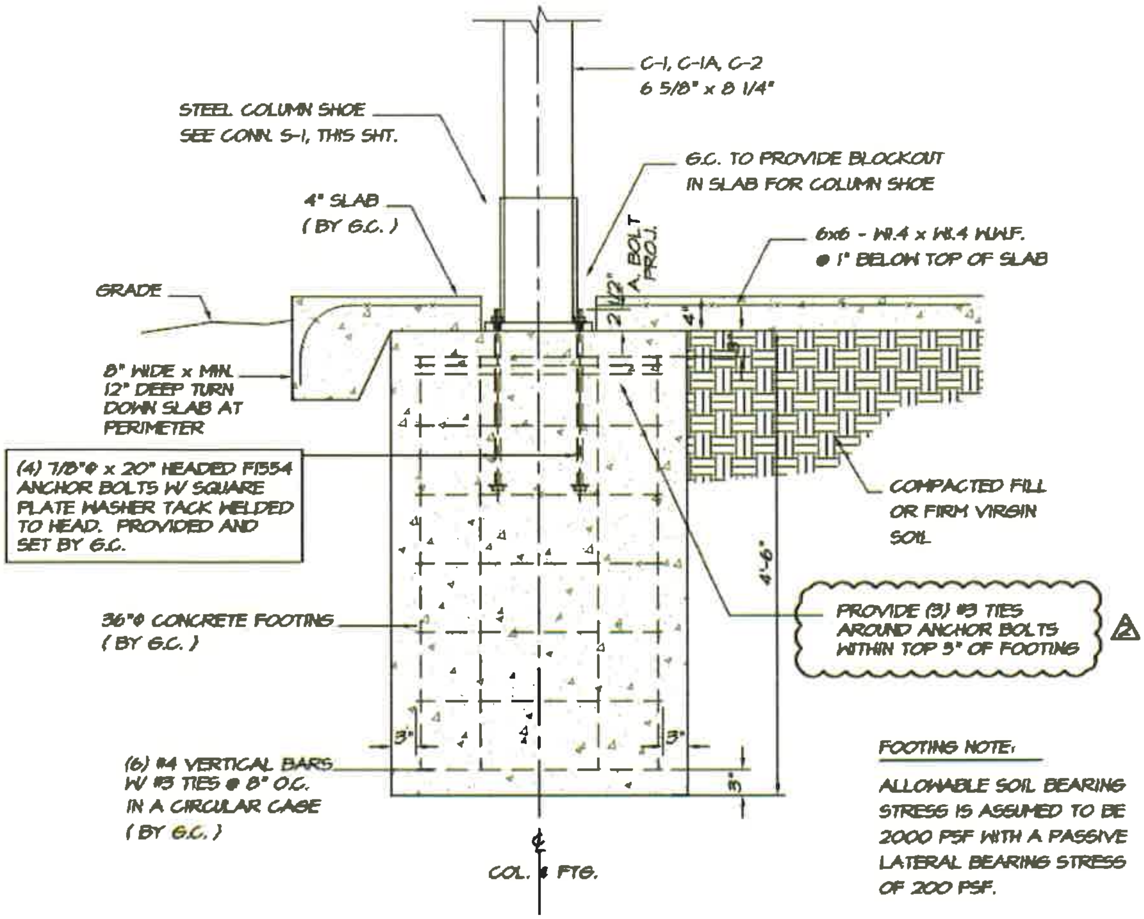
Section modulus	77	in^3
Strong axis bending stress	0.000	ksi
Volume factor	1.00	
Allowable bending stress with adjustments for LDF and Cv	2.560	ksi
F_{cE1}	0.490	
Strong axis bending portion of unity check	0.000	

Weak Axis Bending

Section modulus	63	in^3
Weak axis bending stress	2.055	ksi
Allowable bending stress with adjustments for LDF	2.880	ksi
F_{cE2}	0.490	
Weak axis bending portion of unity check	0.783	

Total	0.874

Concrete Footing



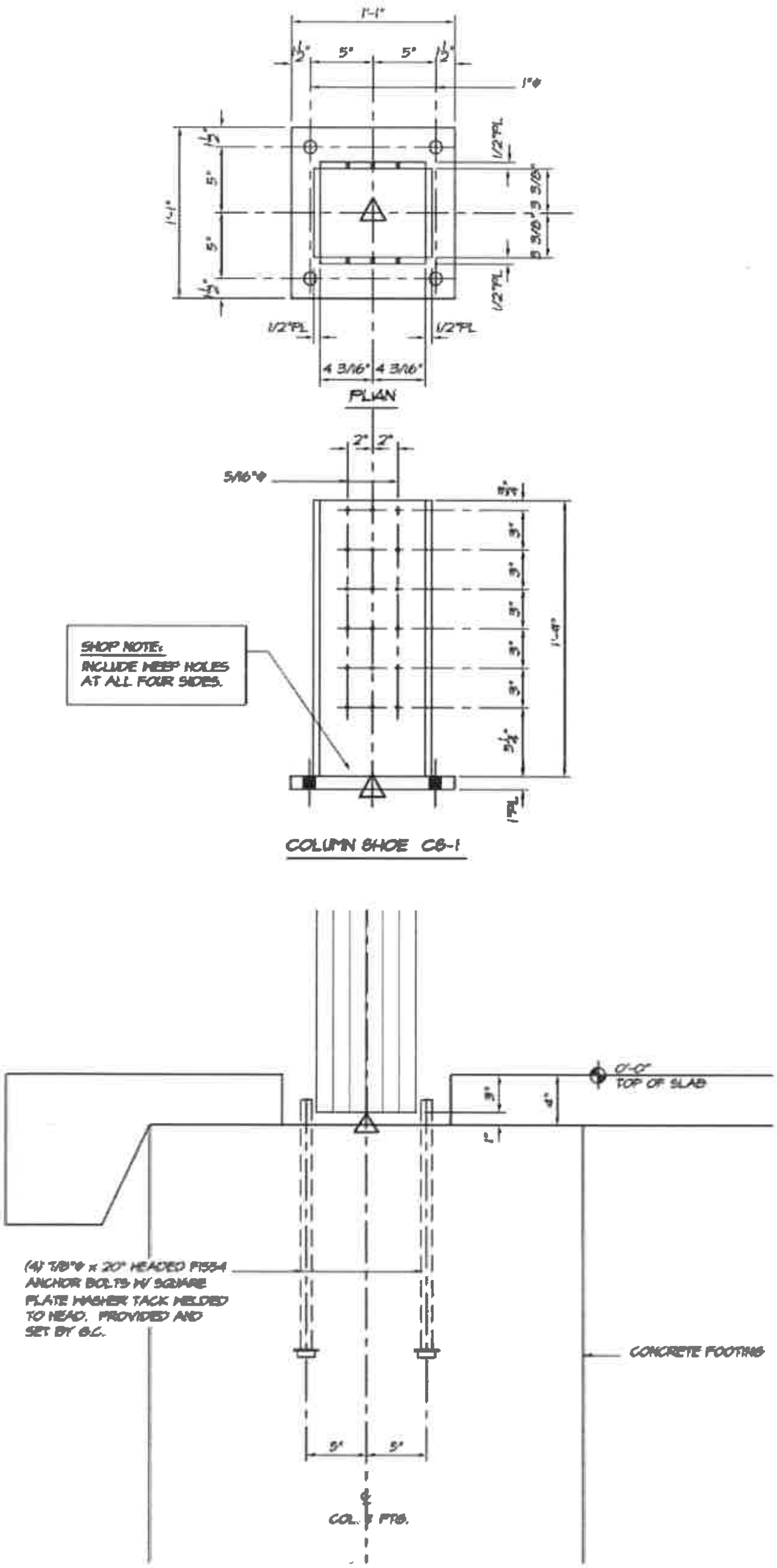
COLUMN FOOTING DETAIL

(BY G.C.) (3/4" = 1'-0")

Design with Constraint at the Ground Surface

Allowable lateral soil bearing pressure per foot from Table 6.6	S_0	400	lbs/sqft/ft
Applied horizontal force on pole	P	1052	lbs
Height above ground at which force P is applied	h	11	ft
Diameter (or width) of concrete casing	B	3.00	ft
Required depth of embedment	d reqd	3.5	ft
Actual embedment depth		4.5	ft
Status		OK	

Conn S1



1'-1"
1/2"
5"
5"
1/2"
1"Φ
1/2"PL
5"
5"
1/2"PL
1/2"PL
1/2"PL
4 3/16"
4 3/16"
PLAN
2"
2"
5/16"Φ
3"
3"
3"
3"
3"
1'-4"
SHOP NOTE:
INCLUDE WEEP HOLES
AT ALL FOUR SIDES.
1"PL
COLUMN SHOE CS-1
0'-0"
TOP OF SLAB
3"
4"
1"
(4) 7/8"Φ x 20" HEADED F1554
ANCHOR BOLTS W/ SQUARE
PLATE WASHER TACK WELDED
TO HEAD. PROVIDED AND
SET BY G.C.
CONCRETE FOOTING
5"
5"
COL. FTG.

Maximum axial load (dead load + live load)	6.5	kips
Maximum axial load (seismic)	1.1	
Maximum moment (seismic)	10.7	ft-k

<u>Check Anchor Bolts</u>

Moment arm on anchor bolts	10	in
Tension force per anchor bolt	6.4	kips/AB
Allowable tension per 7/8" diameter anchor bolt	11.5	
	OK	

<u>Check Bearing Stress</u>

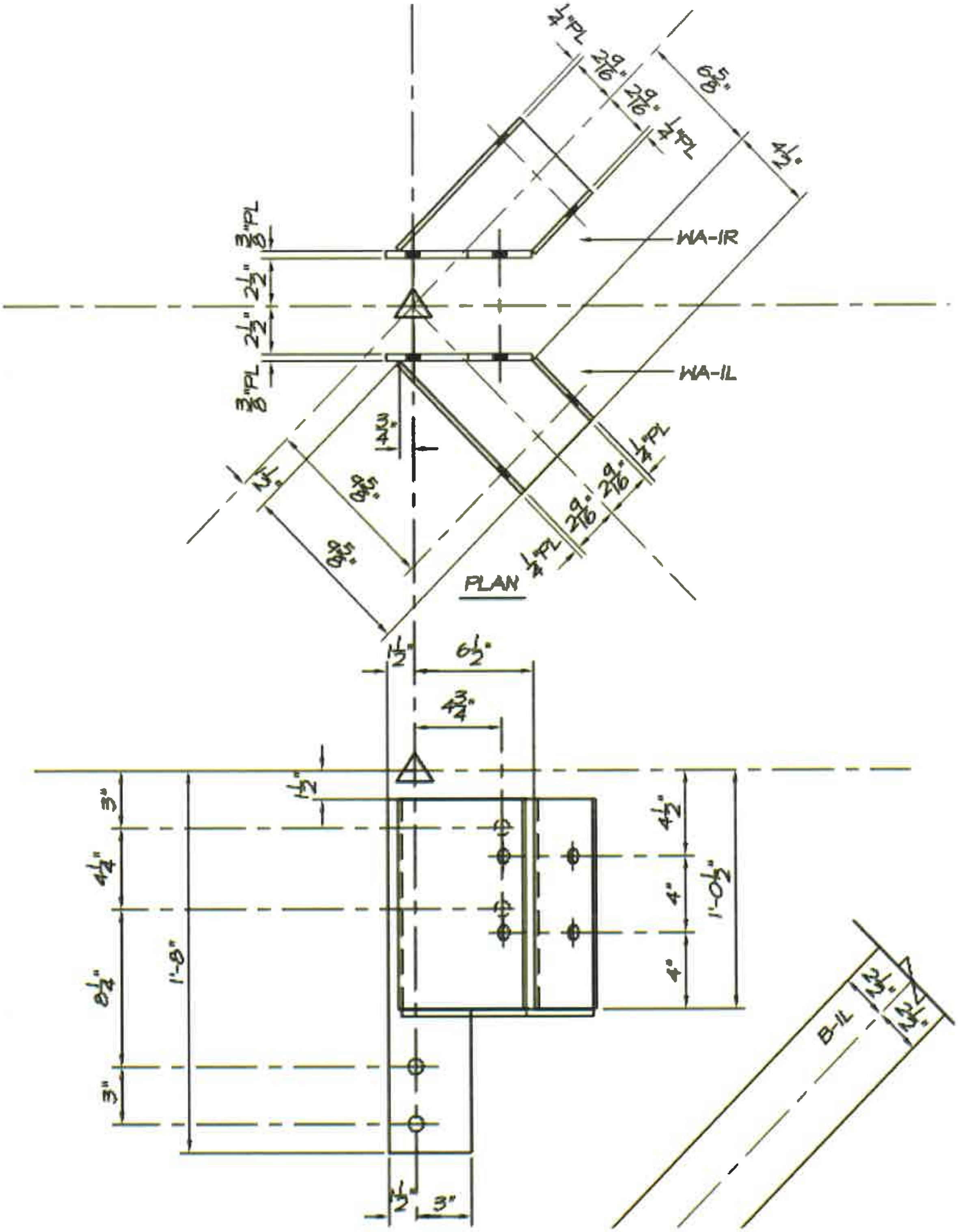
Shoe height	21	
Moment arm (assume 2" uniform bearing top and bottom)	17	
Bearing width	8.25	
Bearing stress	0.459	ksi
Basic allowable bearing stress	0.650	ksi
Wet use factor	0.53	
Load duration factor	1.60	
Adjusted allowable bearing stress	0.551	
Status	OK	

<u>Check Uplift</u>

Dead Load (Use 0.6 * 10 psf = 6 psf)	6.0	psf
Wind uplift	-22.4	psf
Net wind uplift	-16.4	psf
Tributary area to one column	192	sf
Total wind uplift on one column	-3.1	kips
Basic allowable load per Simpson 2 1/2" SDS screw	0.42	kips/screw

<u>By inspection, (36) screws are OK.</u>

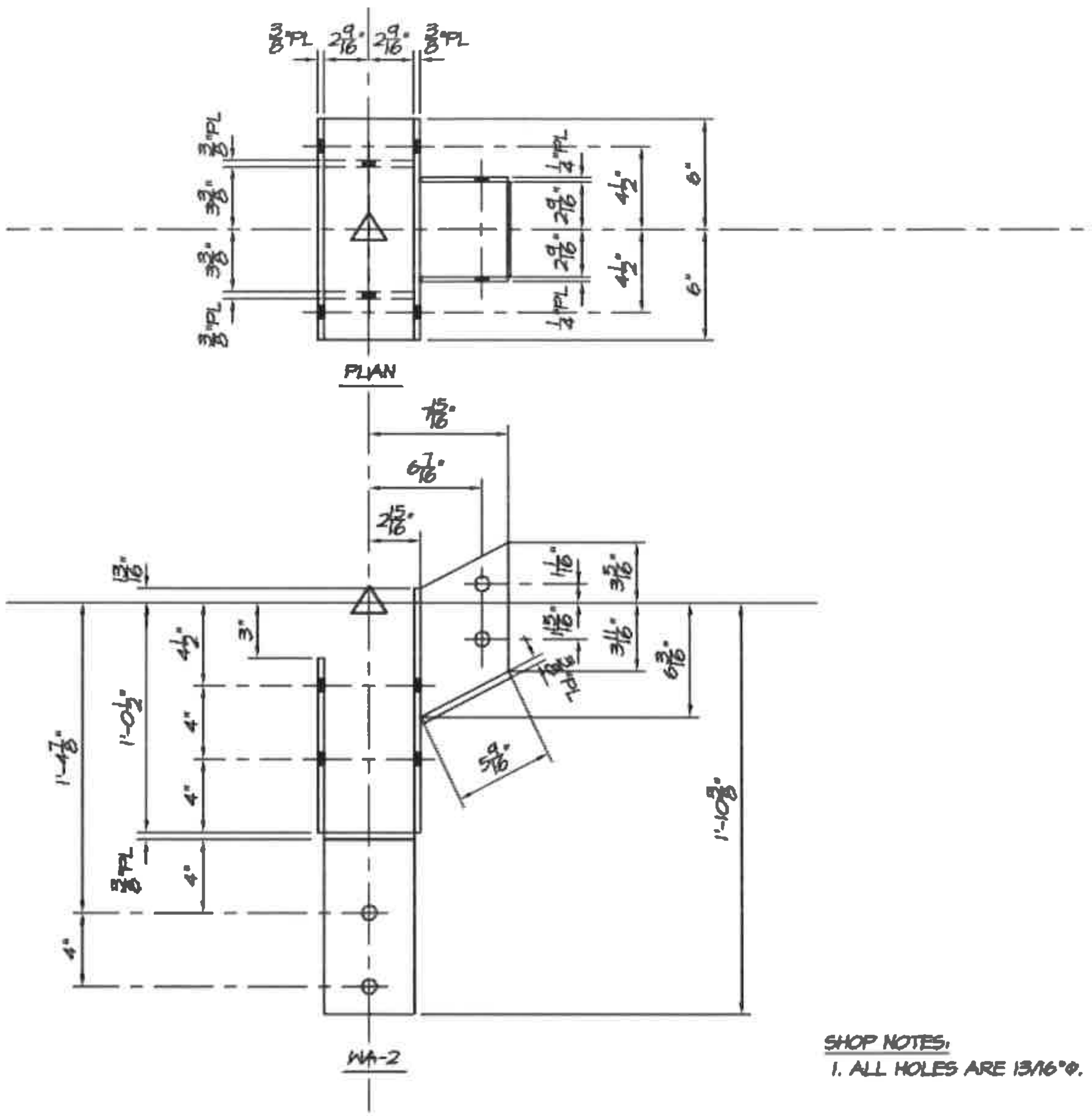
Conn S2



Maximum gravity load per B2	2.3	kips
Maximum uplift load on column	-3.1	kips

<u>Connection is OK by inspection</u>

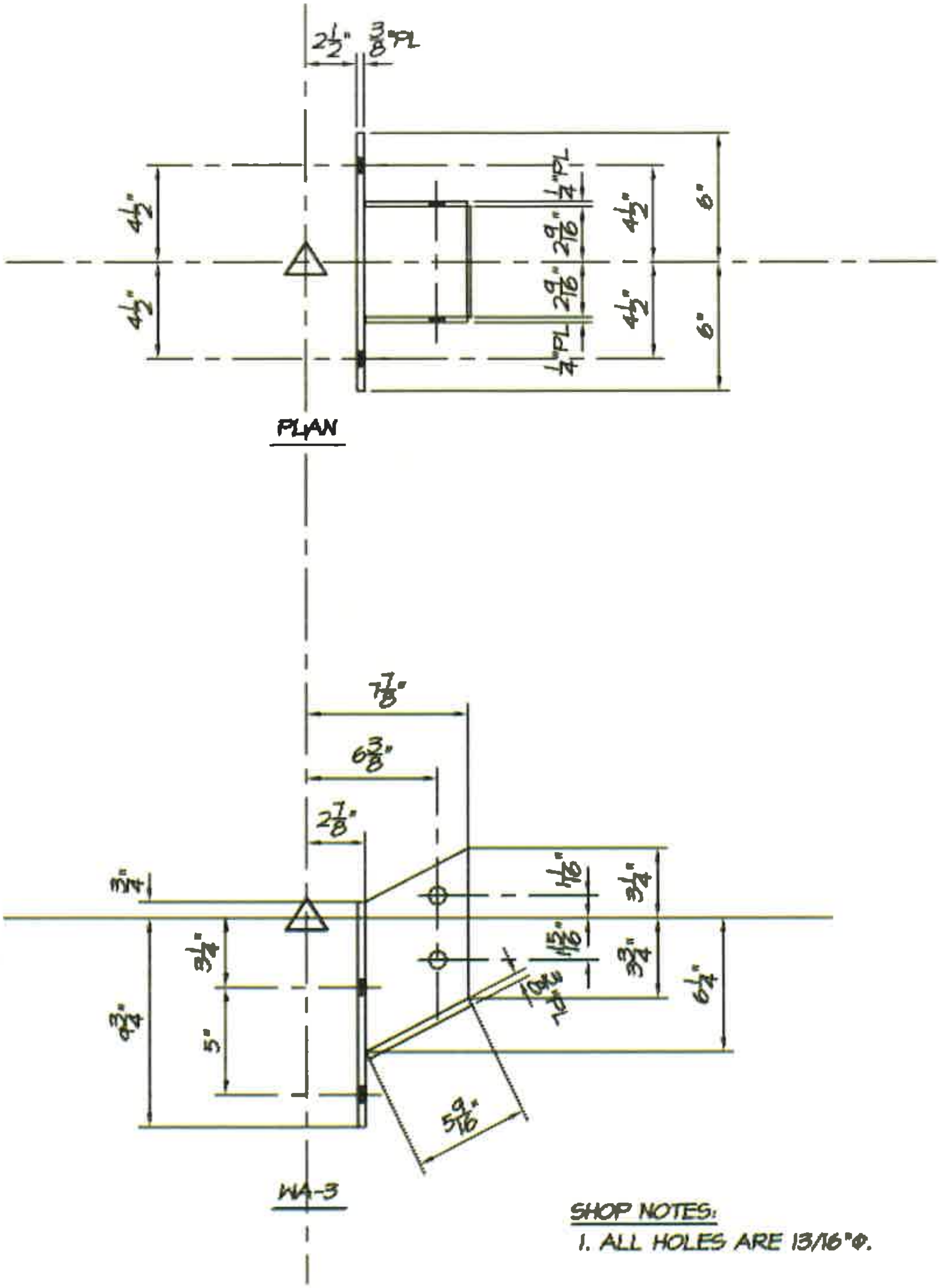
Conn S3



Maximum gravity load per B2	9.1	kips
Maximum uplift load on column	-3.1	kips

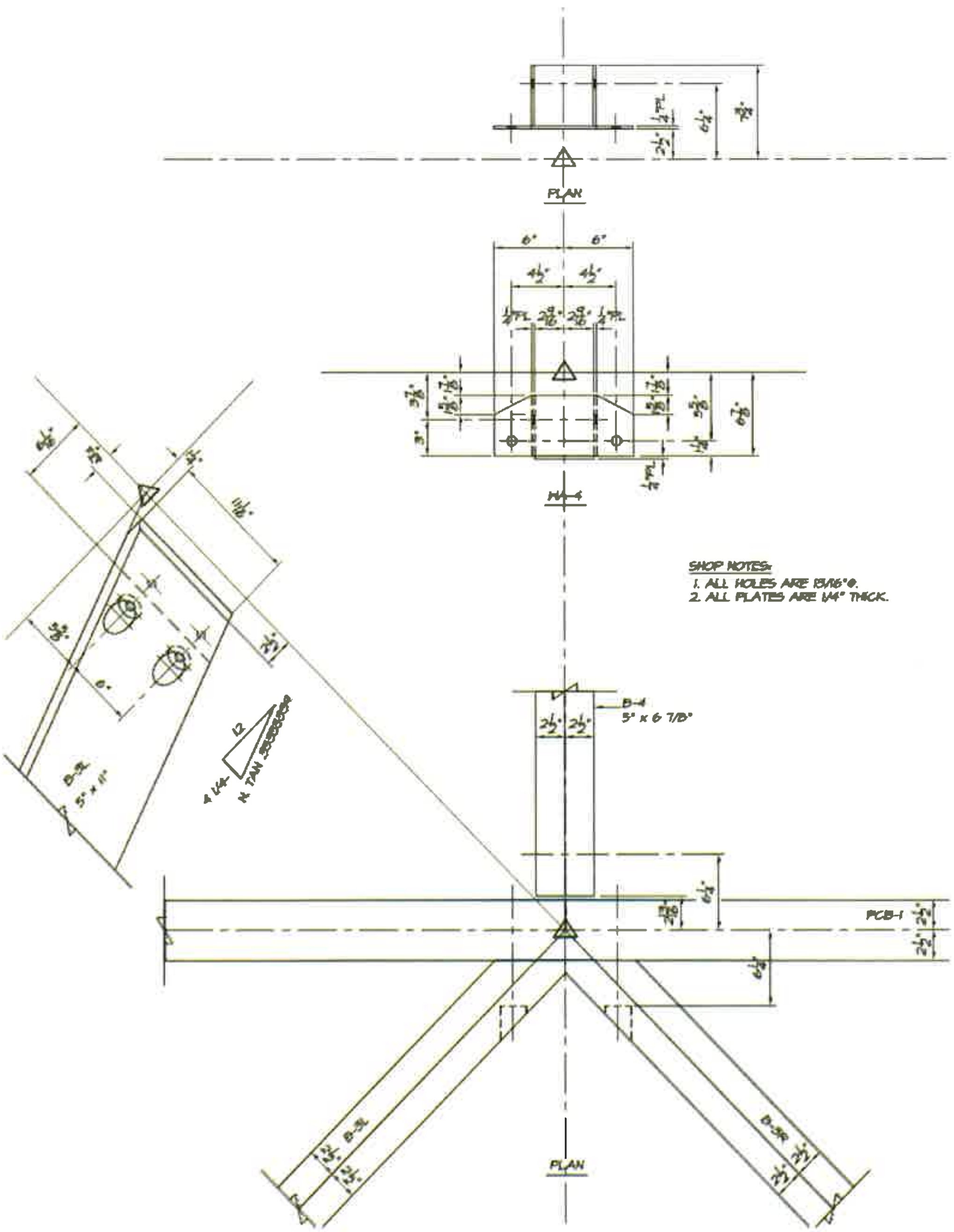
<u>Connection is OK by inspection</u>

Conn S4



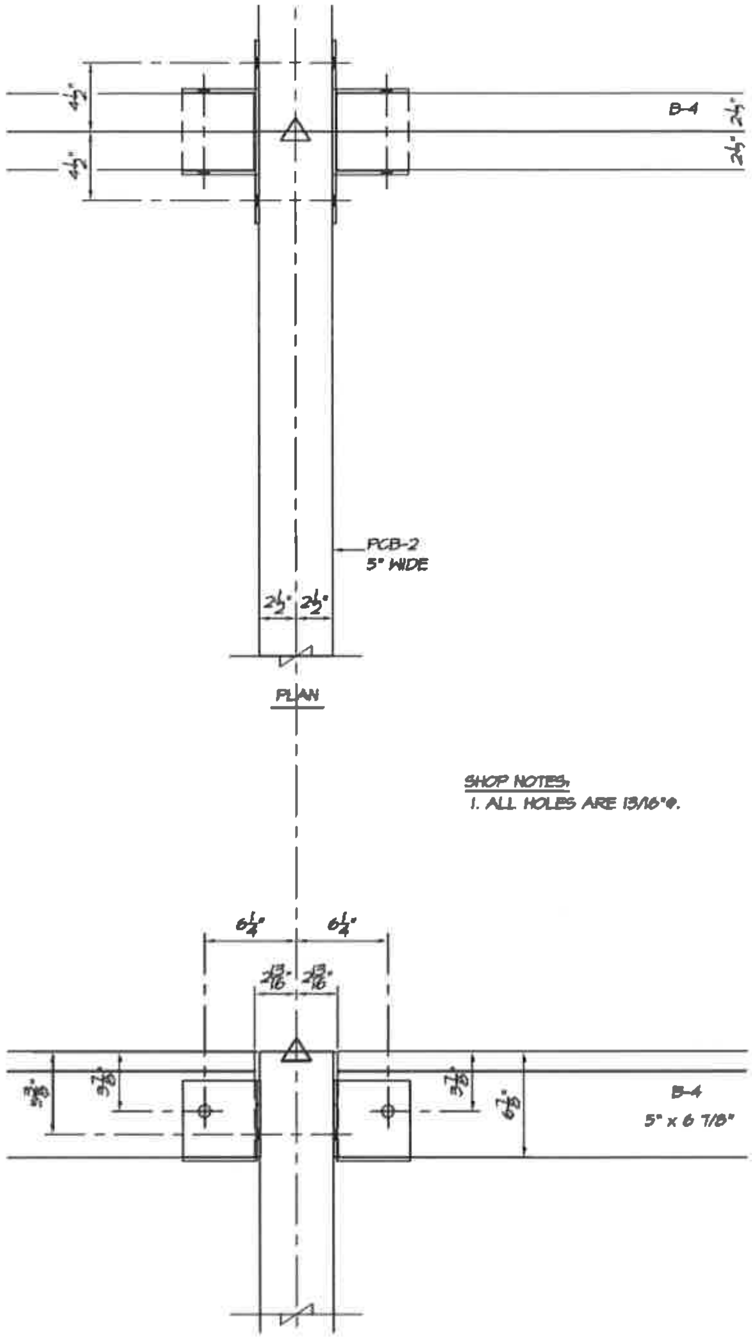
Maximum reaction from CTB	3.8	kips
Basic allowable load for 3/4" diameter bolt at 90 degrees, single shear	1.00	kips/bolt
Allowable for (4) bolts with 1.25 load duration factor	5.0	kips
Status	OK	

Conn S-5



B3 reaction	1.8	kips
B4 reaction	1.0	kips
<u>The shoe for B4 with (2) bolts in back plate is ok by inspection.</u>		
Basic allowable load for 3/4" bolt in single shear at 90 degrees to grain	0.66	
Reduction for end grain	0.6	
Allowable load for (4) bolts with 1.25 load duration factor	2.0	
Status	OK	

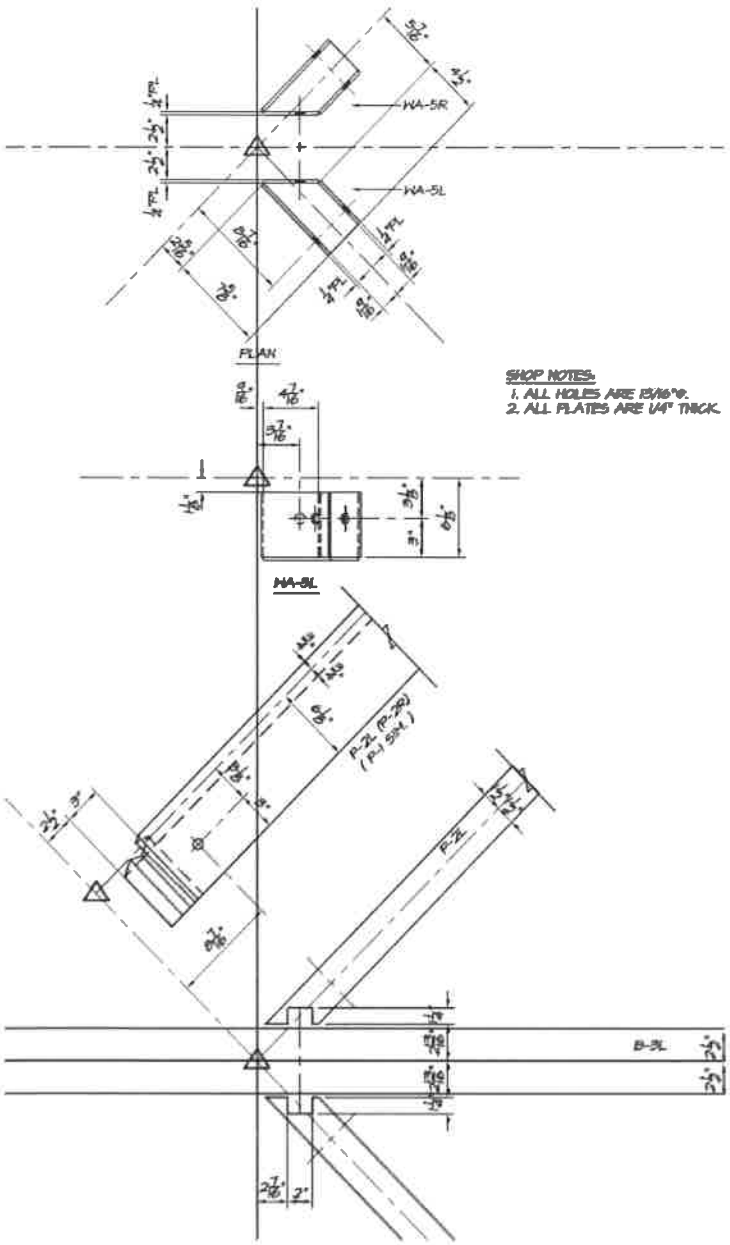
Conn S6



B4 reaction 1.0 kips

OK by inspection per calculation above.

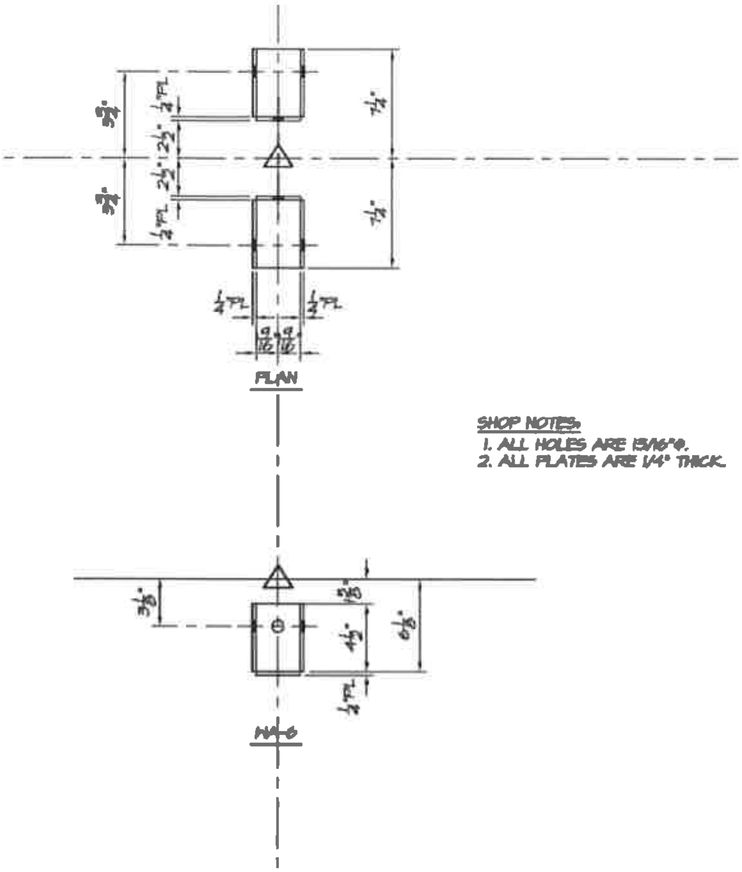
Conn S7



P1reaction 0.8 kips

OK by inspection

Conn S8



P3 reaction | 1.0 | kips

OK by inspection

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5/21/2019

DCSPE Job#				7196
Project Zip Code				98040
City, State				Mercer Islan(
Building Design				
Building Code				2018
Building Category				II
Occupancy Type				Assembly A-5
ASCE				ASCE 7-10
Overall Width				20.0 ft
Overall Length				40.0 ft
Post Spacing				10.0 ft
CTB Width				5.0 in
CTB Length				16.0 ft
CTB Span				16.0 ft
CTB Weight				346.0 lbs
Mean Roof Ht				15.0 ft
Roof Slope				6 :12
Footing Depth				4.6 ft
Footing Diameter				3.0 ft Ø
Soil Bearing				2000 psf
Design Loads				
Roof Dead Load				12 psf
Roof Live Load				30 psf
Wind Design Data				
Wind Speed				110 mph
Exposure				C
Imp wind				1.00
Tributary Area				80.0 ft^2
Kh				0.85
Kd				0.85
Kzt				1
Internal Pressure Coefficient				0.00
Components & Cladding Wind Pressures	Z1	-12.1 psf	Z2	-38.0 psf
	Z3	-58.2 psf		
qh =				22.38
Wind Base Shears	Vxx	1.5 kips	Vyy	2.9 kips

DANIEL C. SMITH STATE OF WASHINGTON 44613 REGISTERED PROFESSIONAL ENGINEER 5-22-2019

SNOW DESIGN DATA

Snow (Pg)	20.0 psf
Snow Exposure (Ce)	1.00
Imp Snow (Is)	1.00
Snow Thermal (Ct)	1.2
Flat Roof Snow Load (Pf) (.7 IS USED FOR FNEAR FLAT ROOFS ONLY)	24.0 psf
Roof Slope (Cs)	1.00
Sloped Roof Snow Load (Ps)	24.0 psf

SEISMIC DESIGN DATA

Seismic Importance Factor (Ie)	1.00
Short Period Spectral Response Accel (Ss from maps)	1.443
1-Sec Period Spectral Response Accel (S1 from maps)	0.488
Seismic Site Class	D
Design Short Period Spectral Response Accel (Sds)	0.96
Design 1-sec Period Spectral Response Accel (Sd1)	0.49
Seismic Design Category	D
Basic Seismic Resisting System	CANTILEVERED COLUMN SYSTEM
Basic Seismic Force Resisting System	TIMBER FRAMES
Response Modification Factor (R)	1.5
Seismic Response Coefficient (Cs)	0.64
Seismic Base Shear (Allowable Stress Design)	0.00

Connection Design Data

Plate Thickness	0.50 in
Screw diameter	0.25 in
# of Screws per Post	36
Max Allowable Force per Bolt	230
Shear of Tube Steel	36000 psi
Width of Post	5.0 in
Length of Post	5.5 in
Bearing Pressure of CTB	

Roofing Board Data

Width of Roofing Board	5.5 in
Height of Roofing Board	1.5 in
Maximum Span of Board	10.0 ft
Modulus of Elasticity	1600000
Cd	1.15
Fb (allowable bending stress)	1350.0 psi

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05/22/19

5-22-2019

Project: DCSPE #: 7196 — Mercer Island,WA
Subject: Shelter Calculations

1. Scope

Daniel C. Smith PE Consulting Engineers (DCSPE) was contacted by SWS , regarding load calculations.

2. Design Codes

2018 International Building Code

Occupancy Type:	Assembly A-5	Wind Speed:	110 mph
Construction Type:	II	Wind Importance:	1.00
Building Height:	15.0 ft	Exposure:	C
Soil Bearing Capacity:	2000 psf	Snow Load:	20 psf
Seismic Category:	C	ASCE 7-10	

3. Design Loads

Dead Load

CTB Load = 346 lbs each/ (10 x 8 ft) =	4.3 psf
DLr = 12 + CTB 4.3 psf =	16.3 psf
Live Load roof (LLr) =	30.0 psf

Wind Load

V (Allowable) =					110 mph
Open Structure	= 1	= 1	= 0.85	= 0.85	= 15 ft
qh = 0.00256 * Kzt * Kd * Kh * 110^2 =					22.4 psf
			EnWood uses WL (up) 20 psf.		20.0 psf
WL (down) 10 psf				Conservative	10.0 psf

Snow Load		
Pg =		20.0 psf
Exp C - fully Exposed Imp = 1 Ct = 1.2		
Flat Roof Snow Load (Pf) = .7 * 20 * 1 * 1.2 * 1		24.0 psf
Cs = 1 (Roof Slope: 6:12)		
Sloped Roof Snow Load (Ps) = 1 x 24		24.0 psf

4. Load Combinations

DL - 0.6WL = 16.3 - .6*22.38 =		4.3 psf down
.75 (DLr + Wldown) = .75 (16.3 + 110) =		19.7 psf
DLr +.75(.6WLdown+LLr) = DLr + .75(.6*10 + 30) =		43.3 psf
DLr +.75(.6WLdown+SL) = DLr + .75(.6*10 + 24) =		38.8 psf
DLr + LLr = 16.3 + 30 =		46.3 psf
DL + SL = 16.3 + 24 =		40.3 psf
Worst Case Scenarios		
Use downward pressure of		46.3 psf
Use wind uplift pressure of	(There is no uplift loads)	4.3 psf

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5. Calculations

CTB Gravity Loads to Column (Shear)		
46.3 psf x 10 ft x 16 ft/2 =		3704 lbs
Wood bears on 0.5" thick steel plate 5 x 5.5 x 650 =		17875 lbs
36 - 0.25" bolts - 3.16" thick steel	<= 1.0 = OKAY	0.207
Shear of metal tube steel psi x .4 x .187: x 36 faces x 36 bolts =		10771 lbs
	<= 1.0 = OKAY	0.344

Check Screws (Uplift)

Uplift Pressure	Uplift check with 25 psf	25
Uplift Force Total		2000
Quantity of Screws		36
Force per Screw		55.56
Maximum Allowable Force per Screw		230
	<= 1.0 = OKAY	0.242

Check Bolts (Uplift)

Uplift Pressure	Uplift check with 25 psf	25
Uplift Force Total		2000
Quantity of Bolts (5/5" diameter)		2
Force per Bolt		1000.00
Max Allowable Force perBolt (NDS Parallel to Grain)		1900
	<= 1.0 = OKAY	0.526

Check footings

<u>Calculated load</u>

Tributary area supported by each post is 10 ft * 16 ft/2 =		80.0 ft^2
Volume of Footing =		32.52 ft^3
Weight of Footing =		4877 lbs
46.3 psf x 80 ft^2 = 3704 lbs + Weight of Footing =		8581 lbs

<u>Calculated soil resistance</u>

2000 psf soil bearing x (3 ft Ø)^2 x Pi/4 =		14138 lbs
	<= 1.0 = OKAY	0.607
Required Area of Footing = Calculated Load / Soil Bearing =		4.29
Provided Area of Footing = (Footing Diameter^2 * Pi) / 4		7.07
	<= 1.0 = OKAY	0.61

Wind Uplift is negligible.

7. Check Roof Deck Boards

2x6 Tongue and groove boards - SYP #1		
Modulus of Inertia (I) = 5.5 x 1.5^3/12 =		1.55 in^4
Section Modulus (S) = 5.5 x 1.5^2/6=		2.06 in^3
Worst case load combination is =		46.3 psf
Uniform load per board (w)= 46.3 x 5.5 in/(12 in/ft)		21.2 plf
Cd =		1.15

Bending Stress	10' Span		
Moment (M) = $w*L^2/8$ftx12in/ft			3180.0 lbs-in
fb (bending stress) = M/(S*Cd)			1340.7 psi
Fb (allowable bending stress) =			1350.0 psi
		<= 1.0 = OKAY	0.993

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Project Name:	Mercer Island Wa	DCSPE 7196
Location:	Mercer Island Wa	

Curved Taper Beam Calculation

Material Properties

Fb	2400	psi	F'b	2275.62	psi
Fv	200	psi	F'v	223	psi
Frt	66.67	psi	F'rt	67.08	psi
Cm	0.97		Cfbend	0.84	
Cd	1.15		Cftan	0.88	
Cf	1		Cr	0.85	
Ey	1800000		E'	1620000	psi

Structural Dimensions

Length/Span (L)	16	ft	(l)	192	in
Trib Width/Spacing	10	ft		120	in
Top Pitch/Slope (P)	6	:12		26.57	degrees

A=	0.135	D=	2.76
B=	0.060	E=	-2.7554426
C=	0.120	F=	3.19

Estimated Beam Size

width/b	5	in	vert end depth/de	7	in
Radius (R)	16	ft	vert CL depth/dc	30	in
	192	in			

Structural Loads

DL=	20	psf	w=	500	plf
SL=	15	psf			
LL=	30	psf			

Stress Factors

Radial Stress Factor	Kr	0.1462944	A+B(dc/Rm*12)+C(dc/Rm*12)^2
Bending Stress Factor	Ktheta	2.43	D+E(dc/Rm*12)+F(dc/Rm*12)^2
Radial Stress Red Factor	Cr	0.9371981	

Design of CTB

1. Determine minimum end depth — OK

SHEAR AT END OF BEAM	Rv=	4000	lbs	wL/2
UNADJUSTED END DEPTH?	d=	5.4	in	3Rv/2bF'v
EFFECTIVE LENGTH FOR SHEAR	Le=	15.1	ft	L-2d
SHEAR BASED ON EFFECTIVE LENGTH	V=	3776	lbs	wLe/2
MINIMUM END DEPTH	**de=**	5.1	**in**	3V/2bF'v

2. Determine approximate trial centerline depth dcb from the bending stress limitation

M=	192000	in-lb	wL^2/8
F'b=	2275.62	psi	Fb*Cf
dcb=	16.7	**in**	sqrt(6MD/bF'b)

3. Determine trial minimum centerline depth dcdelta from the deflection limitation

deltamax	1.07	in	l/180
deff=	4.56	in	((Wl^3)/(6.4*E'*b*deltamax*cosT^3))^(1/3)
dcdelta=	4.0	**in**	2deff-de

4. Determine trial minimum centerline depth dcrt from radial stress limitation.

dcrt=	22.4	in	sqrt(6MKr/bF'rt)
To reduce depth design for radial reinforcement, using maximum radial tension stress Fv/3			
dcrt=	21.0	**in**	sqrt(6MKr/(b(Fv/3)*1.15))

5. Determine height of apex ha, trial bottom slope thetaB, and soffit radius R

HEIGHT OF APEX POINT	ha=	4.58	ft
LARGEST DEPTH	**dc=**	30.0	**in**
HEIGHT OF SOFFIT MIDSPAN	hs=	2.08	ft
MAXIMUM BOTTOM SLOPE	max bot sl	29.19	º
MAX EFFECTIVE BOTTOM SLOPE	thetaB ma	26.6	º
MINIMUM BOTTOM SLOPE	thetaB mir	25.3	º
TRIAL BOTTOM SLOPE	trial bot slo	25.3	º
EFFECTIVE SOFFIT RADIUS	R=	17.25	ft

6. Find the following values based on the values of thetaB and R determined in step 5

a) length of tapered leg						
lt=	14.04	in	l/2 - RsinB	Lt	1.1	ft
b) Ratio of Span Length to distance between tangent points						
lc=	163.9	in	l - 2lt	Lc	13.66	ft
l/lc=	1.17					
c) Depth of beam at tangent points						
dt=	7.4	in	de + lt(tanT - tanB)			
d)						
Rm=	17.3	in	R+DC/24			
dc/Rm=	1.74					
e)						
ftheta=	256	psi	6M/bdc^2			

7. Check maximum deflection

deb=	12.1		(de+dc)(0.5+0.735*tanT)-(1.41dctanB)
deltaC=	0.55	in	5Wl^3/32E'bdeb^3
	1.06 > 0.55 = OK		

8. Check stresses			
a) Bending stress at centerline			
fb=	622	psi	ktheta*ftheta
F'b=	1911.52		FbCdCf
	622 < 1911.52 = OK		
b) Bending stress at tangent point			
Mt=	49170		wl(lt)/2 - wlt^2/2
fbt=	1080		6Mt/bdt^2
F'b=	2002.55		F'b * Cd
	1080 < 2002.54 = OK		
c) Radial stress at centerline			
frt=	31.8	psi	KrCrf0
F'rt=	67.08	psi	
	31.83 < 67.08 = OK		

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5/20/2019

DCSPE# 7196

LOCATION Mercer Island,WA				98040
BLDG CODE				2018
BLDG CATEGORY				II
Shelter Length				40.0 ft
Shelter Width				20.0 ft
Shelter Mean Roof Height				15.0 ft
ASCE 7-10				
Roof Dead Load				12.0 psf
Roof Live Load				30.0 psf
SNOW DESIGN DATA				
Ground Snow Load (Pg)				20.0 psf
Snow Exposure Factor (Ce)				1.0
Snow Importance Factor (Is)				1.00
Snow Thermal Factor (Ct)				1.2
Flat Roof Snow Load (Pf)				24.0 psf
Roof Slope (Cs)				1.0
Sloped Roof Snow Load (Ps)				24.0 psf
				shingles
WIND DESIGN DATA				
Basic Wind Speed (3-sec gust)				110 mph
Wind Importance Factor (Iw)				1.00
Wind Exposure Category				C
Internal Pressure Coefficient				0.0
Components & Cladding Wind Pressures	Z1	-12.1 psf	Z2	-22.8 psf
	Z3	-34.9 psf		
qh =				22.38
Wind Base Shears	Vxx	2.9 kips	Vyy	1.5 kips

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SEISMIC DESIGN DATA			
Seismic Importance Factor (Ie)	1.00		
Short Period Spectral Response Accel (Ss from maps)	1.443		
1-Sec Period Spectral Response Accel (S1 from maps)	0.488		
Seismic Site Class	D		
Design Short Period Spectral Response Accel (Sds)	0.96		0.66667
Design 1-sec Period Spectral Response Accel (Sd1)	0.49		
Seismic Design Category	D		
Basic Seismic Resisting System	CANTILEVERED COLUMN SYSTEM		
Basic Seismic Force Resisting System	TIMBER FRAMES		
Response Modification Factor (R)	1.5		
Seismic Response Coefficient (Cs)	0.64		
Seismic Base Shear (Allowable Stress Design)	7.20	kips