

Mt. Carmel Shade Structure

1701 Fredericks St, San Luis Obispo, CA 93405

STRUCTURAL CALCULATIONS

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1 Grand Ave., Bldg. 21
San Luis Obispo, 93407
ARCE 453/460
Senior Project
Advisors: Kevin Dong, Thomas
Fowler

Project: Mt. Carmel Shade Structure
Topic: _____
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Author: _____
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LOAD TAKEOFF

DEAD

WOODEN FRAMING

1 psf

STEEL FRAMING

2 psf

MISC.

1 psf

LIVE

ROOF LIVE

20 psf

TOTAL = 24 psf

USGS Design Maps Summary Report

User-Specified Input

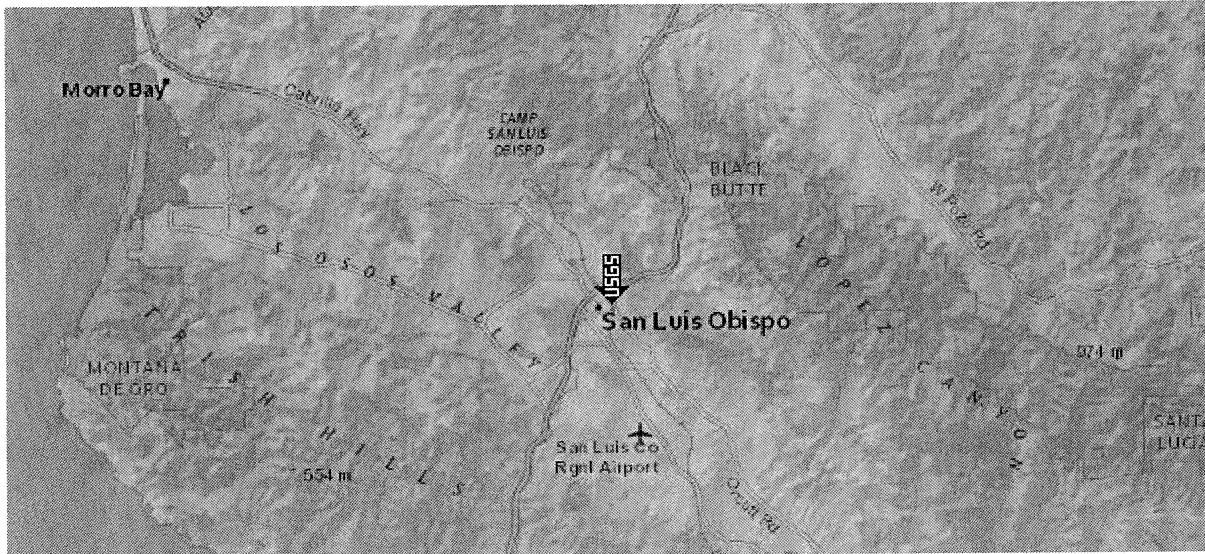
Report Title Mt. Carmel Shade Structure
Sun May 7, 2017 20:09:59 UTC

Building Code Reference Document ASCE 7-05 Standard
(which utilizes USGS hazard data available in 2002)

Site Coordinates 35.29308°N, 120.65444°W

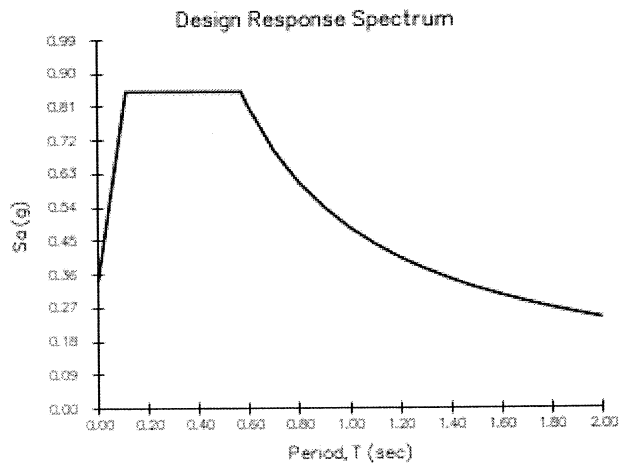
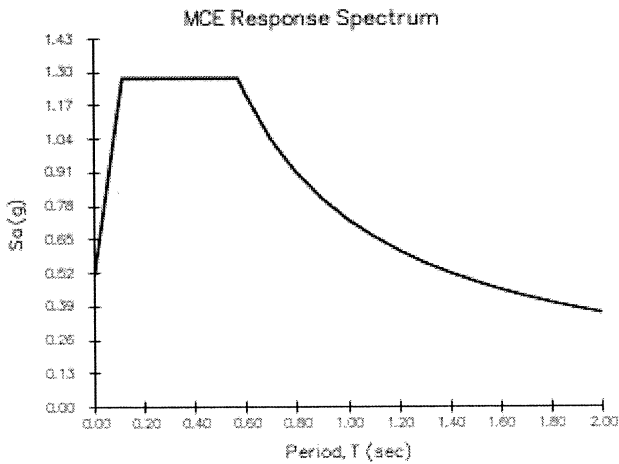
Site Soil Classification Site Class D - "Stiff Soil"

Occupancy Category I/II/III



USGS-Provided Output

$S_s = 1.276 \text{ g}$ $S_{MS} = 1.276 \text{ g}$ $S_{DS} = 0.851 \text{ g}$
 $S_1 = 0.478 \text{ g}$ $S_{M1} = 0.727 \text{ g}$ $S_{D1} = 0.485 \text{ g}$



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DECK DESIGN

ASSUME SINGLE VERCO PLB-36 GAGE 20

FROM VERCO CATALOGUE

UNIFORM LOAD = 24psf

@ 10'-0" SPAN ALLOWABLE LOAD = 26psf

DEMAND = CAPACITY OKAY ✓

USE VERCO PLB-36 GAGE 18 , 10' SPAN



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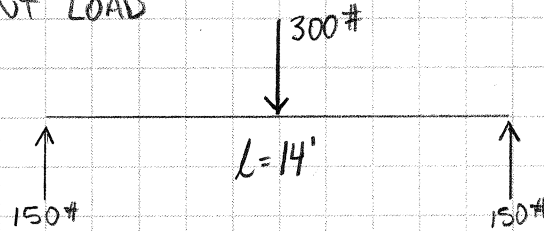
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BEAM ①

ASSUMED 300# MAX POINT LOAD
FIXED CONNECTIONS

HSS 5x3x1/8



FLEXURE

$$M_u(\text{FIX-FIX}) = \frac{PL}{4} = \frac{300\#(168\text{'})}{4} \Rightarrow 12600 \# \cdot \text{in}$$

$$\phi M_n = F_y Z \Rightarrow (0.9)(46000 \text{ psi})(2.93 \text{ in}^3) \Rightarrow 121302 \# \cdot \text{in}$$

$\phi M_n > M_u$ OKAY ✓

DEFLECTION

$$\Delta_{\text{max}} = \frac{PL^3}{48EI} = \frac{300\#(168\text{'})^3}{48(29000000 \text{ psi})(6.03 \text{ in}^4)} = 0.17 \text{''}$$

$$\Delta_{\text{allow}} = L/360 \Rightarrow 168\text{'}/360 = 0.467 \text{''}$$

$\Delta_{\text{allow}} > \Delta_{\text{max}}$ OKAY ✓

HSS 5x3x1/8 OKAY ✓



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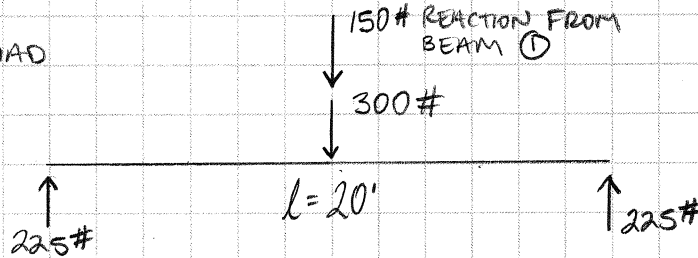
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BEAM 2

ASSUMED 300# POINT LOAD

FIXED CONNECTIONS



HSS 5x3x 1/8

FLEXURE

$$M_{K(FIX FIX)} = PL/4 \Rightarrow 450\#(240'')/4 = 27000\#\cdot in$$

$$\phi M_n = F_y Z \Rightarrow 46000\text{psi}(2.93\text{in}^3) = 134780\#\cdot in$$

$\phi M_n > M_u$ OKAY ✓

DEFLECTION

$$\Delta_{max} = \frac{PL^3}{48EI} = \frac{450\#(240'')^3}{48(29000000\text{psi})(6.03\text{in}^4)} = 0.74''$$

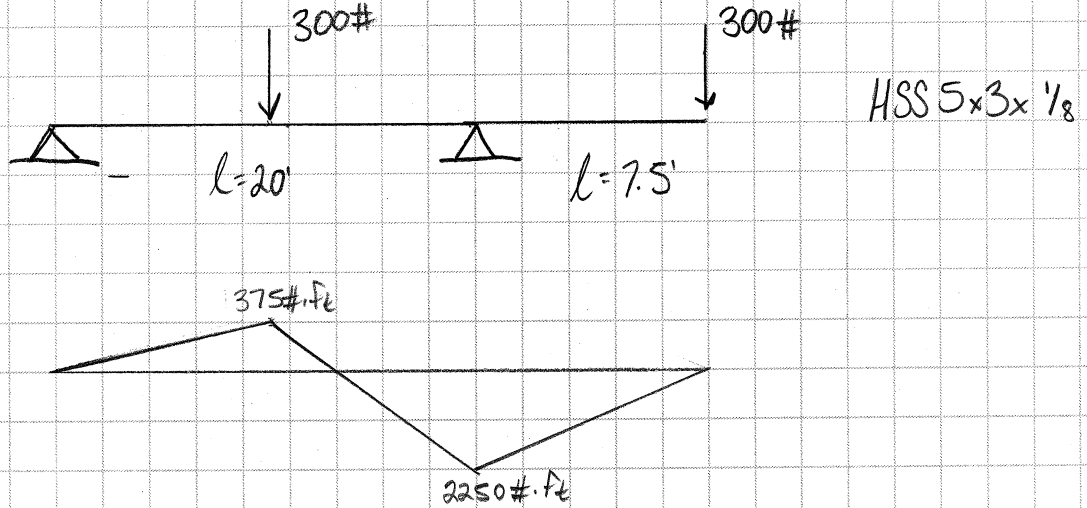
$$\Delta_{allow} = l/360 = 240''/360 = 0.67''$$

$\Delta_{allow} > \Delta_{max}$ Whats 0.07" amongst friends?

HSS 5x3x 1/8 OKAY ✓



BEAM 3



FLEXURE

$$M_u = 2250 \# \cdot ft (12") = 27000 \# \cdot in$$

$$\phi M_n = (0.9) (46000 \text{ ps}) (2.93 \text{ in}^3) = 121302 \# \cdot in$$

$\phi M_n > M_u$ OKAY ✓

DEFLECTION

$$\Delta_{\text{max midspan}} = \frac{Pab(a+2b)\sqrt{3a(a+2b)}}{27EIL} = \frac{300(120)(120)(120+2(120))\sqrt{3(120)(120+2(120))}}{27(29000000)(6.03)(240)} = 0.49'$$

$$\Delta_{\text{max cantilever}} = \frac{Pa^2}{3EI}(l+a) = \frac{300(90^2)}{3(29000000)(6.04)}(240+90) = 1.53''$$

$$\Delta_{\text{allow cantilever}} = l/180 = 330\#/180 = 1.83''$$

$\Delta_{\text{allow}} = \Delta_{\text{max}}$ OKAY ✓

HSS 5x3x 1/8 OKAY ✓



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7.1

Project: Mt. Carmel Shade Structure
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LATERAL DESIGN FORCES

ASCE EQN (12.10-1)

$$F_{px} = 0.4 S_{DS} I_e W_{px}$$

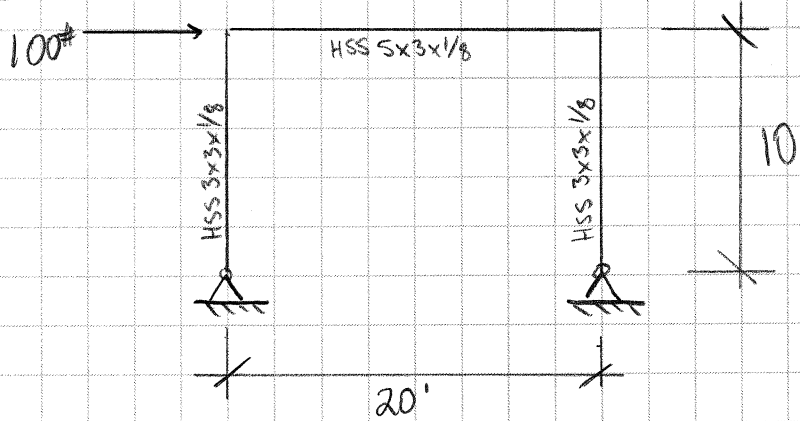
WT TRIB TO EACH MF:

$$4 \text{ psf} (5') (20') = 280 \#$$

$$\begin{aligned} \therefore F_{px} &= 0.4 (0.85 I_g) (1) (280 \#) \\ &= 95.3 \# \approx 100 \# \end{aligned}$$



LATERAL FORCE RESISTING SYSTEM - LINE A



DETERMINE DRIFT (ASCE 7 T. 12.12-1)

$$\Delta_{max} = 0.020 h_{sx} \Rightarrow 0.020 (10' \times 12) = 2.4''$$

$$\Delta_{elastic (allowed)} = \frac{\Delta_{max}}{(C_d/I)} = \frac{2.4''}{3/1} = \boxed{0.8''}$$

ASCE 7-10 T. 12.1

$C_d = 3$ (ORDINARY MF)

$$\Delta_{STORY} = \Delta_{COLUMN (FIX-PIN)} + \Delta_{BEAM}$$

$$\Delta_{STORY} = \frac{Fh^3}{3EI_c} + \frac{Fh^2L}{12EI_b} = \frac{100\#(120'')^3}{3(29000000\text{psi})(1.78\text{in}^4)} + \frac{100\#(120'')^2(20 \times 12)}{12(29000000\text{psi})(6.03\text{in}^4)}$$

FIX-PIN $\Rightarrow 3EI_c$
 FM-FIX = 12EI

$$\Delta_{STORY} = 1.28'' \text{ W/ FIX PIN CONNECTION}$$

$$\Delta_{STORY} = 0.44'' \text{ W/ FIX-FIX CONNECTION}$$



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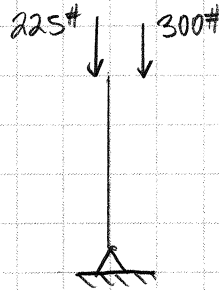
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GRAVITY COLUMN DESIGN

WORST CASE LOADING



HSS 3x3x1/8

MOMENT FRAME: PIN-FIX

$$K = 2.0$$

$$L = 10'$$

$$KL \approx 20'$$

TABLE 4-4 (AISC)

$$\text{HSS } 3 \times 3 \times 1/8, KL \approx 19 \Rightarrow \phi P_n = 7730\#$$

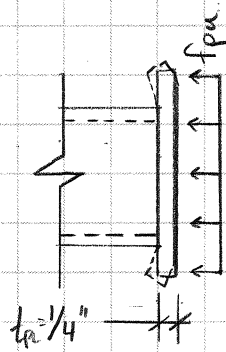
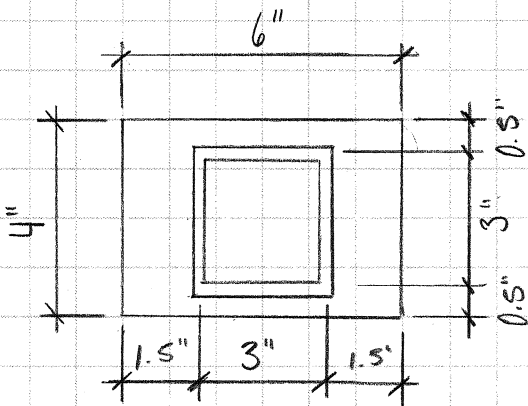
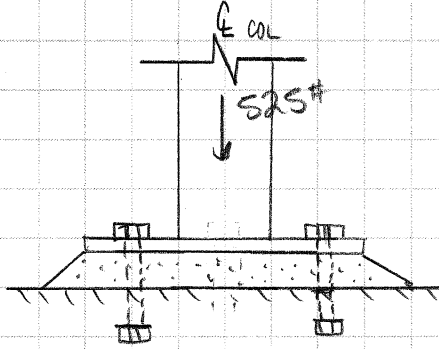
$$P_u = 525\#$$

$$\underline{\underline{\phi P_n > P_u \text{ OKAY} \checkmark}}$$

HSS 3x3x1/8 OKAY ✓



BASE PLATE DESIGN



- NOTES:
 1) ASSUME UNIFORM BEARING UNDER
 BASE PLATE
 2) ASSUME $A_2/A_1 >>$

$$f_{pu} = \frac{525\#}{6" (4")} = 21.875 \text{ psi}$$

$$M_u = \frac{21.875 \text{ psi} (0.5")^2}{2} = 2.73\#$$

$$\phi M_n = 0.9 \left[\frac{4" (0.25")^2}{4} \right] 36,000 \text{ psi}$$

$$\phi M_n = 2025\#$$

IN BOTH CASES,

$$\phi M_n > M_u \text{ OKAY} \checkmark$$

$$f_{pu} = 21.875 \text{ psi}$$

$$M_u = \frac{(21.875 \text{ psi}) (1.5")^2}{2} = 24.6 \# \cdot \text{in}$$

$$\phi M_n = 0.9 \left[\frac{6" (0.25")^2}{4} \right] 36,000 \text{ psi}$$

$$\phi M_n = 3037.5 \# \cdot \text{in}$$



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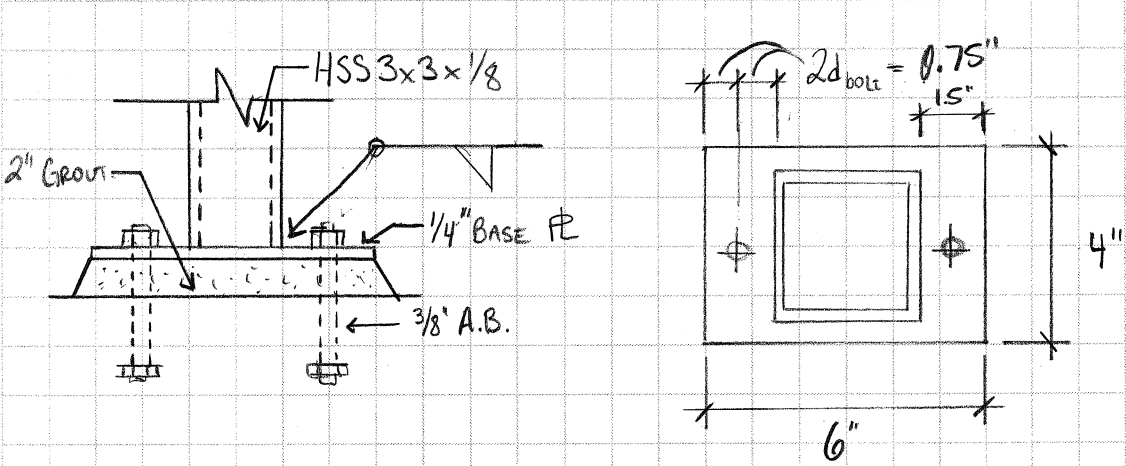
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 Topic: BASE PLATE

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$$f_{pu} = \frac{525\#}{6"(4")} = 21.875 \text{ psi}$$

$$n = \frac{6" - 0.95(3")}{2} = 1.575"$$

$$m = \frac{4" - 0.8(3")}{2} = 0.8"$$

$$\lambda n' = 1.0 \left[\frac{\sqrt{3" \cdot 3"}}{4} \right] = 0.75"$$

$$t_{pl} > 1.575 \sqrt{\frac{2(21.875")}{0.9(36000 \text{ psi})}} = 0.058"$$

$t_{pl} = 0.25 > 0.058"$ OKAY ✓

USE PL 6" x 4" x 1/4" W/(2) 3/8" Φ ANCHOR BOLTS

MT. CARMEL SHADE STRUCTURE ESTIMATE (All Wood Modular 10" o.c.) w/ Cantilever Redwood (Donation)

Item	Count	Length	Width	Height		Pricing	
FOOTINGS						Price/CY	Price/Unit
Concrete	4	0.7853		1	0.0349 CY	\$ 130.00	\$ 18.15
Sonotube (12" dia. 48")	1	-	-	-	-	\$ 13.97	\$ 13.97
						Subtotal	\$ 32.12
VERTICAL STEEL						Price/LF	Price/Unit
B&B Lump Sum Quote	1	100	-	-	-	\$ 4.25	\$ 425.00
Bases	9	-	-	-	-	\$ 10.00	\$ 90.00
Bolts	18	-	-	-	-	\$ 5.00	\$ 90.00
Caps	3	-	-	-	-	\$ 10.00	\$ 30.00
						Subtotal	\$ 635.00
HORIZONTAL STEEL						Price/LF	
B&B Lump Sum Quote	1	320	-	-	-	\$ 5.70	\$ 1,824.00
						Subtotal	\$ 1,824.00
METAL DECK						Price/SF	
Main Roof	1	26	11	-	286 SF	DONATED	
Raised Portion	1	8.5	3.5	-	30 SF		
Module A Metal Deck	4	9.75	4.5	-	176 SF		
Module B Metal Deck	1	7.125	4.5	-	32 SF		
METAL DECK TOTAL					523 SF		\$ -
						Subtotal	\$ -
STEEL PAINT						Price/Can	Cans Req.
Columns	9	10	3	3	90 SF	\$ 3.98	33
Beams	1				360 SF		
STEEL PAINT TOTAL					450 SF		
PAINT CAN COVERAGE					15 SF		
						Subtotal	\$ 131.34
ANGLE STEEL						Price/FT	
Mid Supports	18	0.333	-	-	6 FT	\$ 2.12	\$ 21.18
Corner Supports	12	0.333	-	-	4 FT		
ANGLE STEEL TOTAL					10 FT		
						Subtotal	\$ 21.18
MODULE A (Wood)						Price/BF	
Edge Board	2	30	2	6	30 BF	\$ 0.63	\$ 99.79
Joists		49	2	6	49 BF		
SINGLE MODULE TOTAL					79 BF		
GRAND TOTAL					158 BF		
						Subtotal	\$ 99.79
MODULE A (Metal Deck)						Price/BF	
Edge Board	4	30	2	6	30 BF	\$ 1.22	\$ 212.28
Double Edge Board		14	2	6	14 BF		
SINGLE MODULE TOTAL					44 BF		
GRAND TOTAL					174 BF		
						Subtotal	\$ 212.28
MODULE B (Wood)						Price/BF	
Edge Board	3	23	2	6	23 BF	\$ 1.22	\$ 183.00
Joists		27	2	6	27 BF		
SINGLE MODULE TOTAL					50 BF		
GRAND TOTAL					150 BF		
						Subtotal	\$ 183.00
MODULE B (Metal Deck)						Price/BF	
Edge Board	1	23	2	6	23 BF	\$ 1.22	\$ 39.04
Double Edge Board		9	2	6	9 BF		
SINGLE MODULE TOTAL					32 BF		
GRAND TOTAL					32 BF		
						Subtotal	\$ 39.04
MODULE A Stain (Wood)						Price/Gal	Amount Req
Edge Board	2	30	2	6	40 SF	\$ 36.98	3
Joists		41	2	6	55 SF		
SINGLE MODULE TOTAL					95 SF		
GRAND TOTAL					190 SF		
						Subtotal	\$ 110.94
MODULE A Stain (Metal Deck)						Price/Gal	Amount Req
Edge Board	4	30	2	6	40 SF	\$ 36.98	3
Double Edge Board		14	2	6	18 SF		
SINGLE MODULE TOTAL					58 SF		
GRAND TOTAL					233 SF		
						Subtotal	\$ 110.94
MODULE B Stain (Wood)						Price/Gal	Amount Req
Edge Board	2	23	2	6	31 SF	\$ 36.98	3
Joists		32	2	6	43 SF		
SINGLE MODULE TOTAL					74 SF		
GRAND TOTAL					147 SF		
						Subtotal	\$ 110.94
MODULE B Stain (Metal Deck)						Price/Gal	Amount Req
Edge Board	1	23	2	6	31 SF	\$ 36.98	3
Double Edge Board		9	2	6	12 SF		
SINGLE MODULE TOTAL					43 SF		
GRAND TOTAL					43 SF		
ALL MODULES GRAND TOTAL					613.7 SF	\$ 36.98	\$ 110.94
						Subtotal	\$ 110.94

TOTAL	\$ 3,288.69
TOTAL (+18%)	\$ 3,880.65
Delivery (Hayward)	\$ 65.00
GRAND TOTAL	\$ 3,945.65

RECEIPT	PURCHASED FROM	PURCHASER	DATE PURCHASED	ITEM	PRICE/COUNT	COUNT	PRICE	
#1	Home Depot	Chris Carter	5/1/2017	Concrete Sonotube 12" x 48"	\$ 13.97	1	\$ 13.97	
				90 lb Quikrete Concrete Mix	\$ 3.65	5	\$ 18.25	
				Kwik Seal Caulking 10.1 oz.	\$ 5.28	1	\$ 5.28	
				Subtotal			\$ 37.50	
Tax:		7.76%		\$ 2.91				
Total							\$ 40.41	
#2	Home Depot	Julian Reyes	5/5/2017	90 lb Quikrete Concrete Mix	\$ 3.65	2	\$ 7.30	
				Subtotal			\$ 7.30	
				Tax:		7.76%		\$ 0.57
				Total				
#3	B and B Steel and Surplus	Julian Reyes	5/8/2017	2x2x1/8 H.R. Angle 20'	\$ 21.12	1	\$ 21.12	
				5x3x.120 H.S.T. 20'	\$ 114.00	14	\$ 1,596.00	
				3x3x.120 H.S.T. 20'	\$ 85.00	5	\$ 425.00	
				Subtotal			\$ 2,042.12	
Tax:		8.00%		\$ 163.37				
Total							\$ 2,205.49	
#4	Amazon	Adam MacLean	5/8/2017	12" x 24" A36 Steel Plate	\$ 35.55	1	\$ 35.55	
				Subtotal			\$ 35.55	
				Tax:		7.76%		\$ 2.76
				Total				
#5	Home Depot	Chris Carter	5/15/2017	High Strength Anchor Epoxy	\$ 24.97	1	\$ 24.97	
				1/2" x 12" Threaded Rod	\$ 1.57	18	\$ 28.26	
				1/2" Hex Nuts (Pack of 50)	\$ 7.97	1	\$ 7.97	
				1/2" Cut Washers	\$ 0.20	36	\$ 7.20	
				1/2" Lockwashers	\$ 0.21	18	\$ 3.78	
				Subtotal			\$ 72.18	
				Tax:		7.75%		\$ 5.59
Total							\$ 77.77	
#6	Home Depot	Chris Carter	5/21/2017	High Strength Anchor Epoxy	\$ 22.50	1	\$ 22.50	
				1/2" x 12" Threaded Rod	\$ 1.57	3	\$ 4.71	
				Subtotal			\$ 27.21	
				Tax:		7.75%		\$ 2.11
Total							\$ 29.32	
#7	Big Creek Lumber	Adam MacLean	5/23/2017	2x6 10' Redwood Con/Common	\$ 12.17	12	\$ 146.04	
				2x6 14' Redwood Con/Common	\$ 17.04	4	\$ 68.15	
				2x6 18' Redwood Con/Common	\$ 21.91	18	\$ 394.31	
				Delivery	\$ 69.00	1	\$ 69.00	
				Subtotal			\$ 677.50	
				Tax:		7.86%		\$ 53.25
Total							\$ 730.75	
#8	Amazon	Adam MacLean	5/8/2017	12" x 24" A36 Steel Plate	\$ 38.24	1	\$ 38.24	
				Subtotal			\$ 38.24	
				Tax:		7.75%		\$ 2.96
				Total				
#9	Home Depot	Chris Carter	5/25/2017	#10 x 3" PG10 Ext Screw 5 lb	\$ 23.48	1	\$ 23.48	
				Eb Neo Self-Drilling Screw 1 lb	\$ 9.87	1	\$ 9.87	
				Sharp Point Screw w/ Washer	\$ 8.98	1	\$ 8.98	
				Subtotal			\$ 42.33	
				Tax:		7.75%		\$ 3.28
Total							\$ 45.61	
#10	Home Depot	Chris Carter	5/28/2017	Behr PPUe 9853 1 Gal	\$ 36.98	2	\$ 73.96	
				Paintcare Fee	\$ 0.75	2	\$ 1.50	
				6 Pack Pocket Rags	\$ 2.98	1	\$ 2.98	
				KS Phosphoric Gallon	\$ 15.78	1	\$ 15.78	
				Better 3x3/8 In Knit Rollers	\$ 3.97	1	\$ 3.97	
				3 pk 3/8in Pylam Roller	\$ 7.33	1	\$ 7.33	
				Paint Tray Liner	\$ 0.98	1	\$ 0.98	
				8pc Tray Set	\$ 10.97	1	\$ 10.97	
				Subtotal			\$ 117.47	
				Tax:		7.75%		\$ 9.10
Total							\$ 126.57	

WOOD SKEWNESS QUALITY CONTROL

2x6 REDWOOD 18'		
Piece #	Skewness (in)	Quality
1	0.2500	G
2	0.1875	G
3	0.2500	MD
4	0.1875	G
5	0.2500	G
6	0.3125	G
7	0.6875	G
8	0.2500	MD
9	0.1250	G
10	0.1250	G
11	0.3125	G
12	0.3750	MD
13	0.1250	G
14	0.1250	MD
15	0.0625	G
16	0.1875	MD
17	0.8750	G
18	0.0625	LD

2x6 REDWOOD 14'			
Piece #	Skewness (in) X-X	Skewness (in) Y-Y	Quality
1	0.25	0.125	G
2	0.1875	0.25	G
3	0.4375	0.375	G
4	0.125	0	G

2x6 REDWOOD 10'			
Piece #	Skewness (in) X-X	Skewness (in) Y-Y	Quality
1	0.125	0.4375	G
2	0.0625	0	G
3	0.0625	0	G
4	0	0	MD
5	0.125	0	G
6	0	0	LD
7	0.0625	0	G
8	0.0625	0	G
9	0	0	G
10	0	0.125	G
11	0.1875	0.1875	G
12	0.1875	0.1875	G

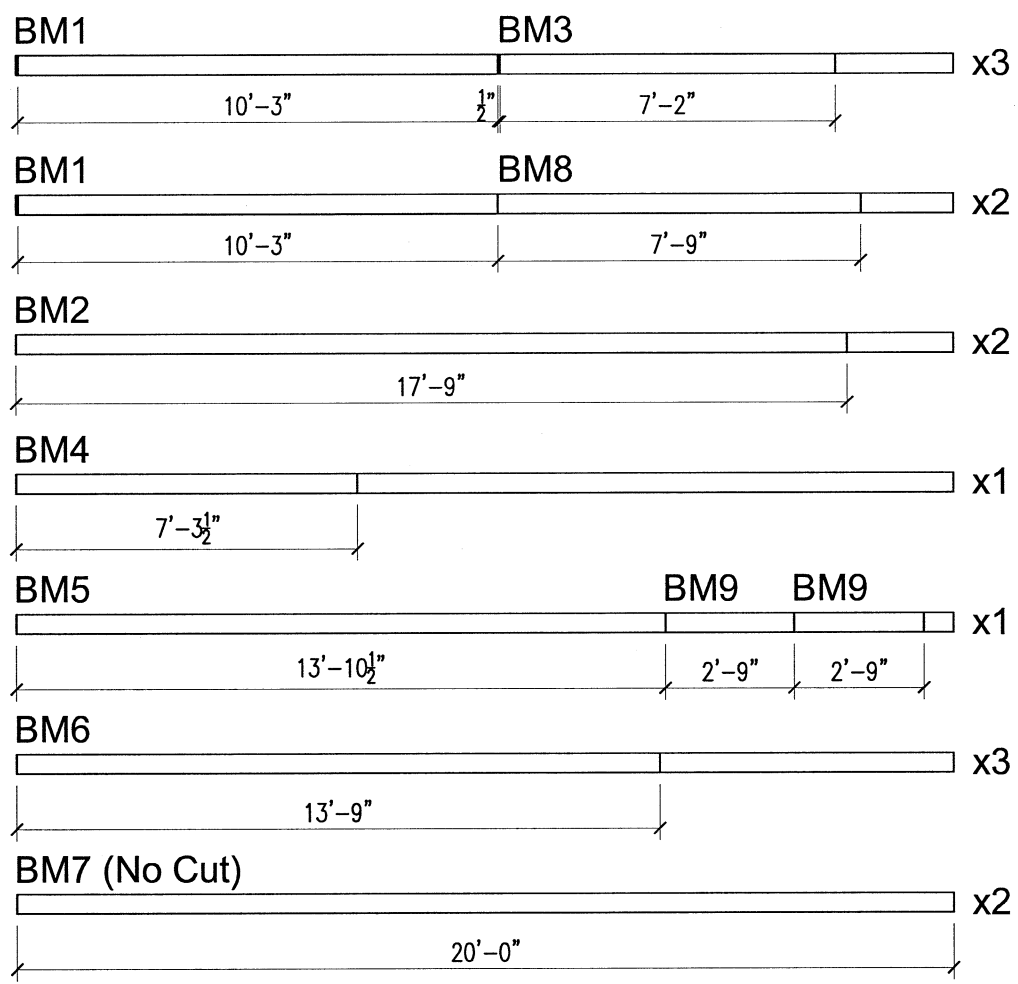
KEY

G	GOOD	Great for Use
LD	LIGHT DAMAGE	Light Marks
MD	MED. DAMAGE	Marks. Heavy Chips
HD	HEAVY DAMAGE	Unusable

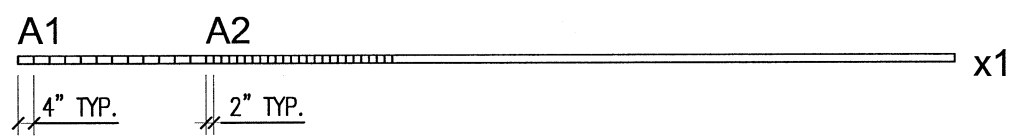
2x6 REDWOOD 18'	
Avg. Skew (in)	0.2639
Avg. Skew (% of length)	0.12%
2x6 REDWOOD 14'	
Avg. Skew (in) X-X	0.2500
Avg. Skew (% of length)	0.15%
Avg. Skew (in) Y-Y	0.1875
Avg. Skew (% of length)	0.11%
2x6 REDWOOD 10'	
Avg. Skew (in) X-X	0.0729
Avg. Skew (% of length)	0.06%
Avg. Skew (in) Y-Y	0.0781
Avg. Skew (% of length)	0.07%

ALL GOOD QUALITY WOOD

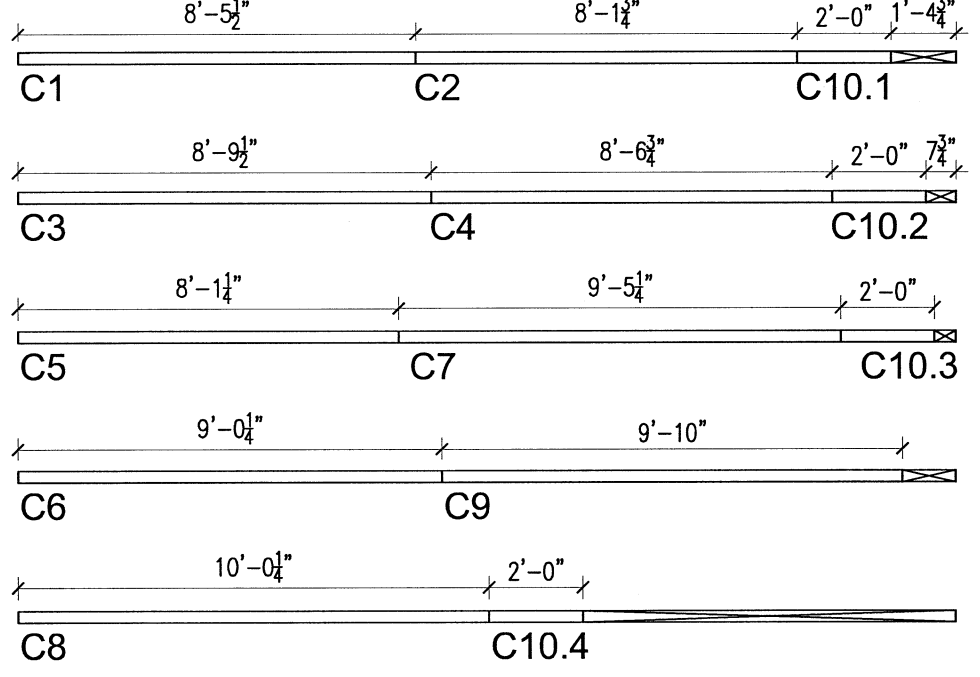
HSS 3 x 5 x 1/8 Cut List (14)



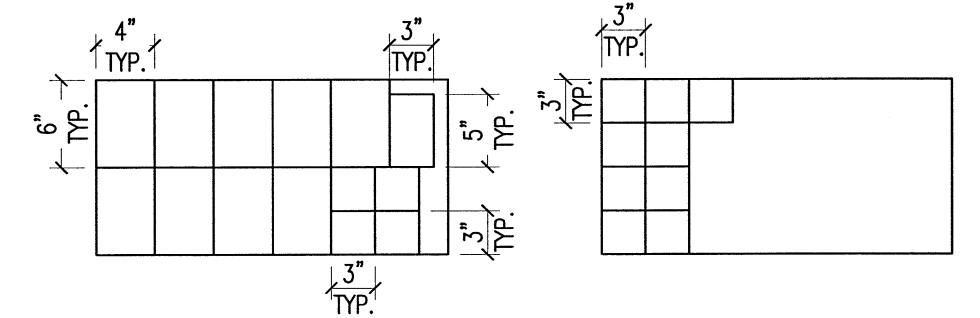
ANGLE 2 x 2 x 1/8 Cut List



HSS 3 x 3 x 1/8 Cut List (5)



1/4" PLATE 12" x 24"



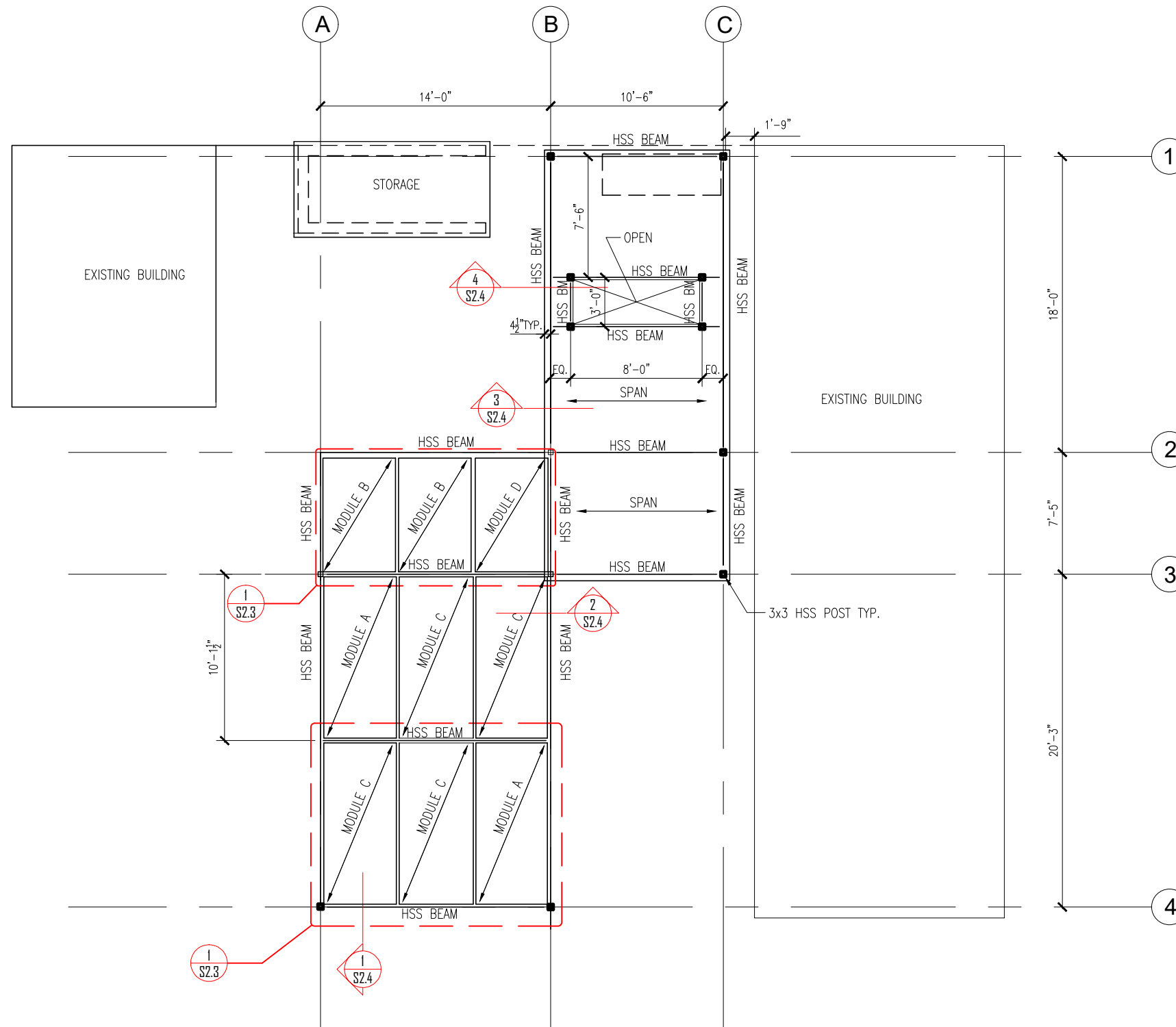
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 Senior Project 2017
 Professor Kevin Dong

PRELIMINARY-
 NOT FOR
 CONSTRUCTION

NAME Carter
 MacLean
 Moraga
 Reyes
 DATE 4/5/17
 SCALE NTS
 U.O.N.
 SHEET CL



PLAN

SCALE: 1/8" = 1' - 0"

GENERAL PLAN NOTES

1. ALL COLUMNS ARE HSS 3" x 3" x 1/8"
2. ALL BEAMS ARE HSS 5"x 3" x 1/8"
3. ALL TIMBER IS CONST. RED WOOD
4. ALL WELDS ARE 1/8" FILLET

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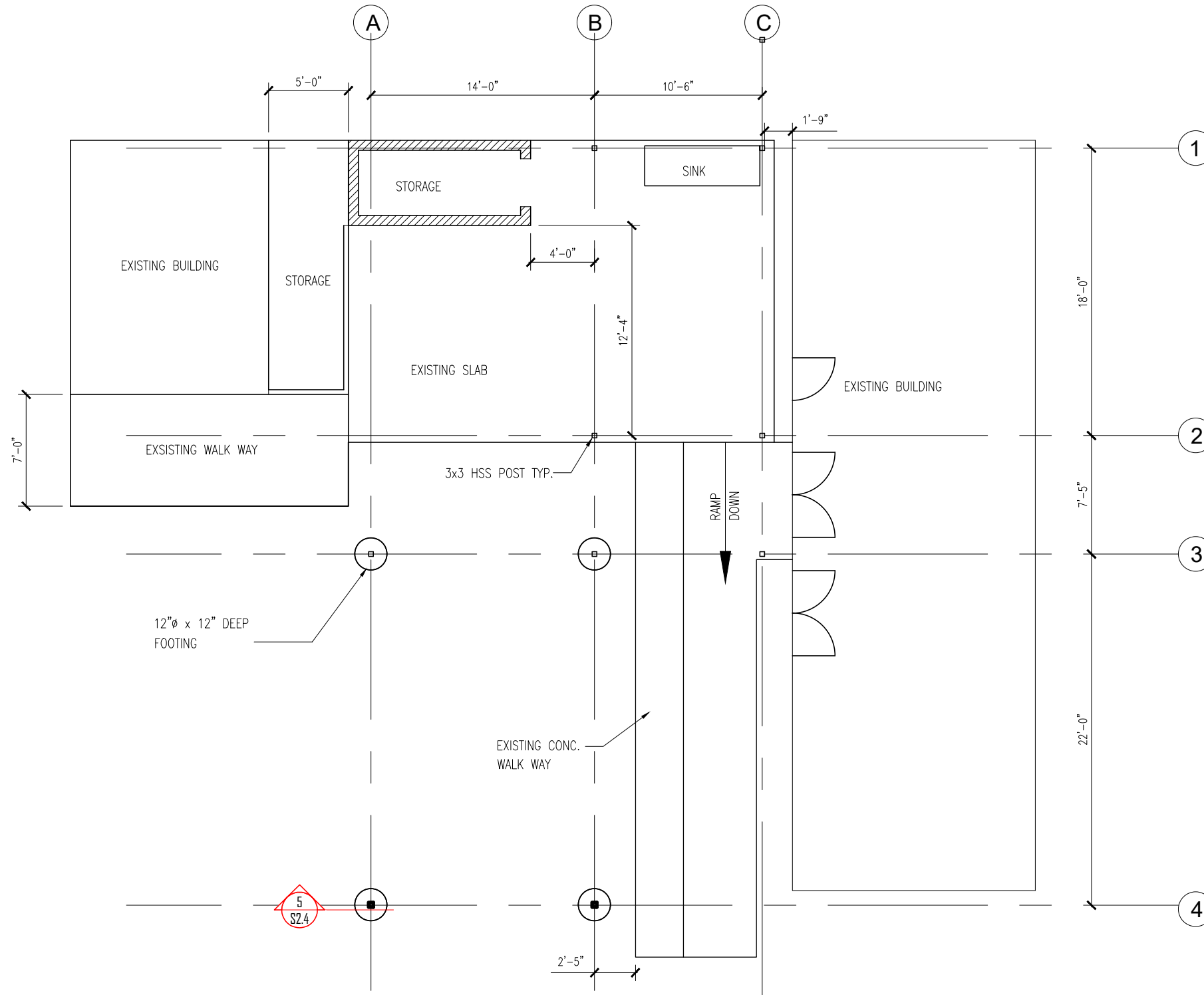
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MacLean
Moraga
Reyes
DATE 4/5/17
SCALE U.O.N. 1/8"=1'-0"
SHEET

S1.2

LEGEND

□ INDICATES HSS COLUMN



FOUNDATION PLAN

SCALE: 1/8" = 1'-0"

GENERAL PLAN NOTES

1. ALL COLUMNS ARE HSS 3" x 3"x $\frac{1}{8}$ "
2. ALL BEAMS ARE HSS 5" x 3"x $\frac{1}{8}$ "
3. ALL TIMBER IS CONST. RED WOOD
4. ALL WELDS ARE $\frac{1}{8}$ " FILLET

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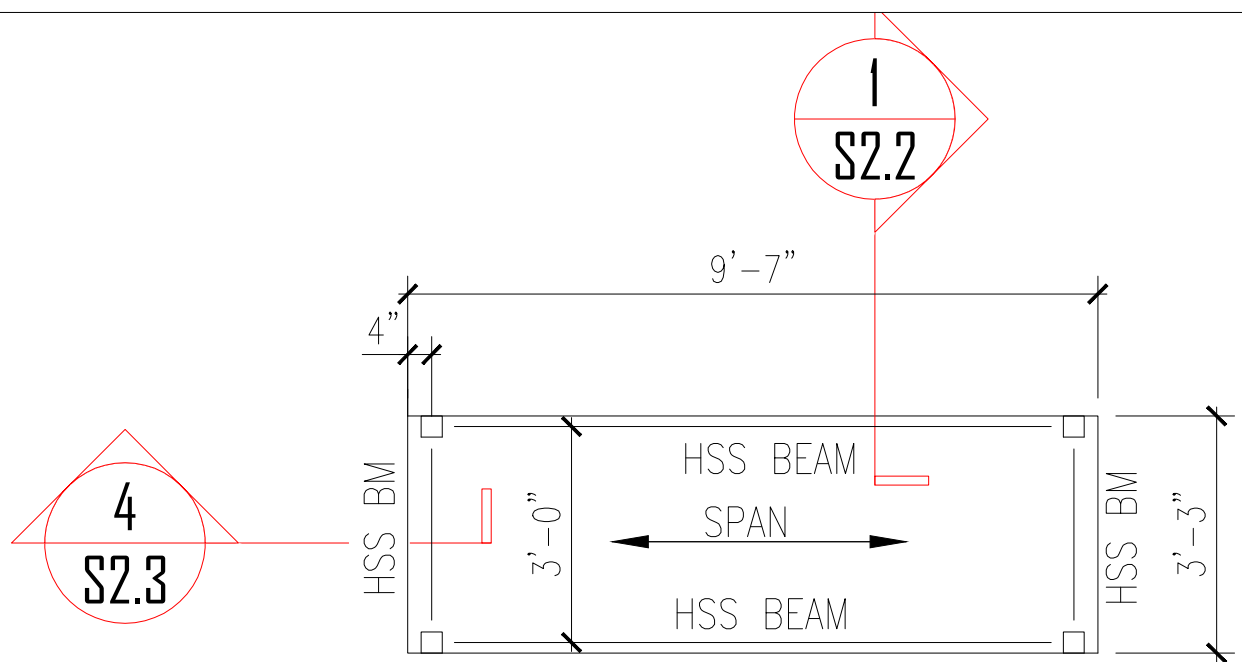
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LEGEND

- INDICATES CONCRETE FOOTING
- INDICATES STRUCTURAL POST

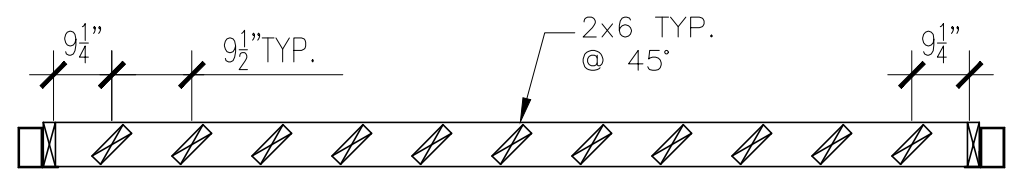
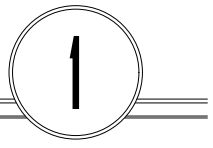
NAME Carter
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Reyes
DATE 4/5/17
SCALE 1/8"=1'-0"
SHEET

SI.1



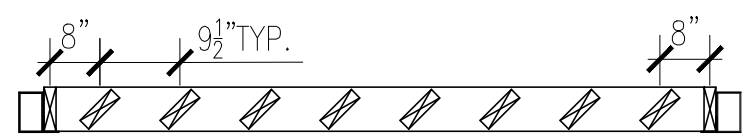
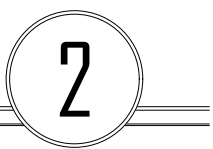
CUT OUT PLAN

SCALE: 3/8" = 1'-0"



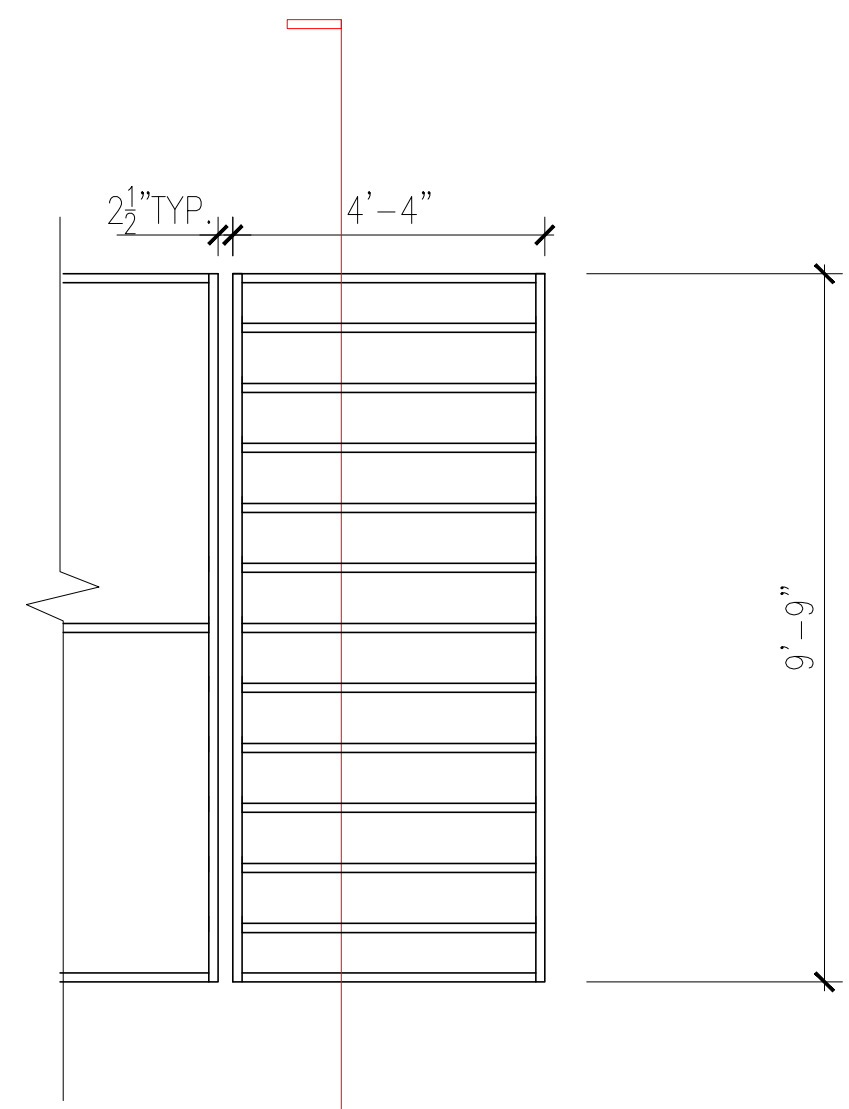
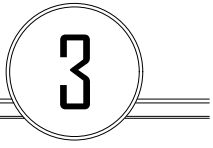
MODULE A SECTION

SCALE: 1/2" = 1'-0"



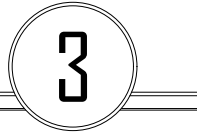
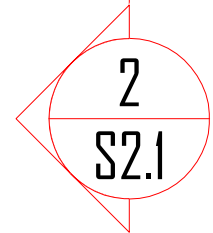
MODULE B SECTION

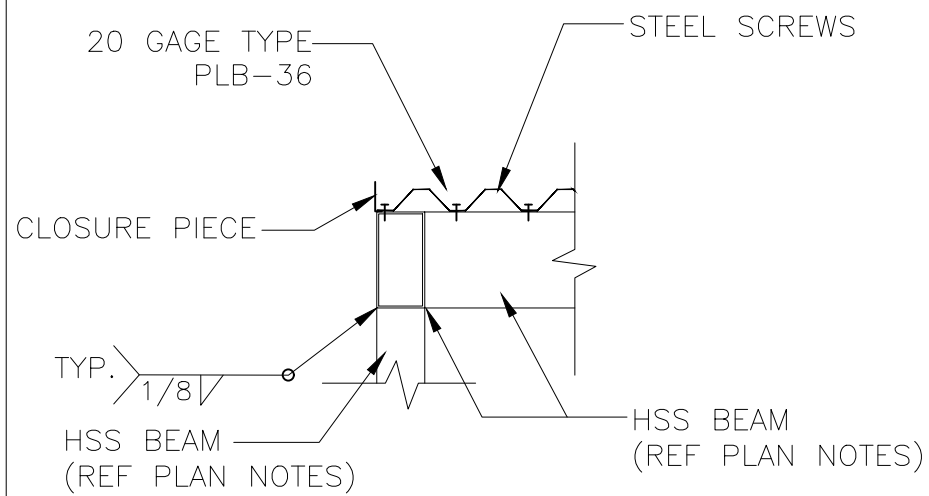
SCALE: 1/2" = 1'-0"



MODULE A PLAN

SCALE: 3/8" = 1'-0"

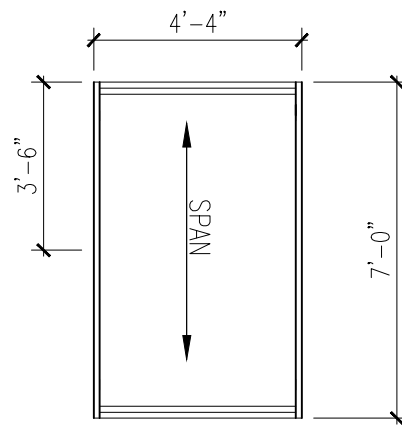




CUT OUT DETAIL

SCALE: 1" = 1'-0"

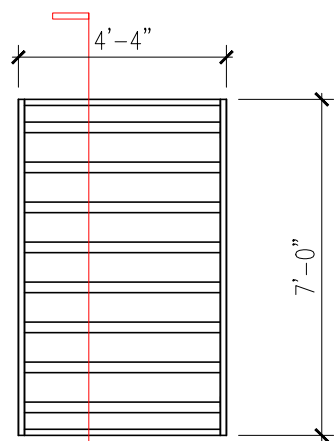
1



MODULE D PLAN

SCALE: 1/4" = 1'-0"

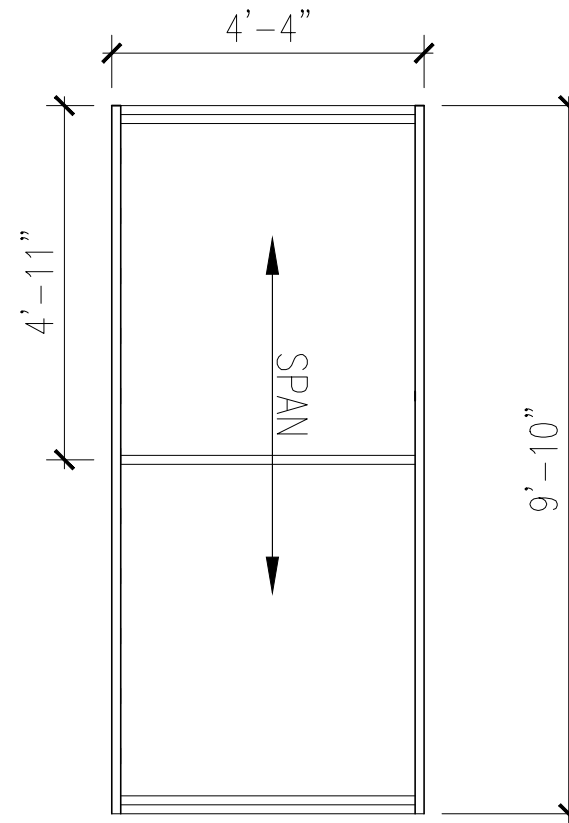
3



MODULE B PLAN

SCALE: 1/4" = 1'-0"

2



MODULE C PLAN

SCALE: 3/8" = 1'-0"

4

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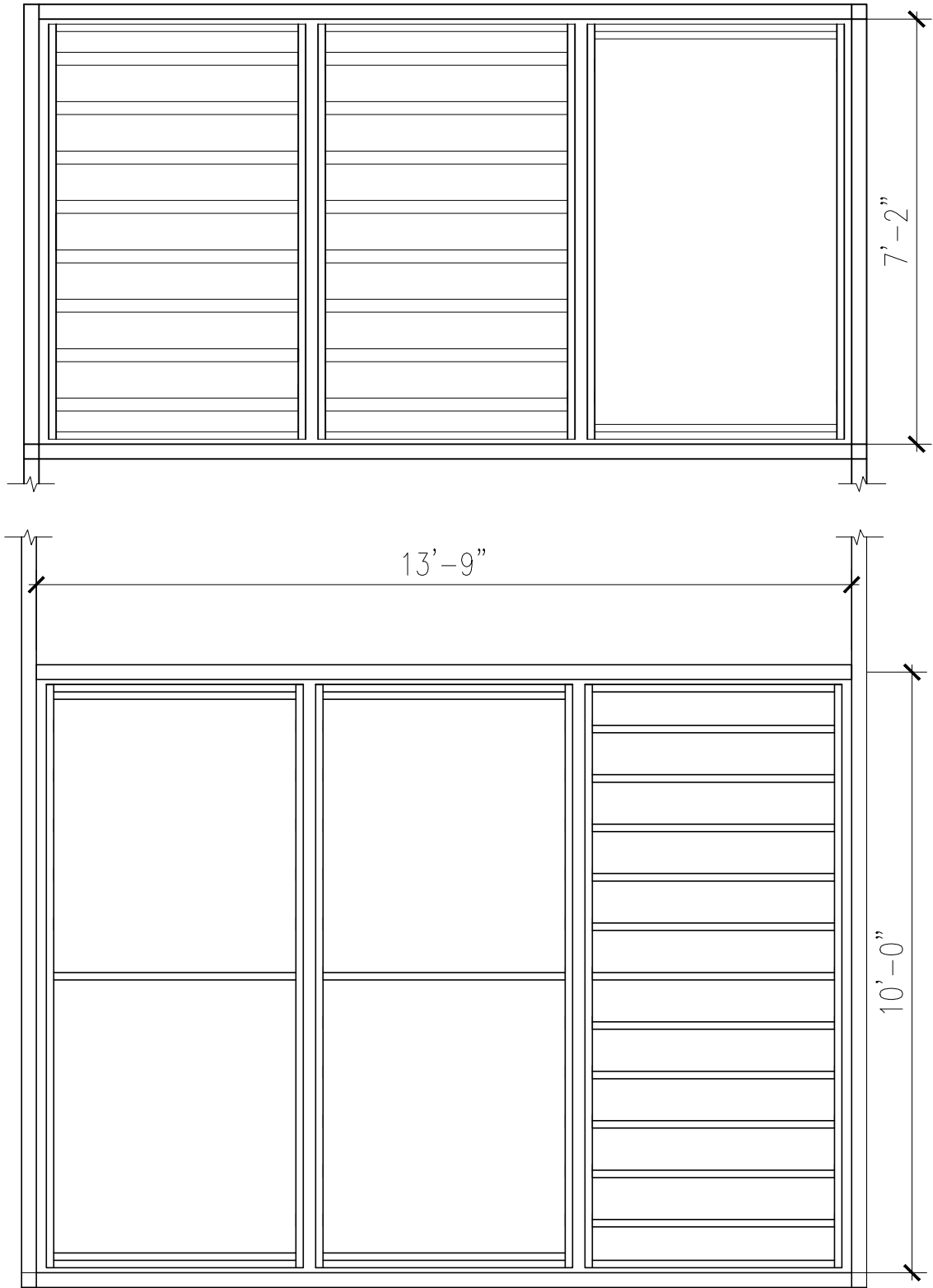
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S2.2



MODULE PLAN

SCALE: 3/8" = 1'-0"

1

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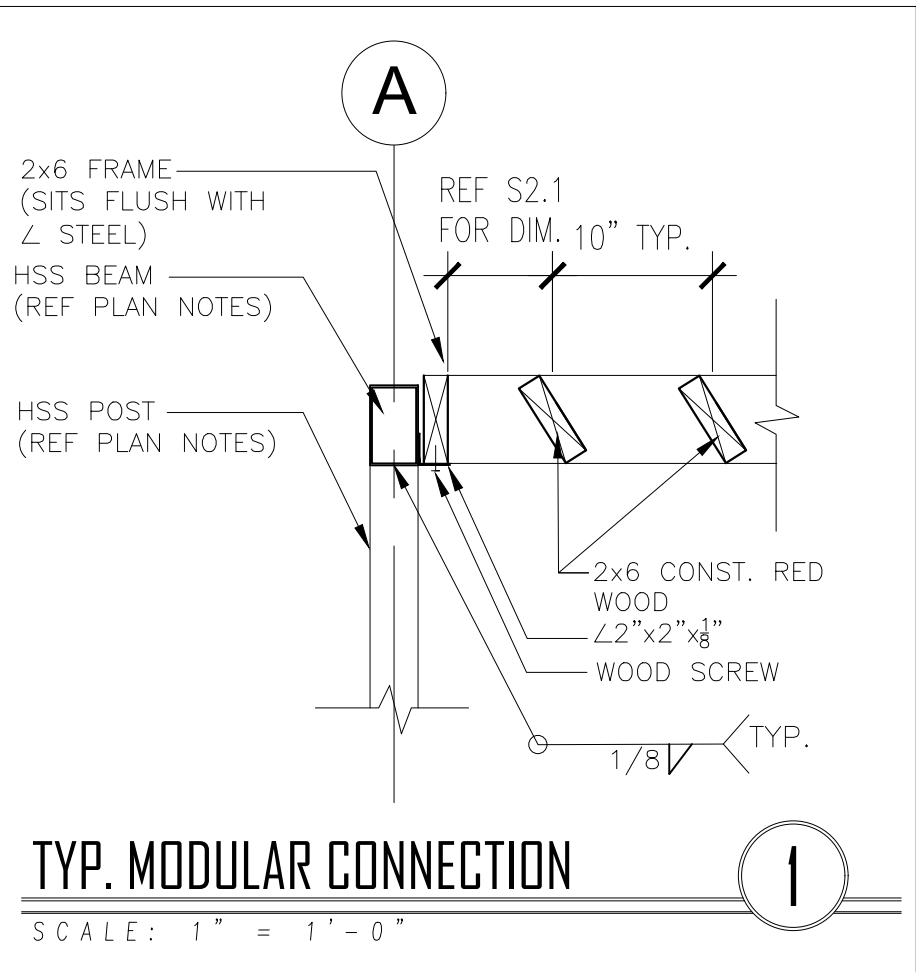
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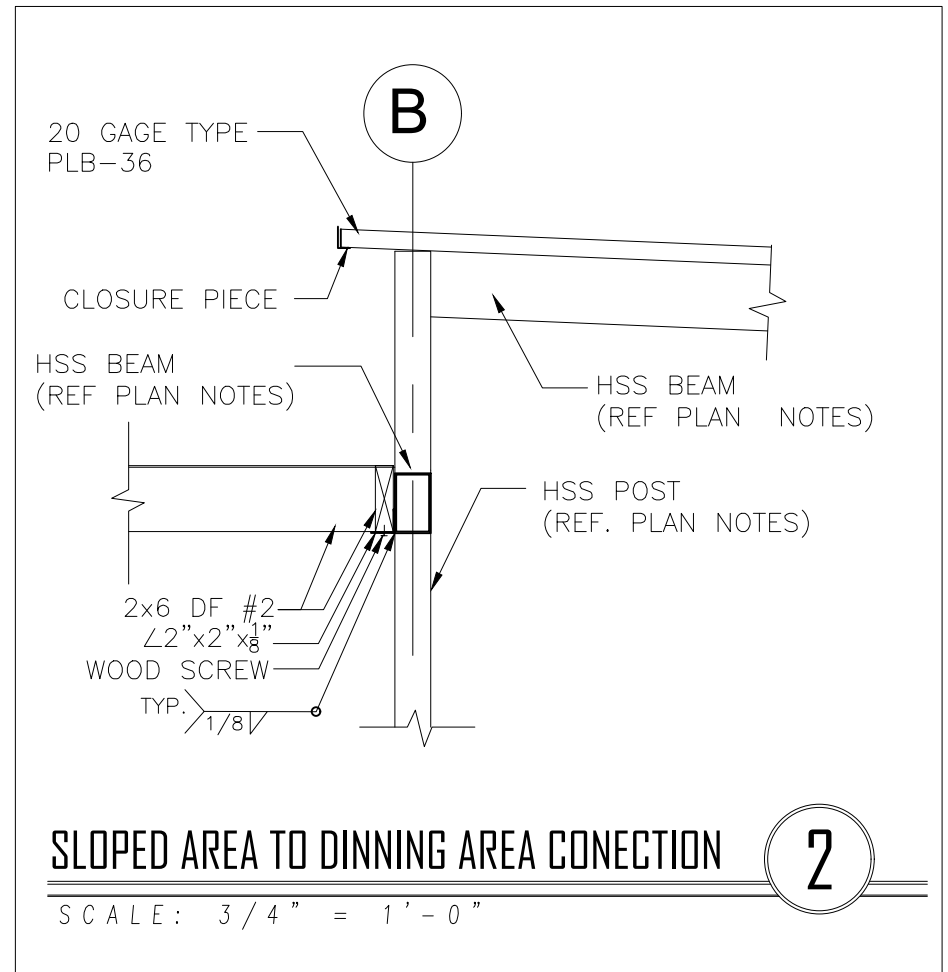
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Moraga
Reyes
DATE 4/5/17
SCALE 1/8"=1'-0"
SHEET

S2.3



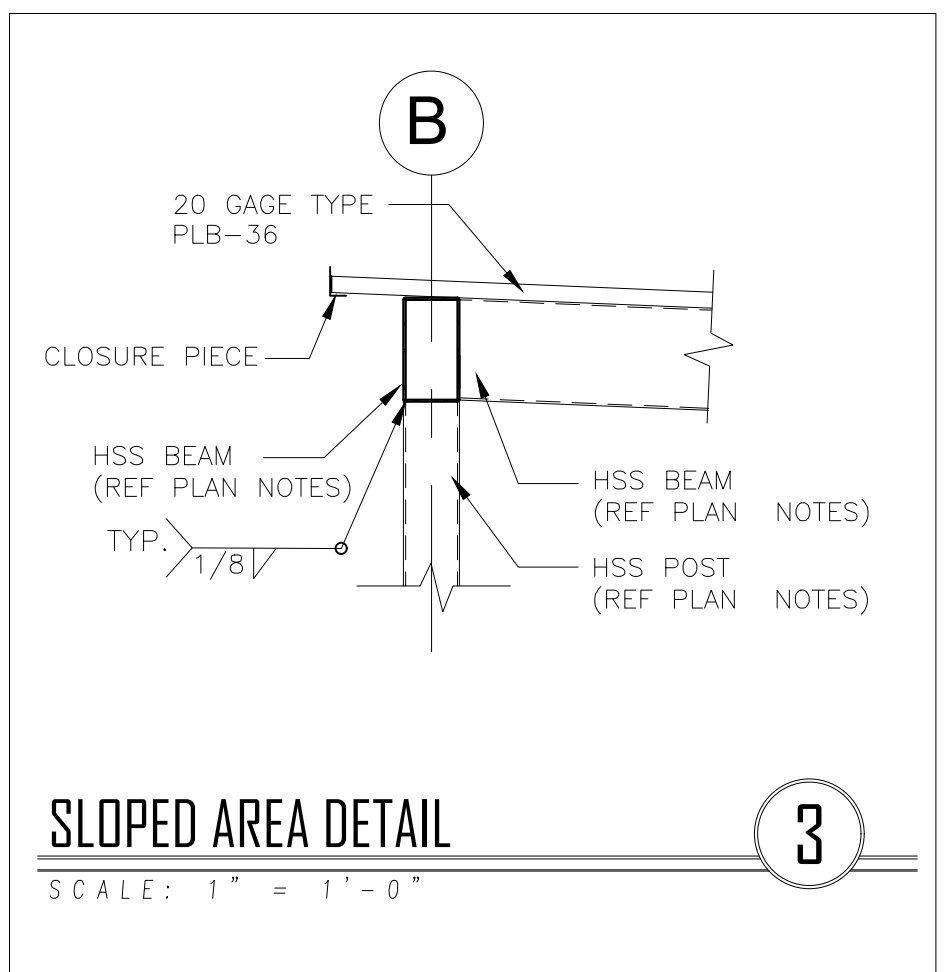
TYP. MODULAR CONNECTION

SCALE: 1" = 1'-0"



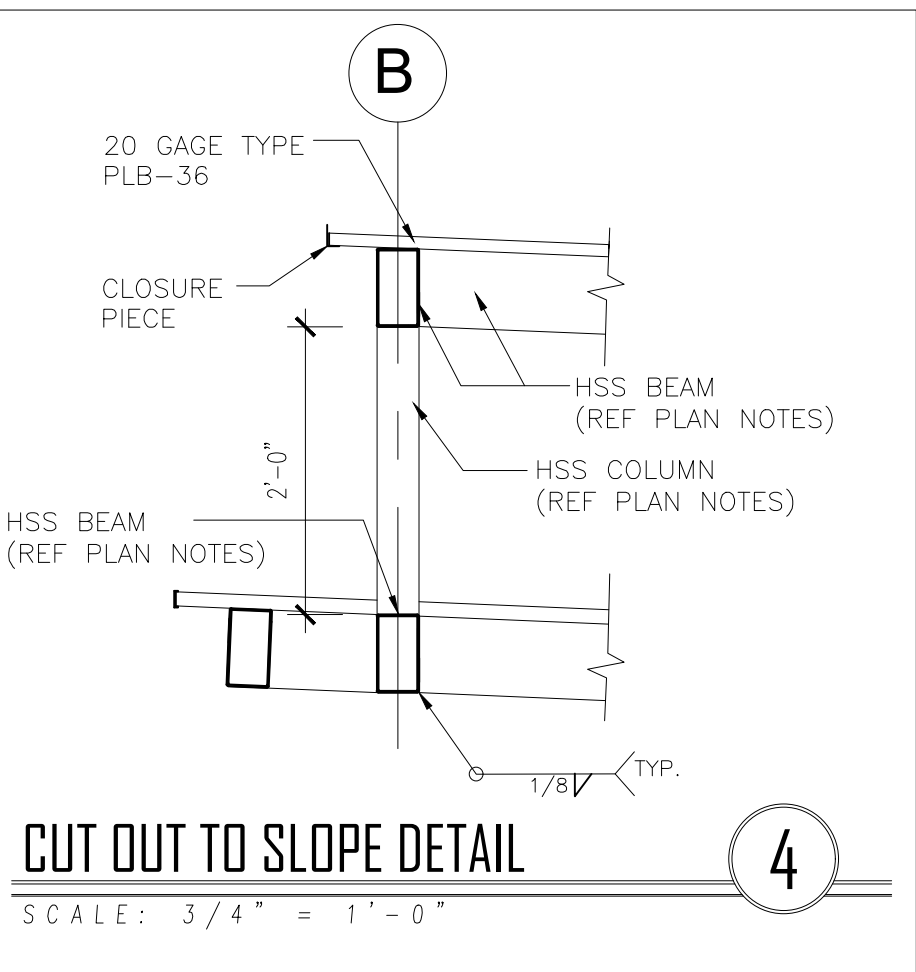
SLOPED AREA TO DINNING AREA CONECTION

SCALE: 3/4" = 1'-0"



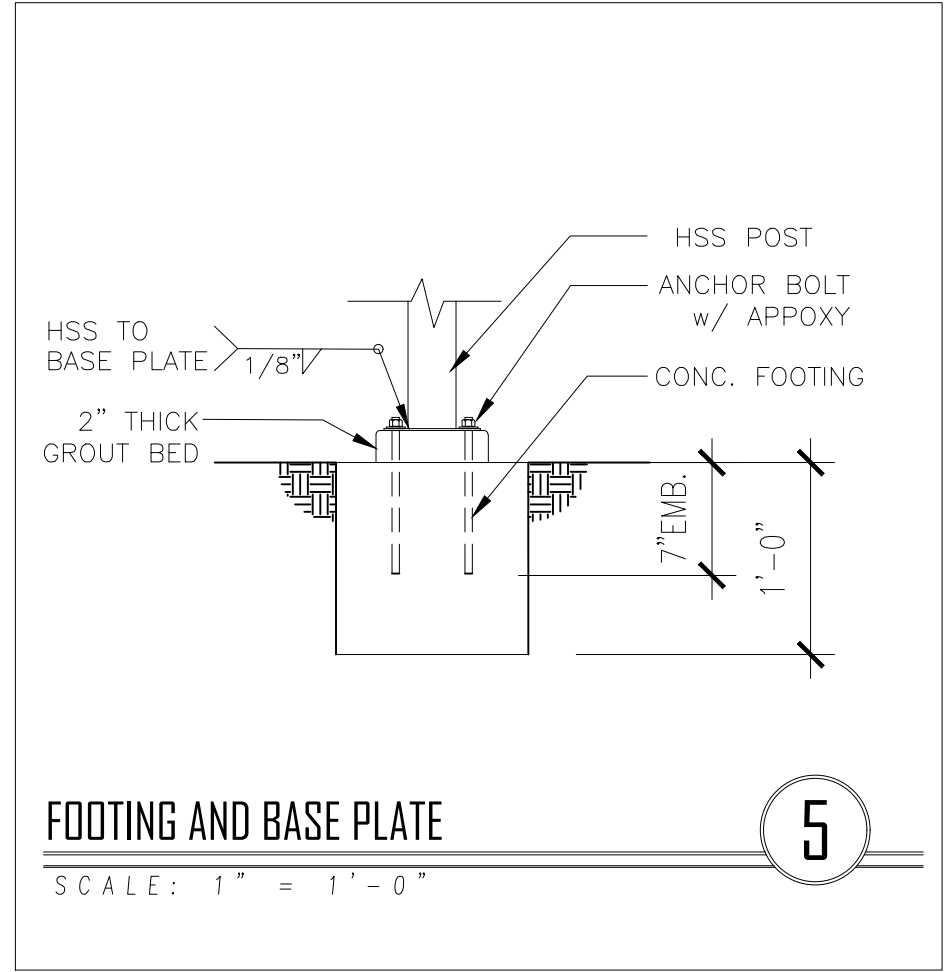
SLOPED AREA DETAIL

SCALE: 1" = 1'-0"



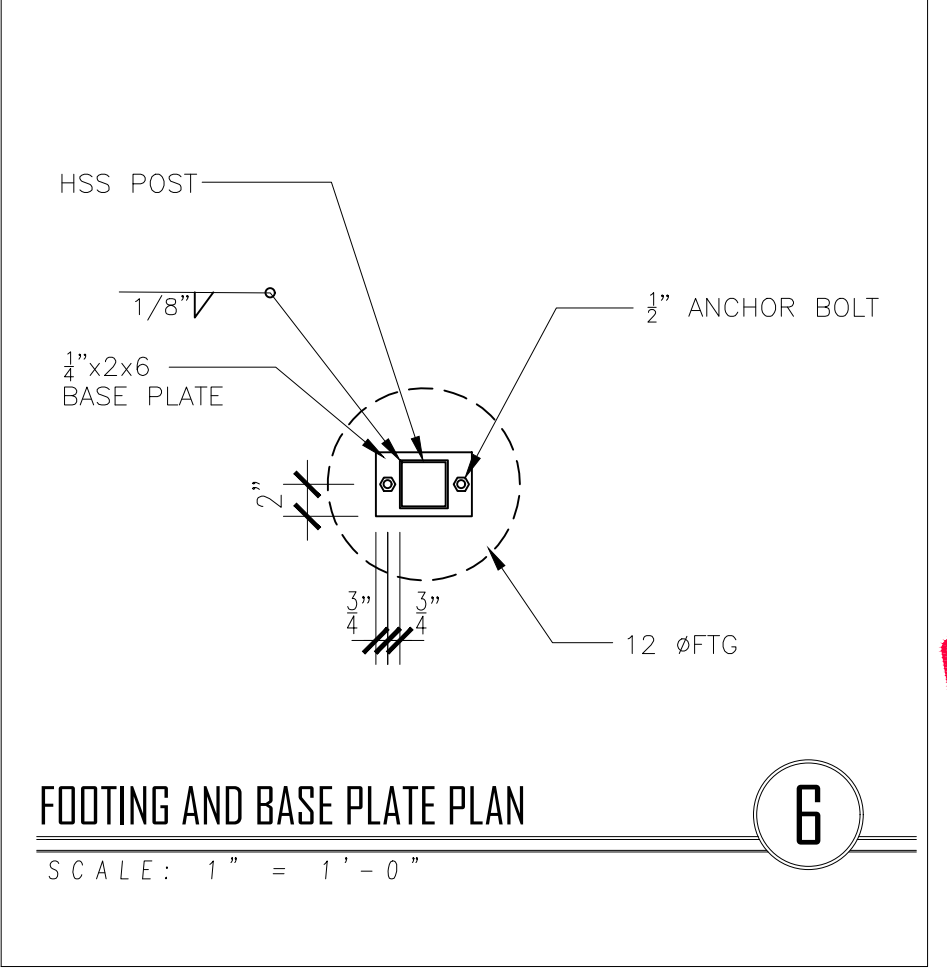
CUT OUT TO SLOPE DETAIL

SCALE: 3/4" = 1'-0"



FOOTING AND BASE PLATE

SCALE: 1" = 1'-0"



FOOTING AND BASE PLATE PLAN

SCALE: 1" = 1'-0"