Wine History Project Moving Pavilion

A Senior Project
presented to
the Faculty of the Architectural Engineering Department
California Polytechnic State University – San Luis Obispo

In Partial Fulfillment
of the Requirements for the Degree
Bachelor of Science

By

Rachel Jakel

December 2019

Table of Contents

Introduction to Project

Background:

The Wine History Project of San Luis Obispo documents and preserves the unique food and wine history of the area. They educate the community through inviting exhibits that teach people about the importance of viticulture and its impact on making San Luis Obispo what it is today. They came forth with a proposal for our studio to design a temporary moving pavilion that will showcase their displays and exhibits at various wineries in the county.

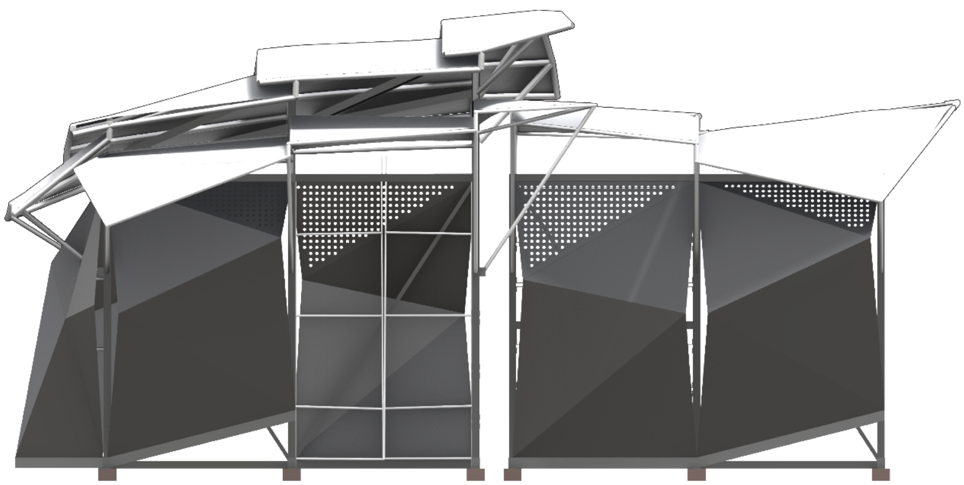
Integrated Project Delivery:

This was an interdisciplinary senior project class that was made up of architectural engineering, construction management and architecture students. We utilized the integrated project delivery method (IPD) to carry out the design process of this project. The class was also sponsored by LPA design firm as they practice IPD and were able to help us understand more about this method through several meetings. IPD is an emerging form of project delivery that includes engineers, contractors and owner as well as the architect in an iterative-opposed to linear- design process. This collaborative method is meant to make for a faster and more successful project delivery as communication between all parties should cut down on confusion and leave less room for error.

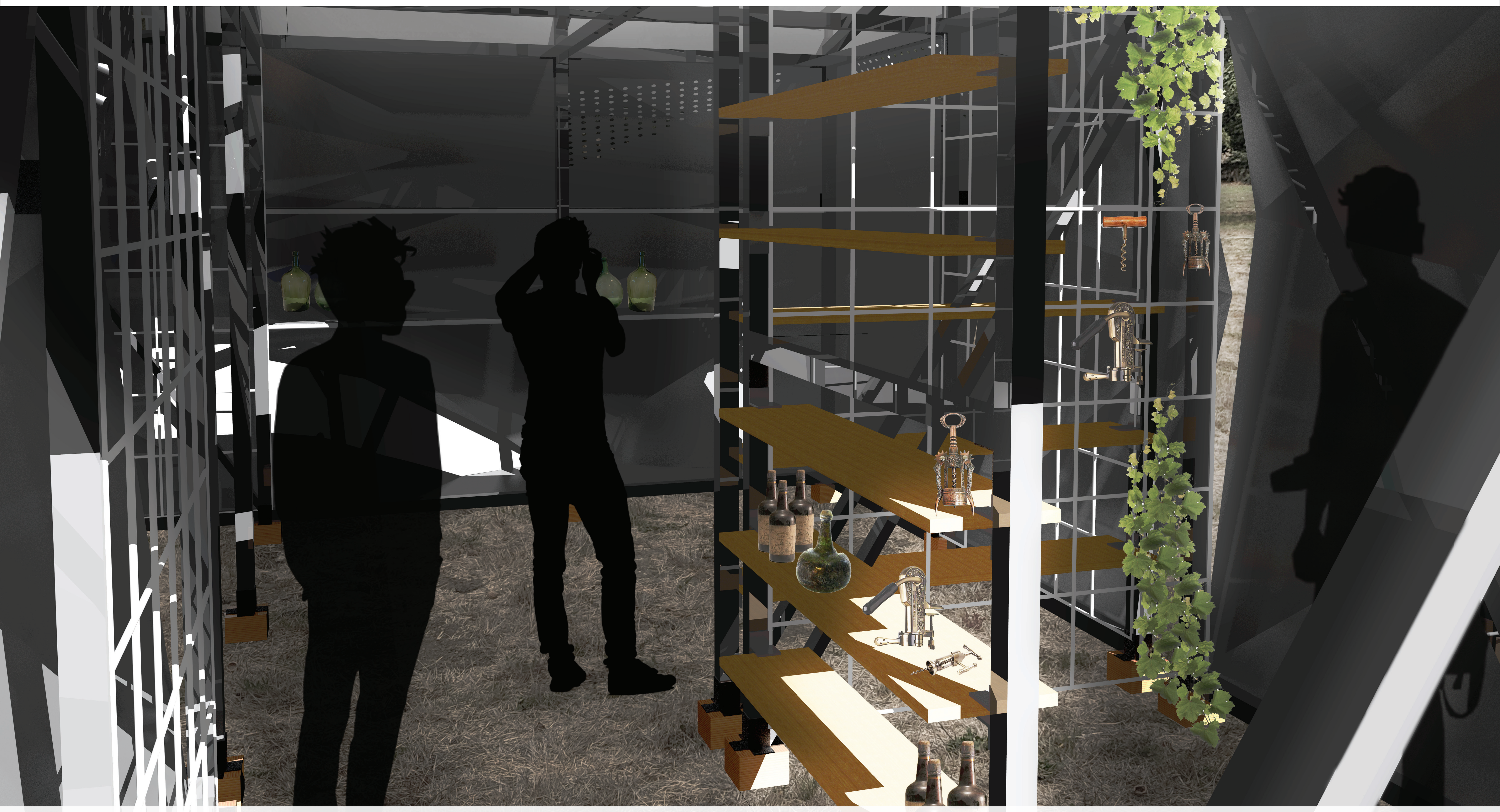
Constraints:

This project was very challenging in that it required the structure to be very flexible yet very portable. The pavilion must be initially built by construction management students utilizing the CAED shop then constructed by "unskilled labor" (i.e. movers, the clients, friends of the clients, etc.) as it moves from site to site. It must be transportable via typical moving truck and assembled without machinery. There should be little disturbance to the ground it sits on, yet it should be stable and have adequate foundations. There was little design direction but it should provide nearly unlimited display options as our clients exhibits change often with various artifacts and posters of various sizes.

[IN/BLOOM]
[IN/BLOOM]
[IN/BLOOM]
[IN/BLOOM]



Architectural Renders and Site Plan

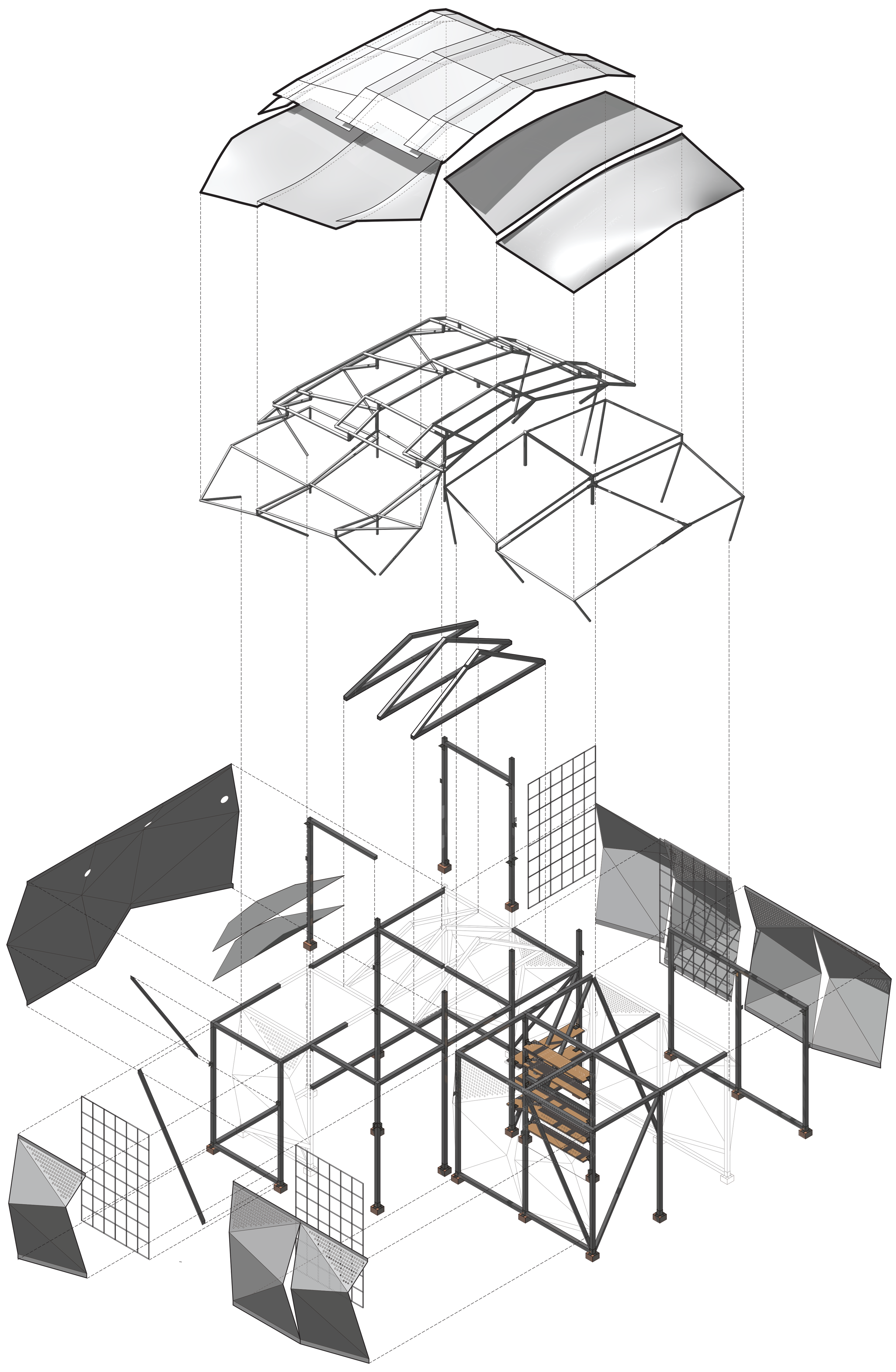


IN BLOOM

What is the Heart? A flower opening.

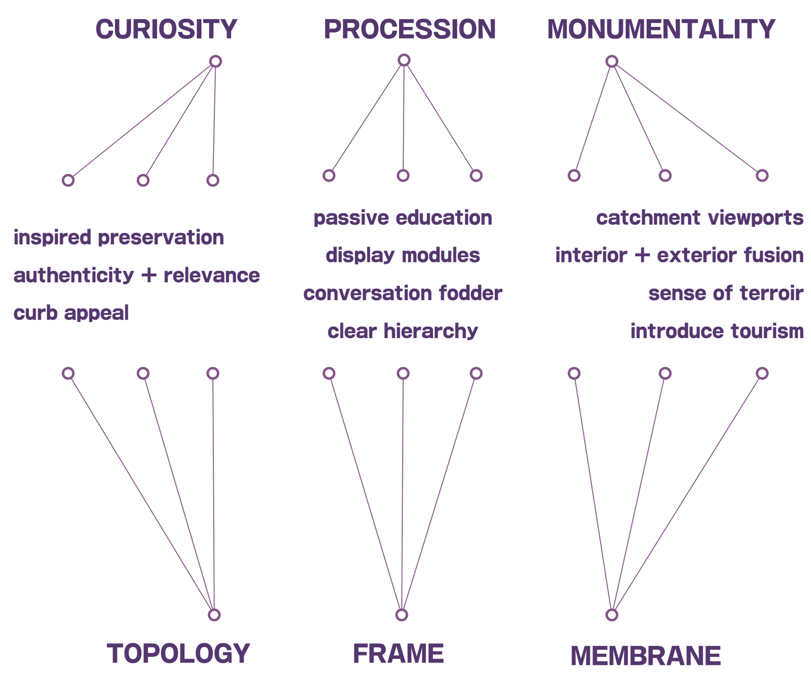
The intellectual quest is exquisite like pearls and coral, But it is not the same as the spiritual quest. The spiritual quest is on another level altogether, Spiritual wine has a subtler taste. The intellect and the senses investigate cause and effect. The spiritual seeker surrenders to the wonder.

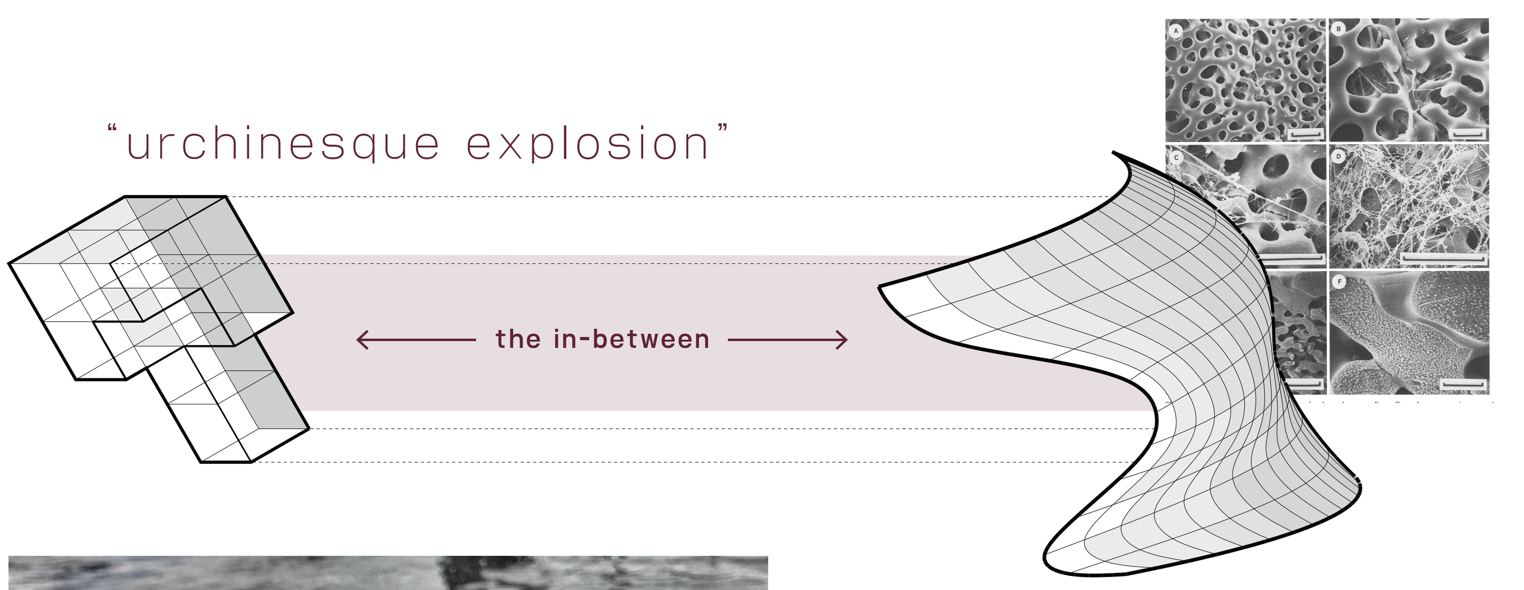
~ RUMI

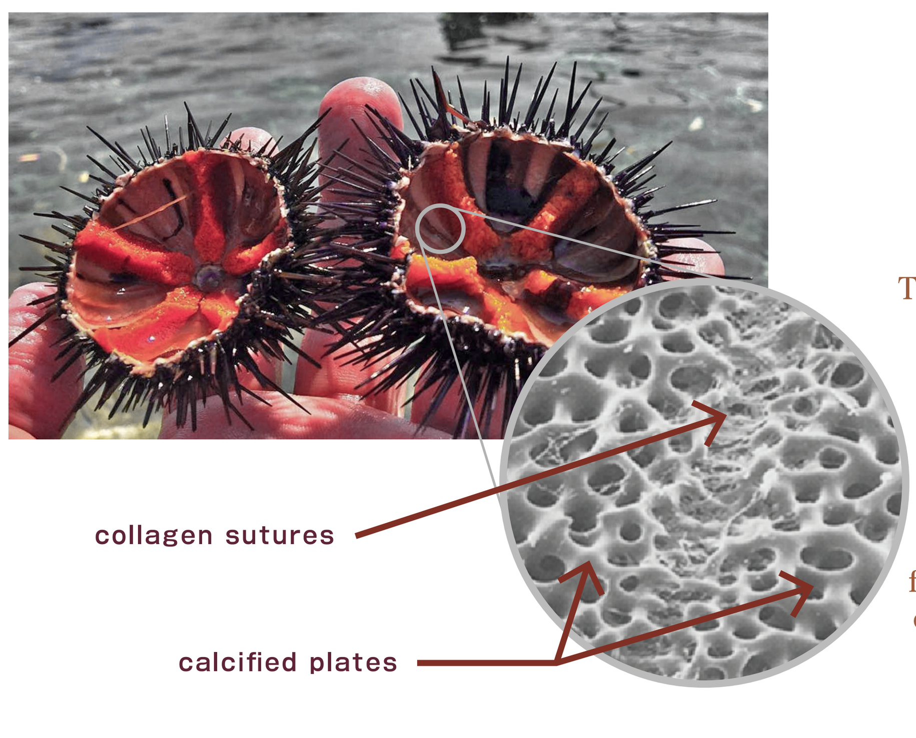


PROJECT GOALS

The Wine History Project of San Luis Obispo has entrusted Cal Poly Architecture, Engineering, & Construction Management majors with the task of designing a pavilion to function as a vital recordkeeping vessel. In their trust is over 200 years worth of artifacts showcasing the region's interlocked cultural traditions in the cultivation and consumption of wine. In an emergent "interdisciplinary" design studio format, students have been tasked with creating a transient home to this history, one which will feature a rotating public display of the WHP's hard work and dedication to preserving two centuries of winemakers' livelihoods, and which will see continuous cohabitation with an interchanging roster of local wineries & tasting rooms carrying the tradition forward.



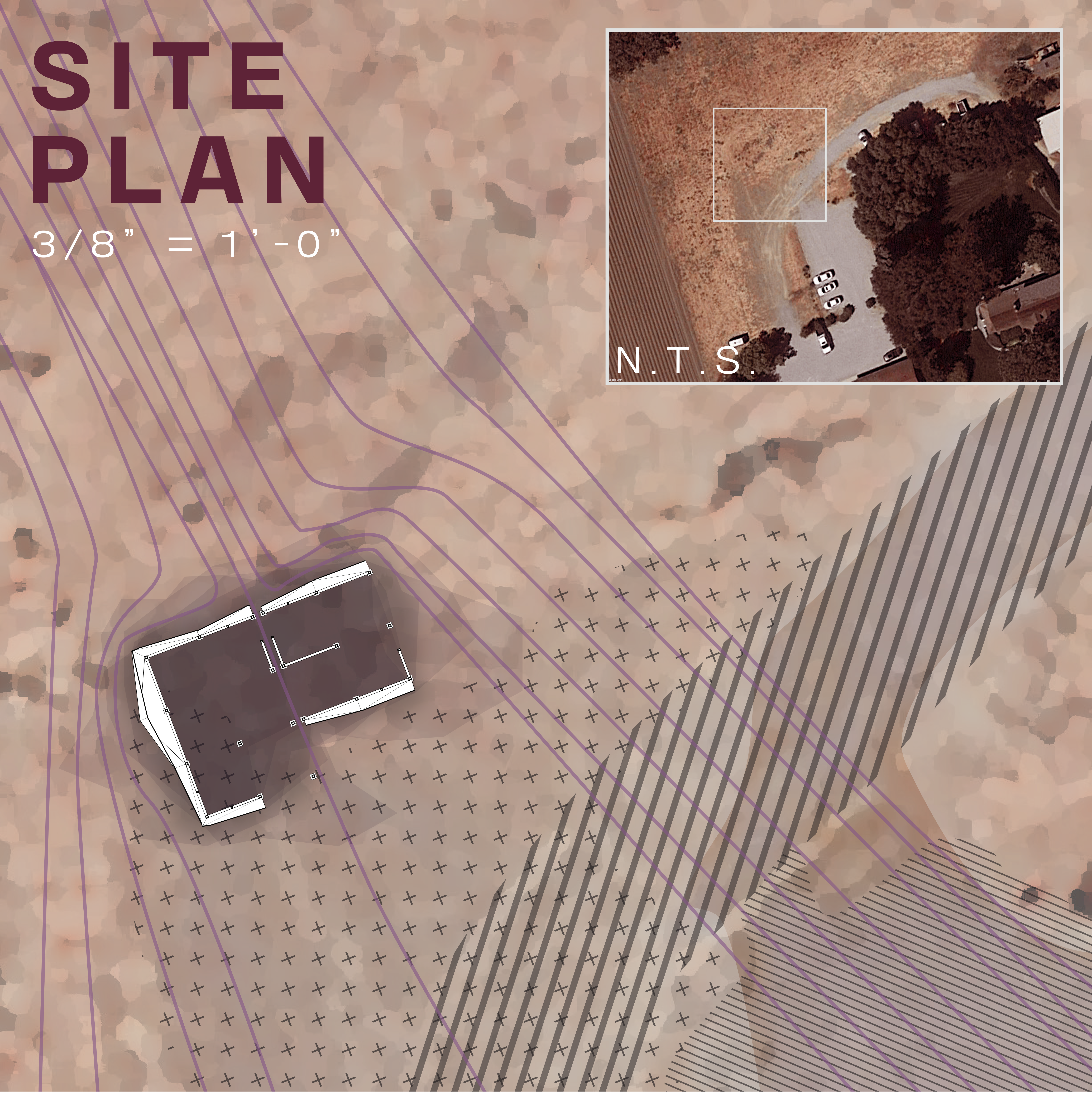




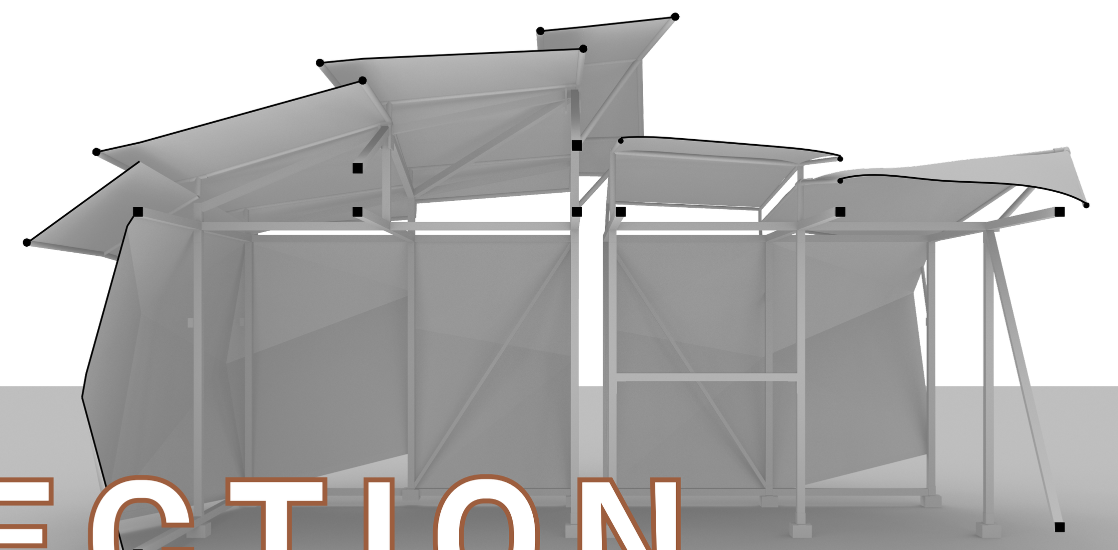
Early experiments in the architectural process revolved around research of the phylum Echinodermata, which includes sea stars, urchins, and the like. The exoskeletons of these organisms rely on the overlapping of rigid plates which are sutured tight by tensile collagen fibers in between. In Bloom seeks to redefine that "in-between" space, utilizing a purposeful explosion of loose-flowing tensile membranes from their rigid structural frame to create volumes for artifact display, light fixture, and ventilation.

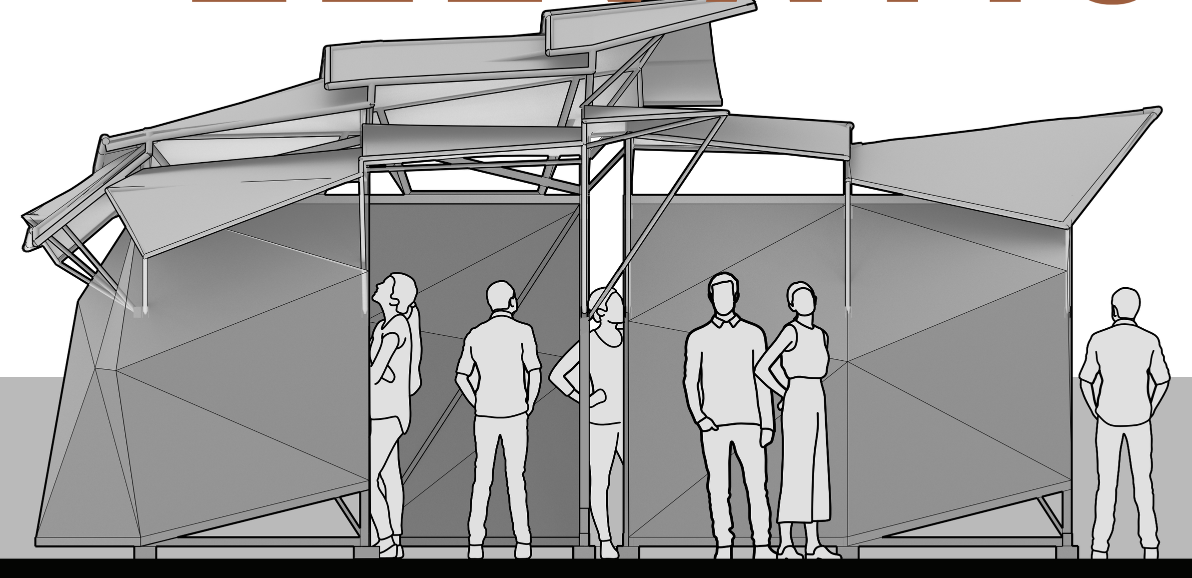
SITE PLAN

3/8" = 1'-0"



ELEVATION

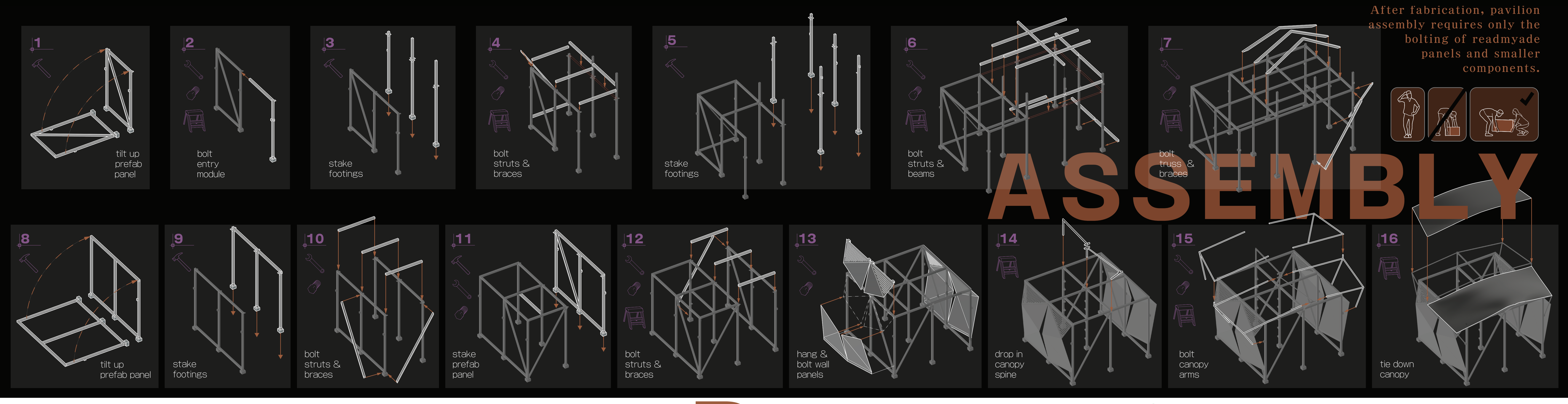




SECTION

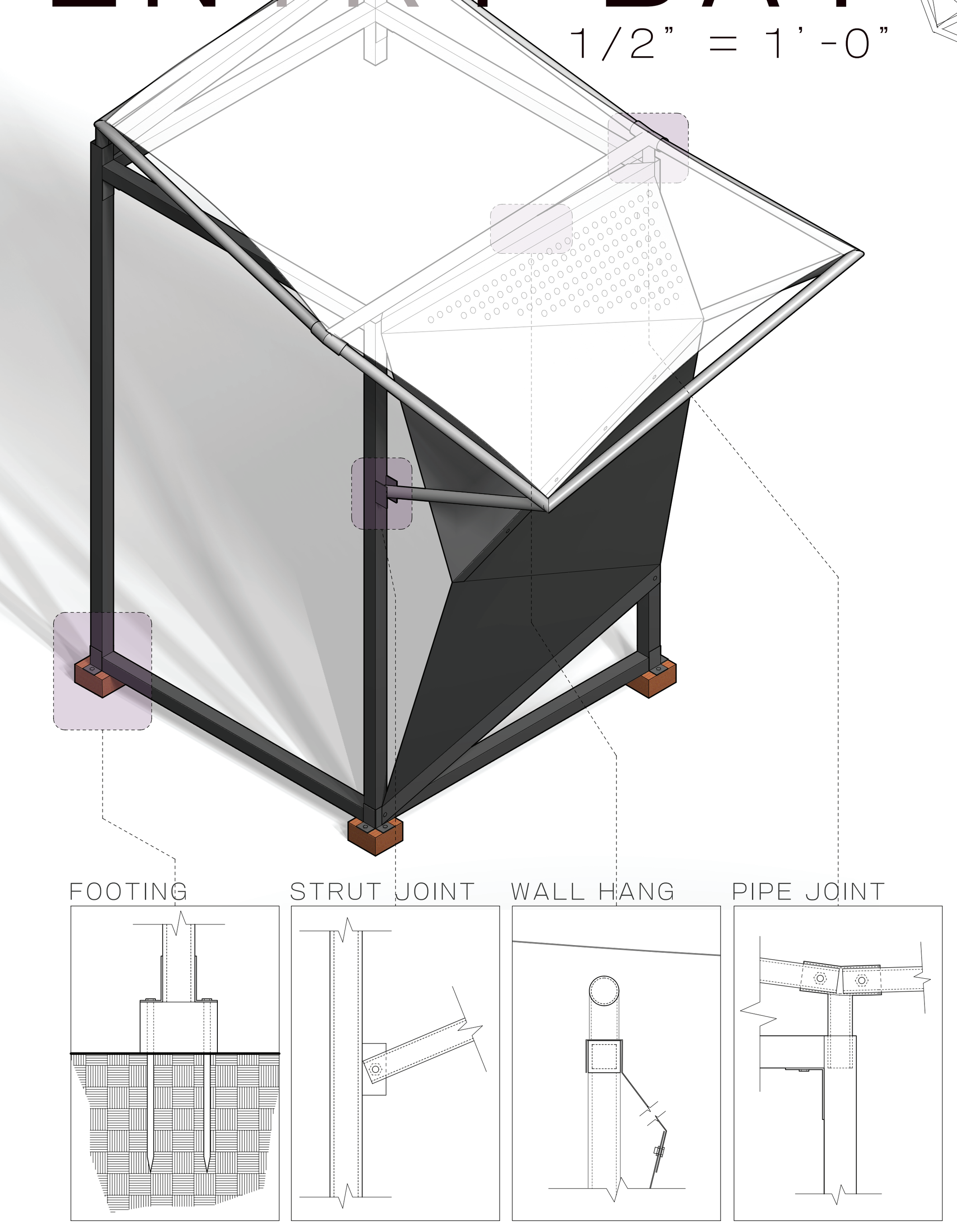
After fabrication, pavilion assembly requires only the bolting of readmyade panels and smaller components.

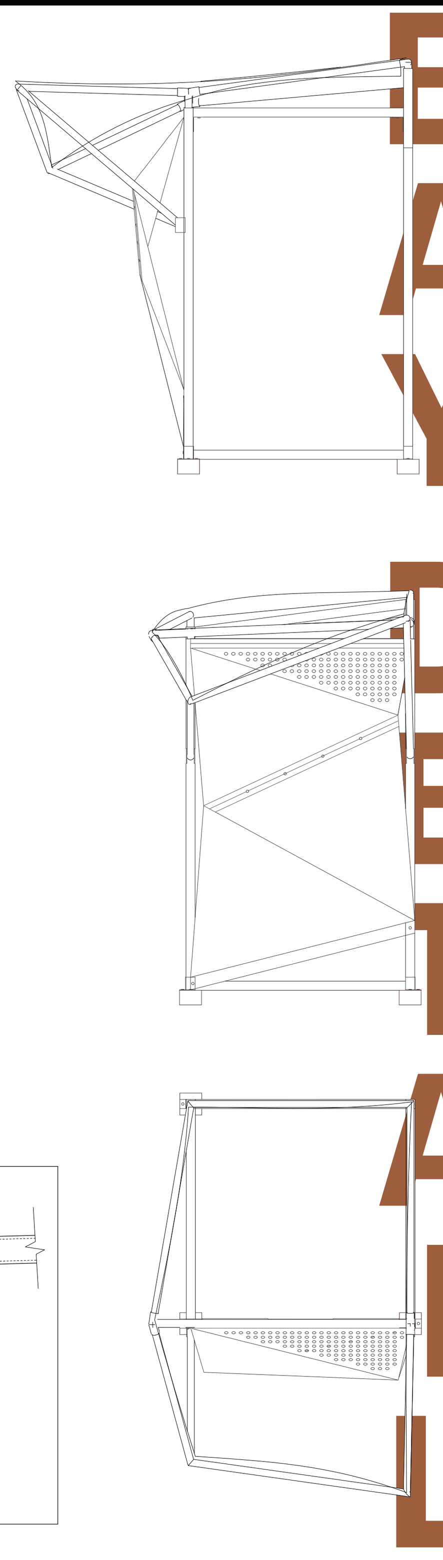
ASSEMBLY



ENTRY BAY

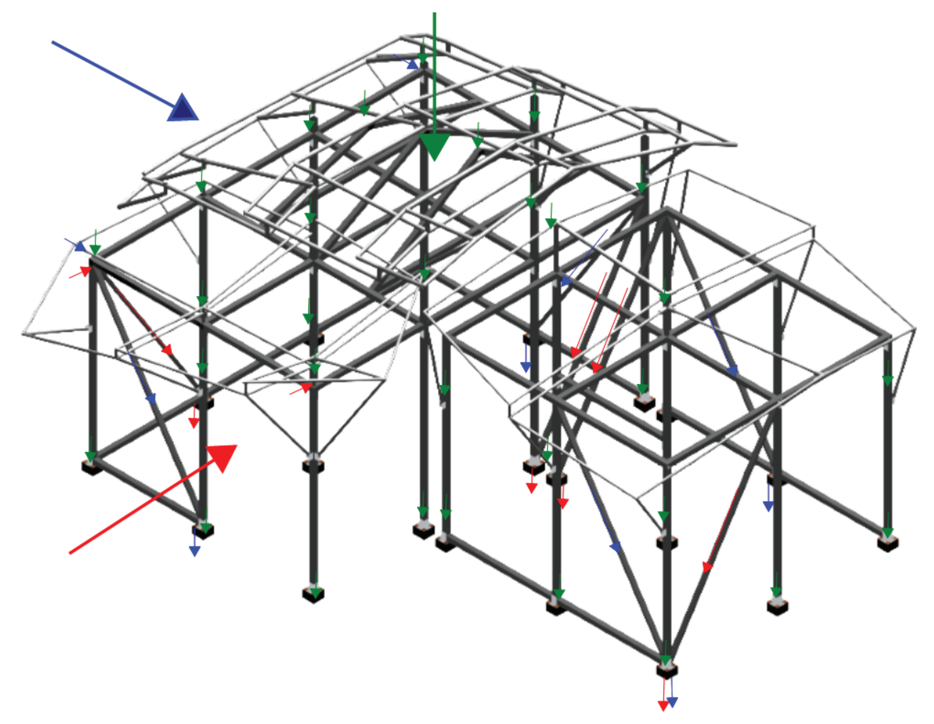
1/2" = 1'-0"



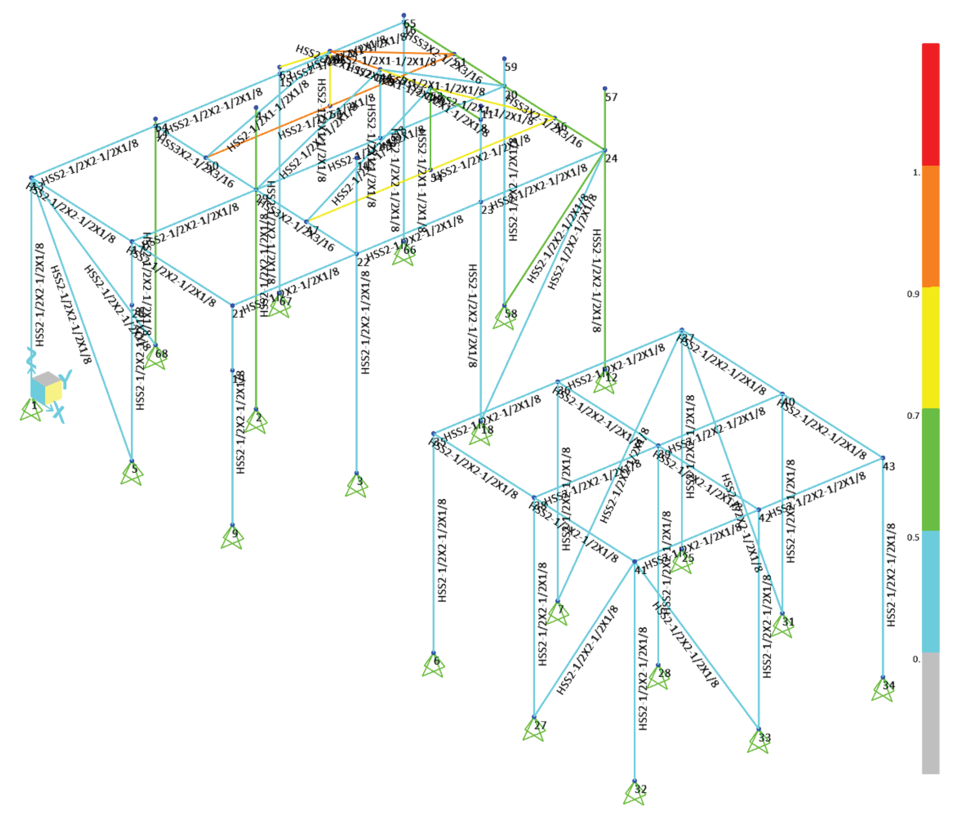


BAY DETAIL

LOAD FLOW DIAGRAM



STRUCTURE ANALYSIS

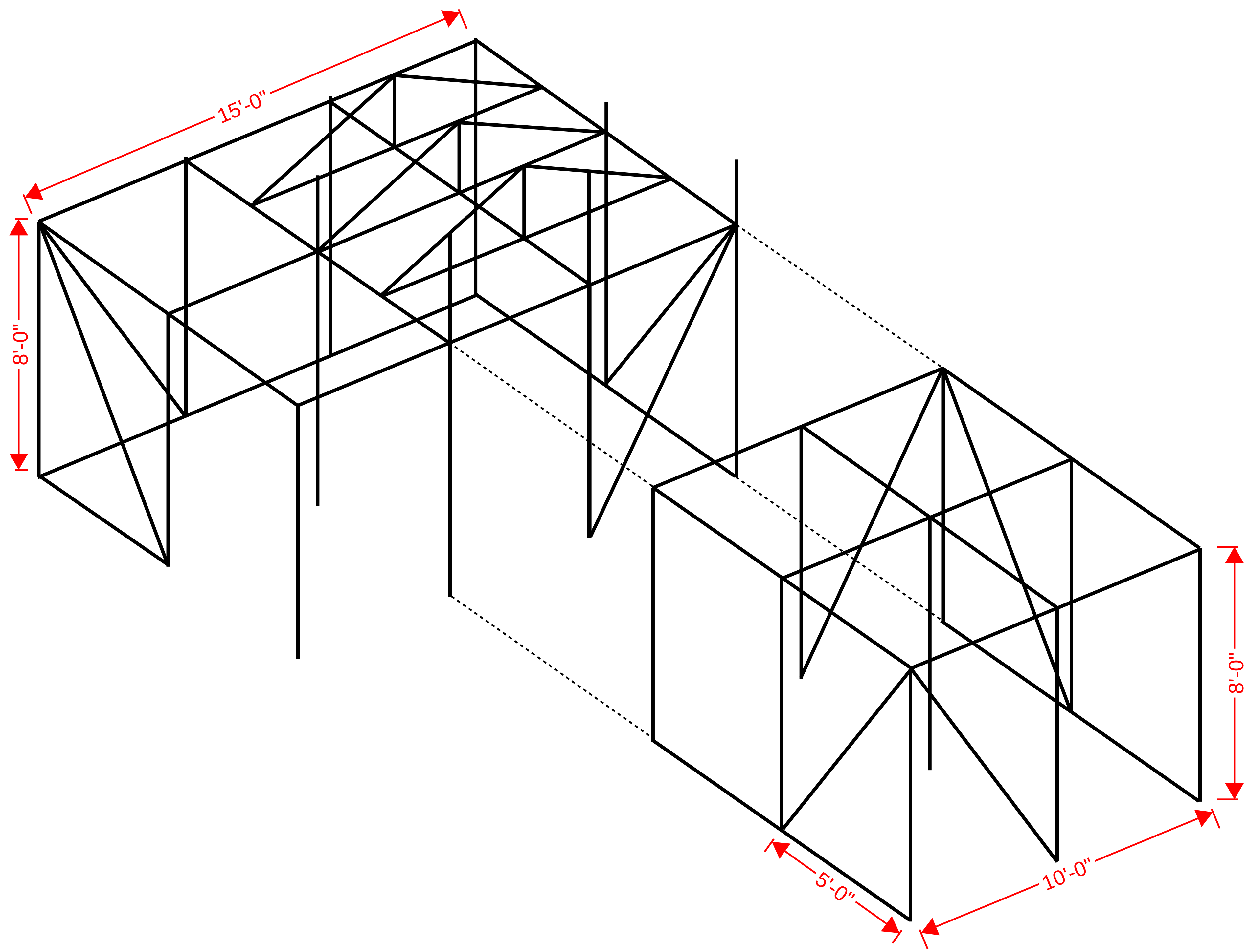


STRUCTURE

Assembly, Transportation and Cost Estimate

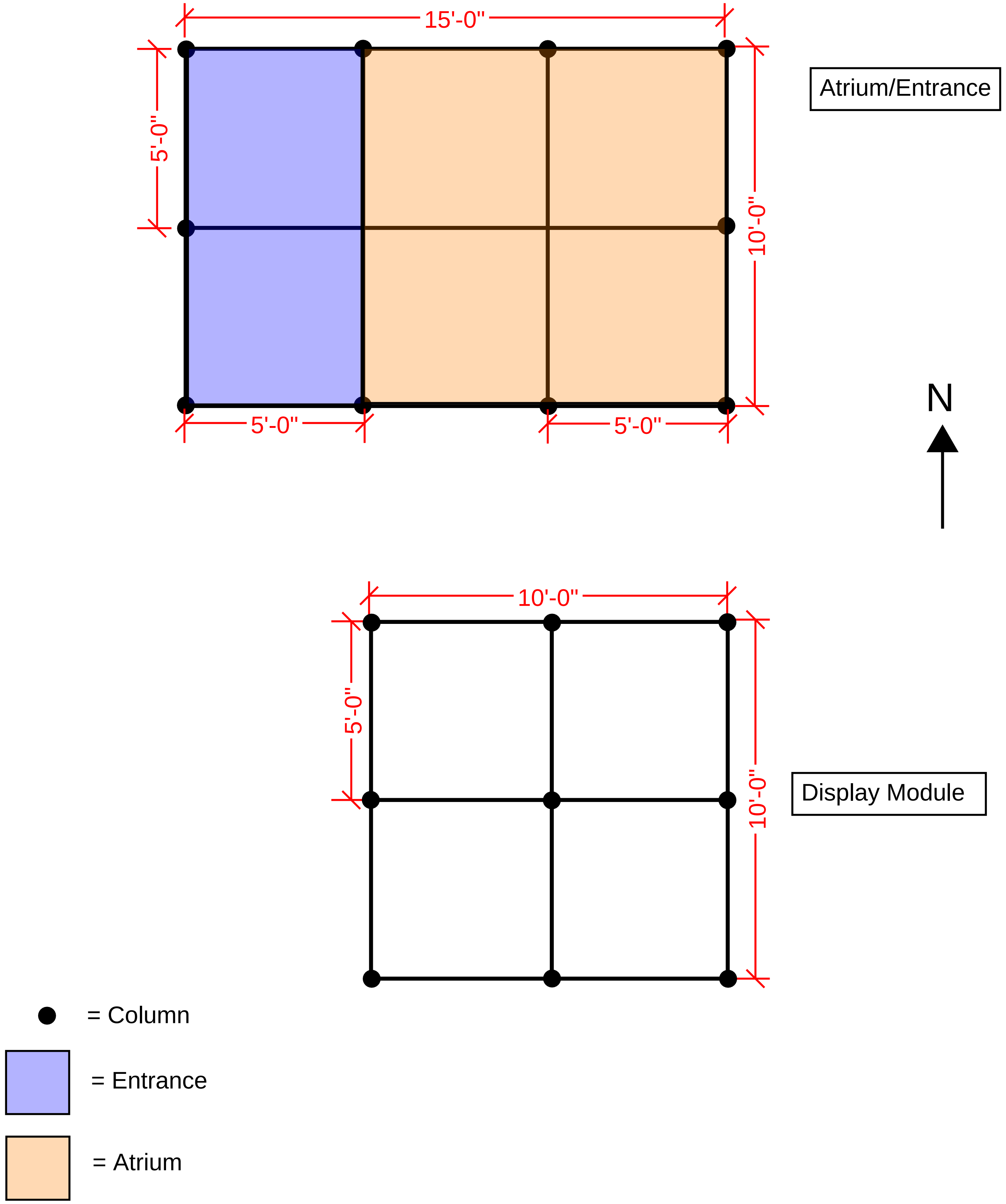
Material	Qty	Supplier	Unit Price	Total Price	Notes/Comments
2-1/2"x2-1/2"x1/8" HSS	447'	B&B	$ 61.00	$ 1,403.00	Sold in 20' Lengths
2-½" x 2-½" x 3/16" HSS	20'	B&B	$ 67.00	$ 67.00	Sold in 20' Lengths
Schedule 40 1-½" Steel Pipe	445'	B&B	$ 50.40	$ 1,108.80	Sold in 21' Lengths
Schedule 40 2" Steel Pipe	20'	B&B	$ 55.00	$ 55.00	Sold in 21' Lengths
20 Gauge Sheet Metal	440 sq ft	B&B	$ 57.00	$ 627.00	Sold in 4x10 sheets
1/8 X 3 Hot Rolled Steel Flat Bar	1	Metals Depot	$ 29.80	$ 29.80	20' Length
Seaman 8421 Architectural Fabric	43 yds	SLO Sail and Canvas	$ 28.00	$ 1,204.00	$28/yard 72" wide roll
Structural bolts A325, Hot dipped galvanized steel, 1/2"-11 x 3"	200	Bolt Depot	$ 81.80	$ 163.60	Bulk Pricing
Structural washers F436, Hot dipped galvanized steel, 1/2"	500	Bolt Depot	$ 62.20	$ 62.20	Bulk Pricing
Structural nuts A194 grade 2H, Hot dipped galvanized steel, 1/2" -11	250	Bolt Depot	$ 59.10	$ 59.10	Bulk Pricing
Hex bolts, Zinc plated steel, 1/2" -18	100	Bolt Depot	$ 7.91	$ 7.91	Bulk Pricing
SAE flat washers, Zinc plated steel, 1/2"	100	Bolt Depot	$ 2.18	$ 2.18	Bulk Pricing
1x8 Oak Board	40 LF	Home Depot	$ 5.92	$ 236.80	Sold per LF
1-1/2 in. x 72 in. Plain Steel Angle with 1/8 in. Thick	1	Home Depot	$ 19.91	$ 19.91	72" Length
			TOTAL	$ 5,046.30	

ISOMETRIC VIEW: HSS STRUCTURAL FRAME

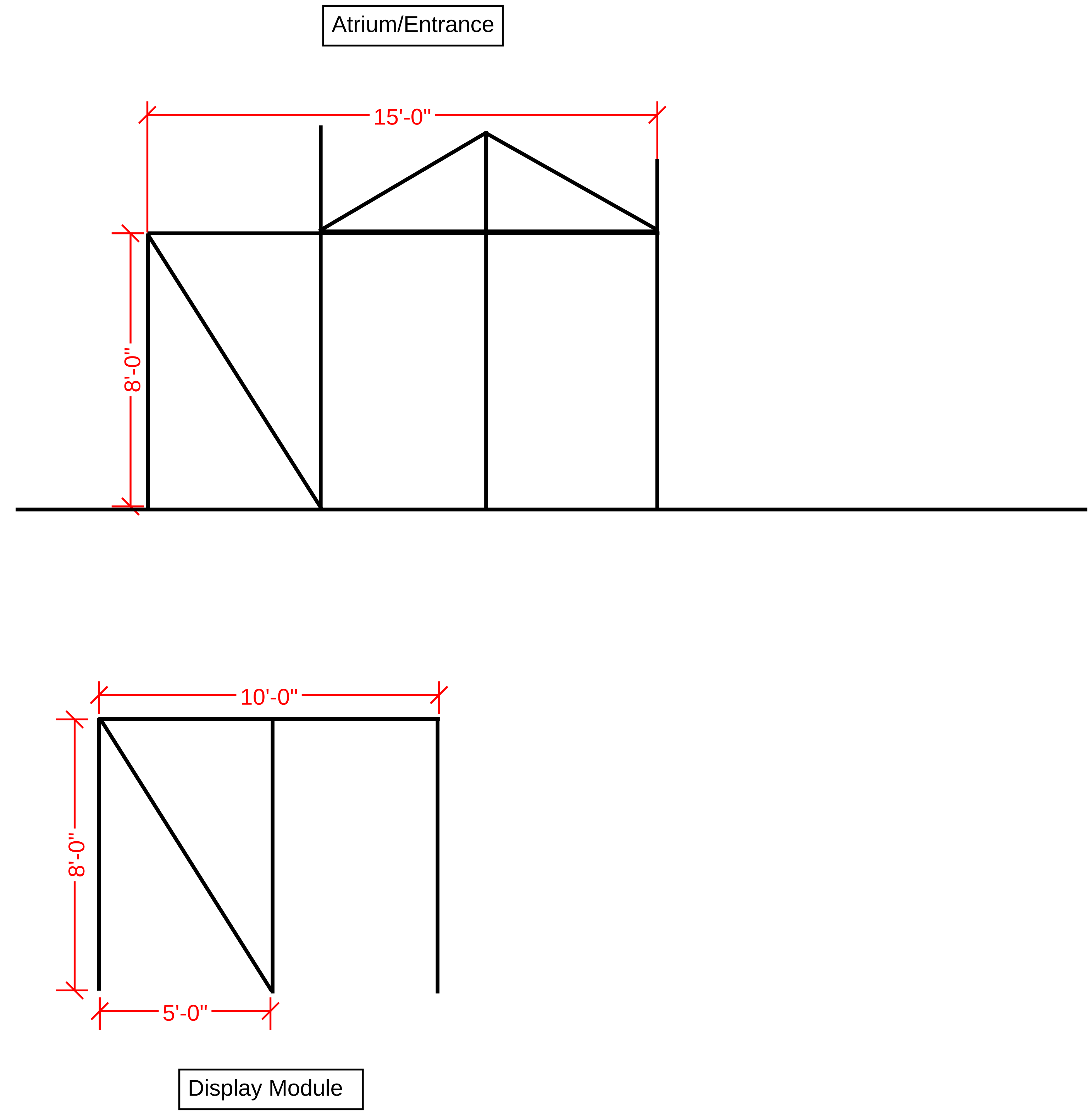


Scale: 1/4" = 1'-0"

TOP/DOWN VIEW



NORTH/SOUTH ELEVATIONS



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

HSS Member Sizes/Weights

15'-0" = 58.5 lbs

10'-0" = 39 lbs

8'-0" = 31.2 lbs

5'-0" = 19.5 lbs

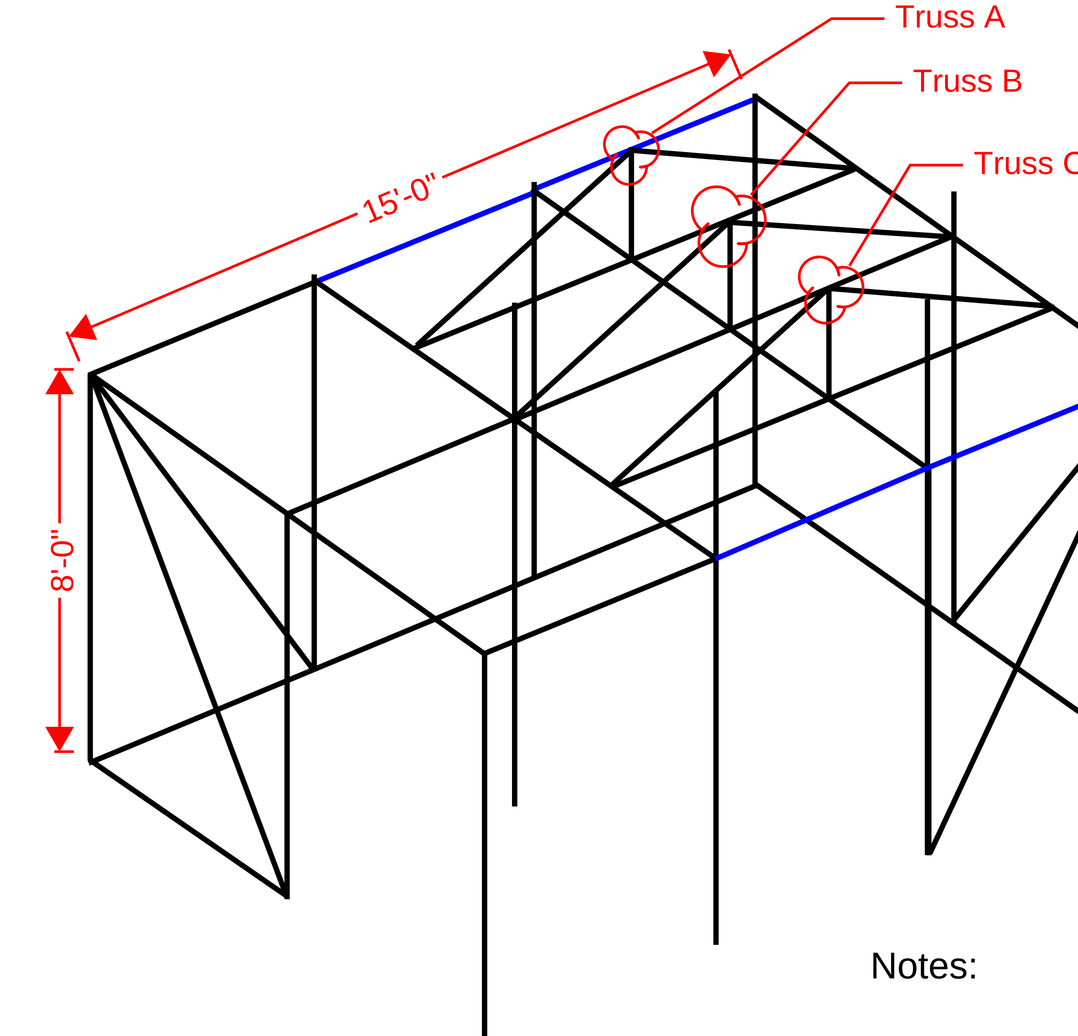
Notes:

2-1/2" x 2-1/2" x 1/8" HSS
Weight: 3.90 lbs/ft

5'-0" = 31.15 lbs

Notes:

Members colored in BLUE are 3" x 2-1/2" x 3/16" HSS
Weight: 6.23 lbs/ft



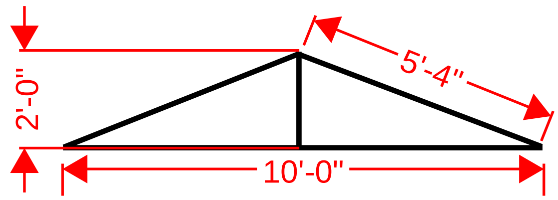
Notes:

Total Weight of HSS: 1135.2 lbs

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

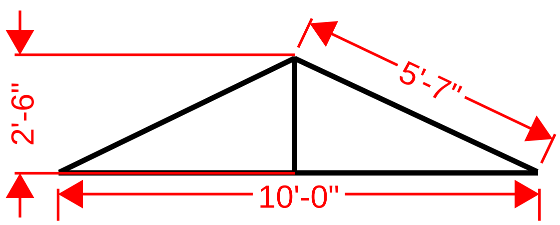
Truss Dimensions/Weight

Truss A



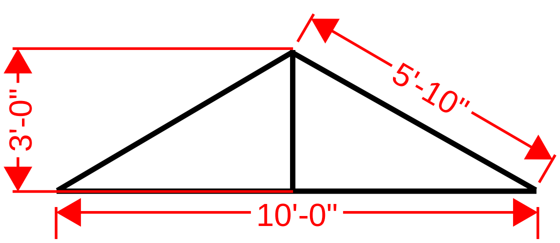
Quantity: 22.67 LF
Weight: 88.4 lbs

Truss B



Quantity: 23.67 LF
Weight: 92.3 lbs

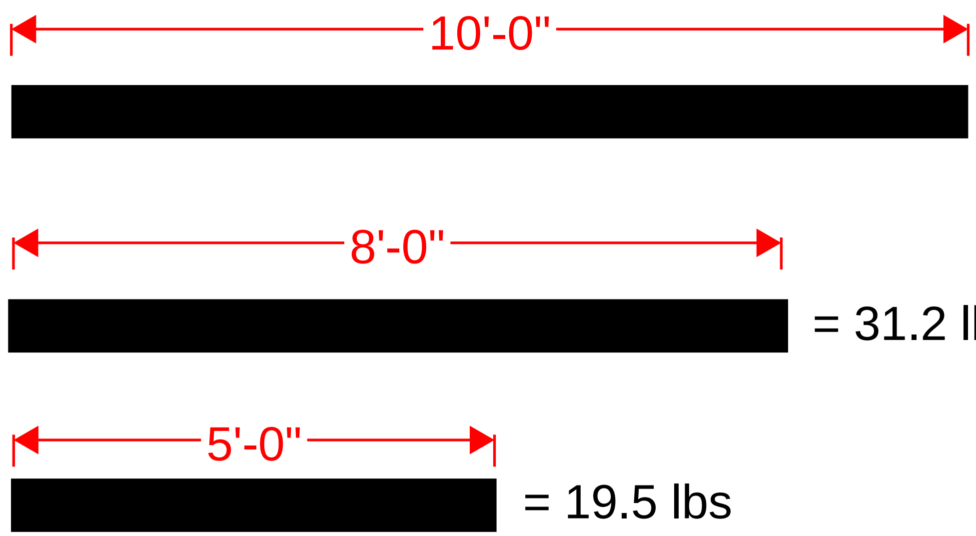
Truss C



Quantity: 24.67 LF
Weight: 96.2 lbs

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

HSS Member Sizes/Weights



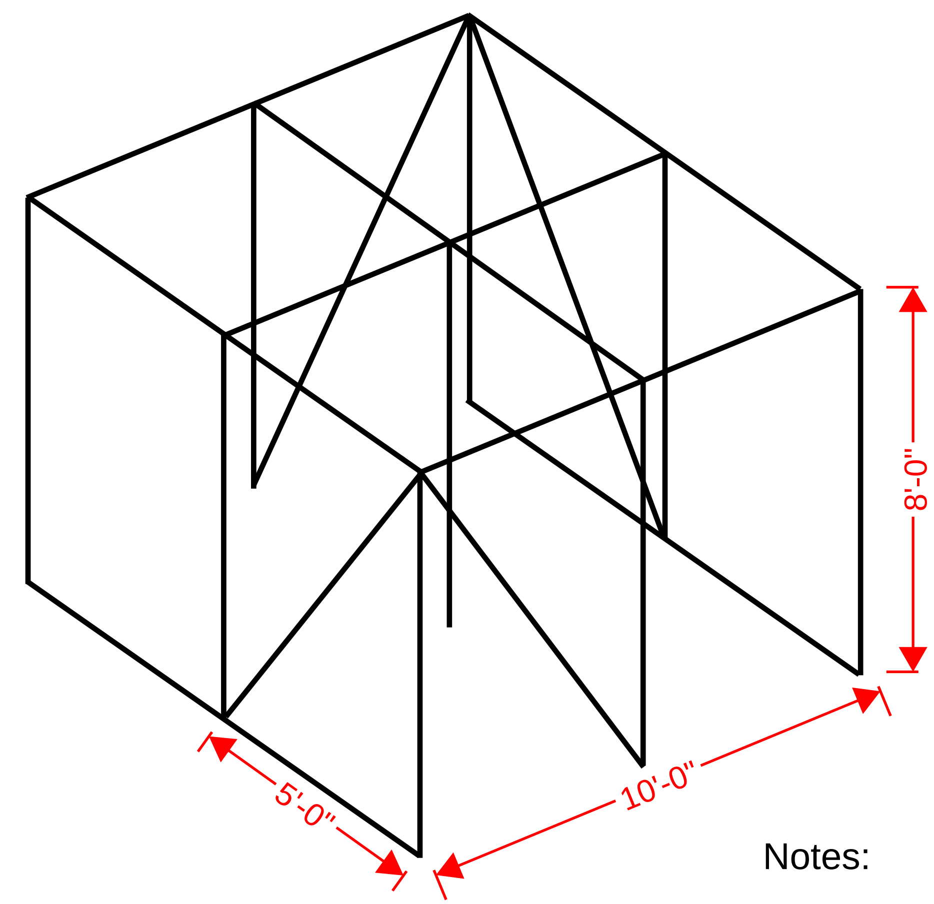
= 39 lbs

= 31.2 lbs

= 19.5 lbs

Notes:

2-1/2" x 2-1/2" x 1/8" HSS
Weight: 3.90 lbs/ft

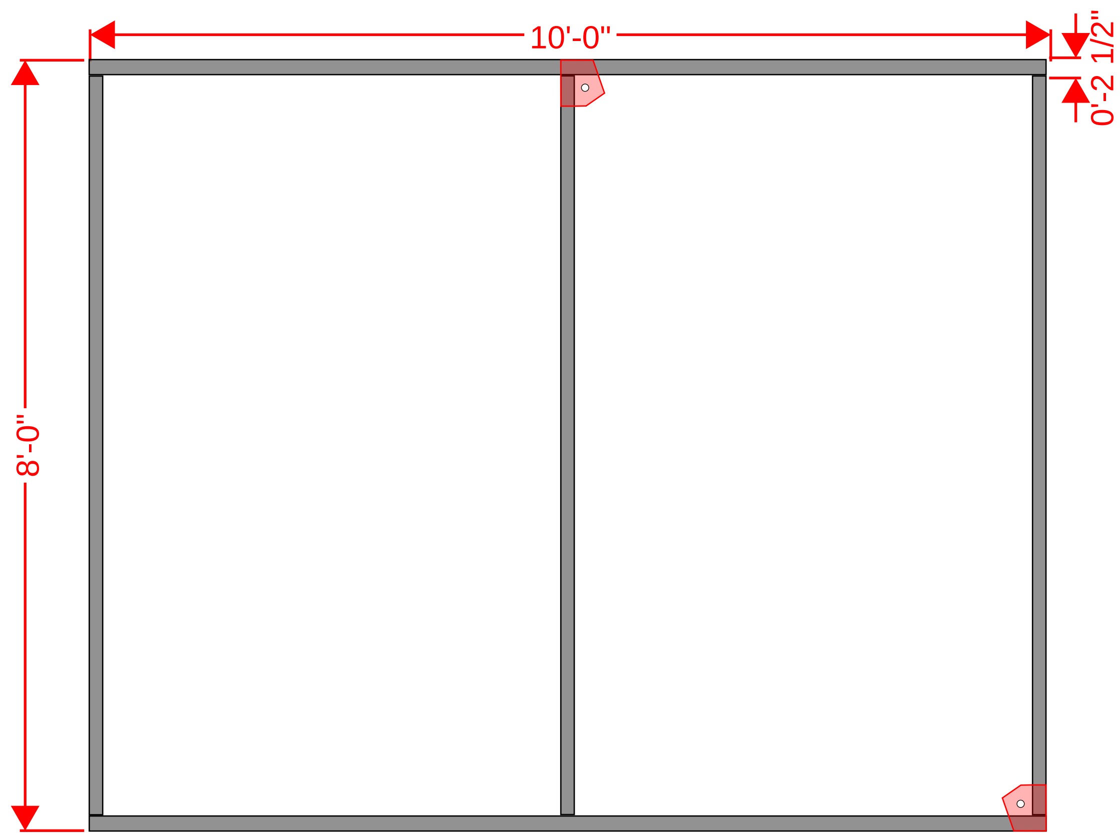


Notes:

Total Weight of HSS: 733.2 lbs

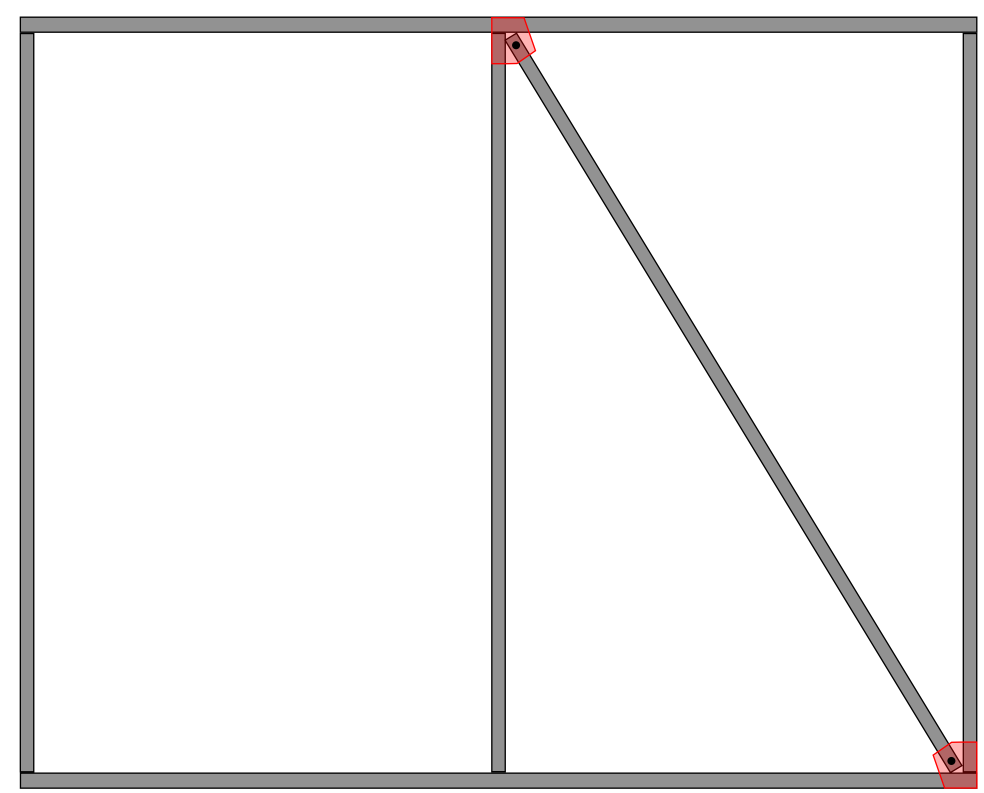
Scale: 1/4" = 1'-0"

Wall Panel Diagram/Portability



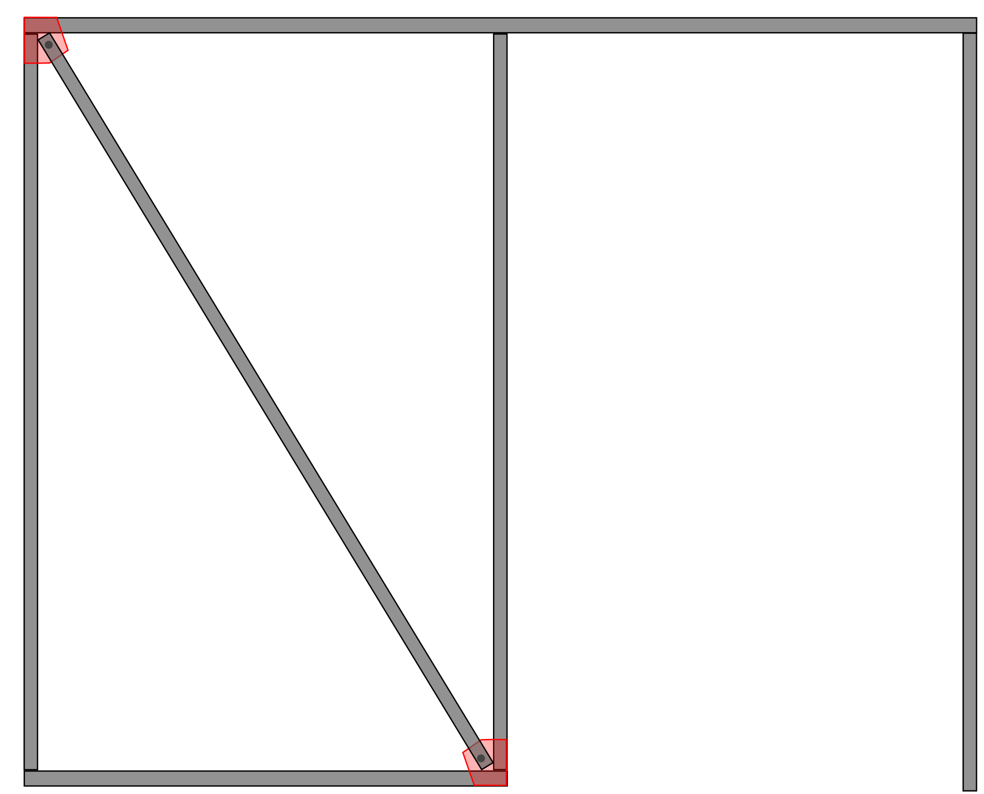
Notes:

- Wall panels will be prefabricated off-site.
- All members will be welded together, if panel requires cross bracing then custom fabricated connecting plates will be welded on.
-During transportation/construction cross brace will be left off until panel is set in place.
- Total weight of wall panel is ~170 lbs, recommended to be carried by 2-3 people,



Notes:

- Final wall panel with cross bracing that will be used to construct the display module.

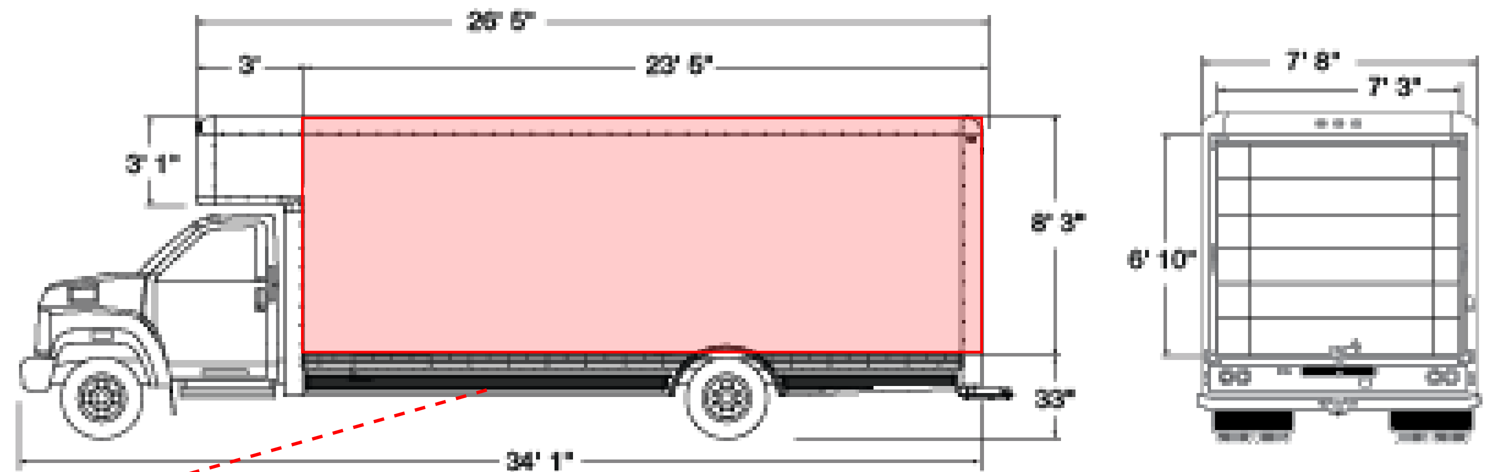


Notes:

- Wall panel that will be used at the entrance to the atrium.

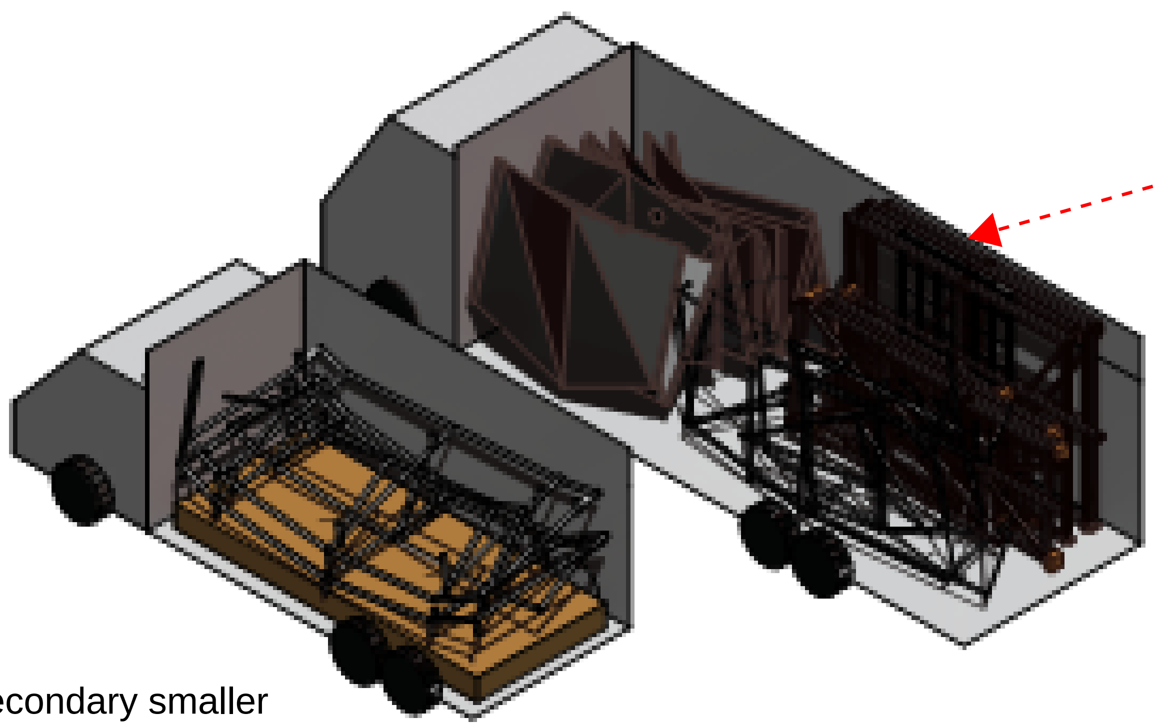
Scale: 1/2" = 1'-0"

Portability Diagram



Interior of Truck Dimensions

Volume: 1,583 cu. ft.
Max Weight: 9,010 lbs



A secondary smaller truck will be needed to transport the remaining prefabricated material.

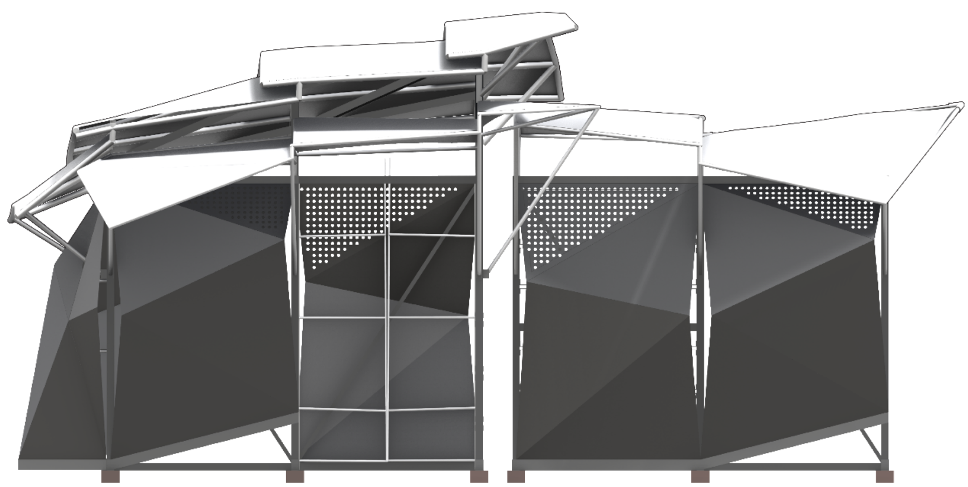
All material is to be strapped down and secured during transportation

Structural Calculation Package for

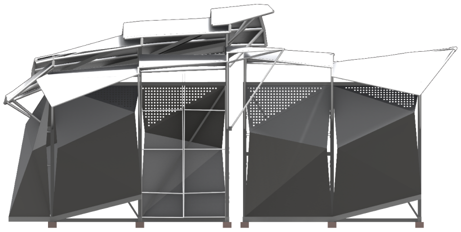
Wine History Project Moving Pavilion: In Bloom

Site 1: Saucelito Canyon Winery Tasting Room

3180 Biddle Ranch Rd, San Luis Obispo, CA 93401



Rachel Jakel



Project: In Bloom
Client: Wine History Project
Calculated by: Rachel Jakel
Date: Dec 6 2019 Sheet No. D1

Table of Contents

Project Description

The Wine History Project documents and preserves the unique food and wine history of San Luis Obispo County. This pavilion made for them will house their exhibits and travel from winery to winery in the San Luis Obispo County. The first site it will see is at the tasting room of Saucelito Canyon Winery. The design of the pavilion stemmed from a biomimetic structure of a mollusk. The use of biomimicry in the design helps it to live and function at any site by adapting the way that a mollusk would. Just as the shell of a mollusk is made up of several different layers of different structure types, In Bloom is made up of two different structures- one that comprises the gravity and lateral force resisting systems as well as an outer shell that provides architectural interest and protection from the elements with that together form the pavilion for the Wine History Project.

The structure itself stands 8 feet tall with protruding architectural elements up to 11 feet with a footprint of 150 square feet for the atrium module and 100 square feet for the optional addition module. The two modules are structurally independent and can be set up according to the needs of the Wine History Project. It is comprised of hollow structural steel for the gravity as well as lateral systems. From site to site the pavilion will be constructed on relatively flat ground and is connected to the ground via pressure treated wood bearing footings with earth anchors.

Design Criteria

1) Codes used:
    - International Building Code 2018
    - American Society of Civil Engineers 7-16
    - American Institute of Steel Construction 360-16
    - National Design Specification for Wood Construction 2015

2) Design Loads:
    - Dead Loads- weights of all materials as shown per calculations
    - Live Loads- uniformly distributed- assumed as 10 psf uninhabitable attic without storage per ASCE 7-16 Table 4.3-1
    - Wind Loads per IBC, Exposure C and wind speed V of 95 mph based off process in ASCE 7-16.

3) Foundation Design:
    - With no geotechnical report provided and soil class unknown, worst case soil bearing pressure of 1000 psf will be used.

Material Criteria

4) Steel
   - For framing members, HSS SQ A500 used for beams columns and braces
   - For canopy members, X-strong pipe
5) Aluminum
   - Auger anchors for foundations
6) Timber
   - Pressure treated lumber for foundation bearing pads.

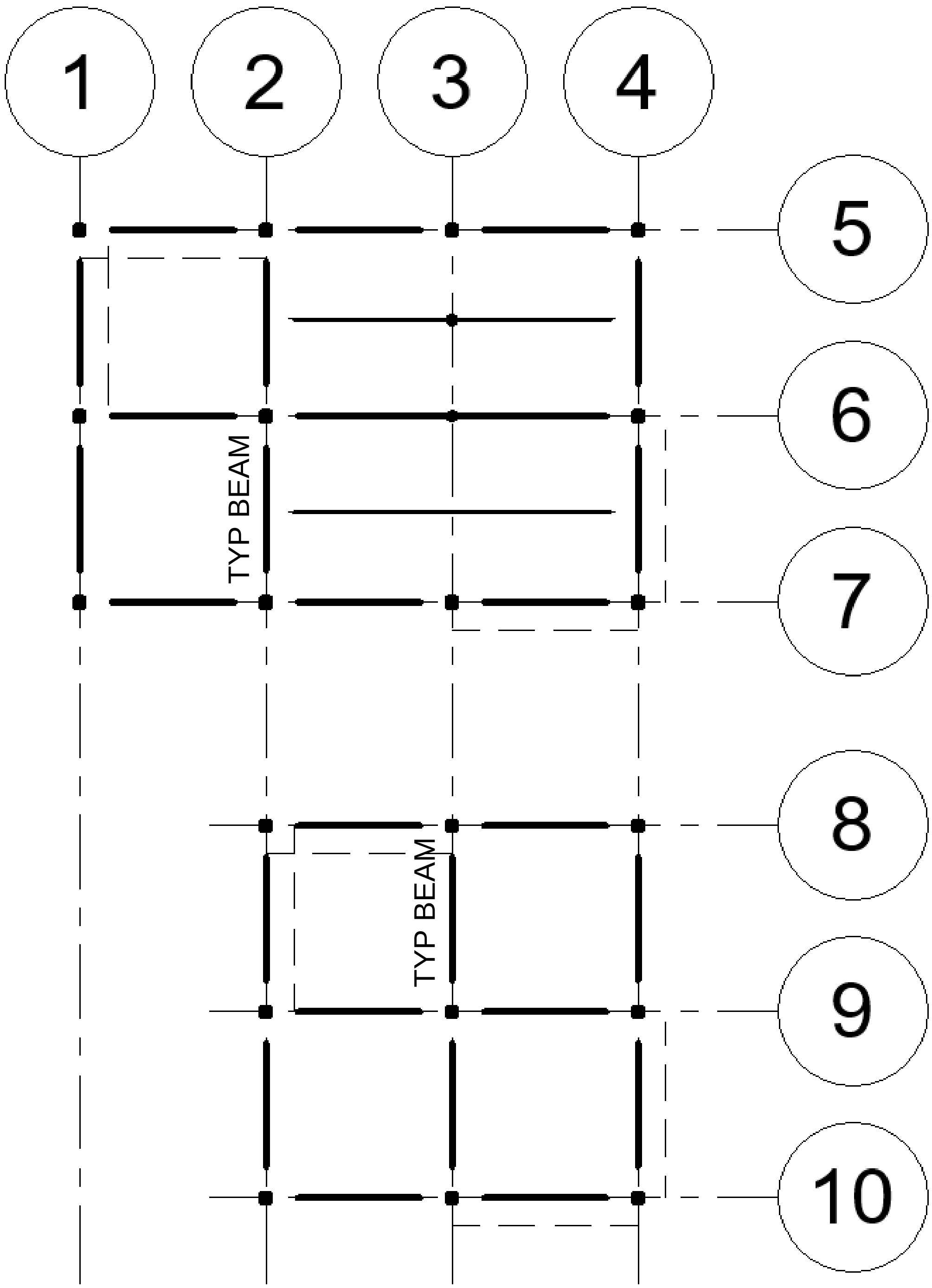
Load Takeoff

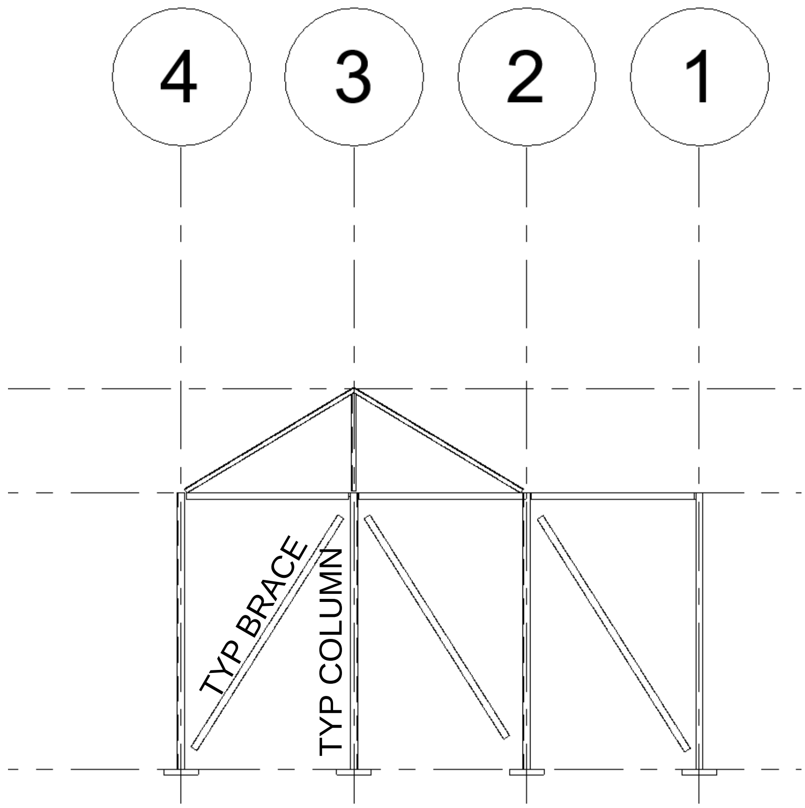
Material	**Weight**
HSS 2.5x2.5x1/8	3.90 plf
Pipe 1 ½ X-strong	3.63 plf
Architectural Fabric	~3psf

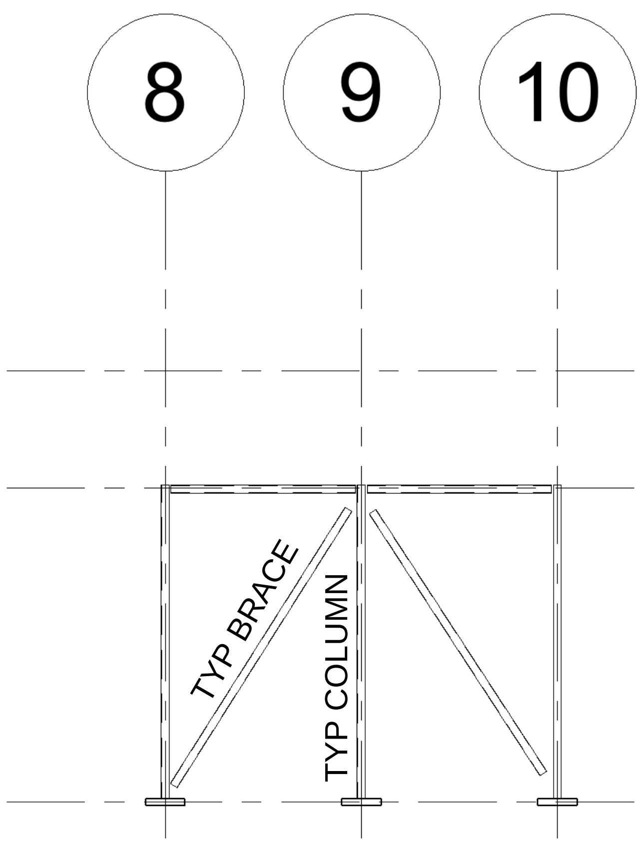
SAP2000 Modeling Criteria

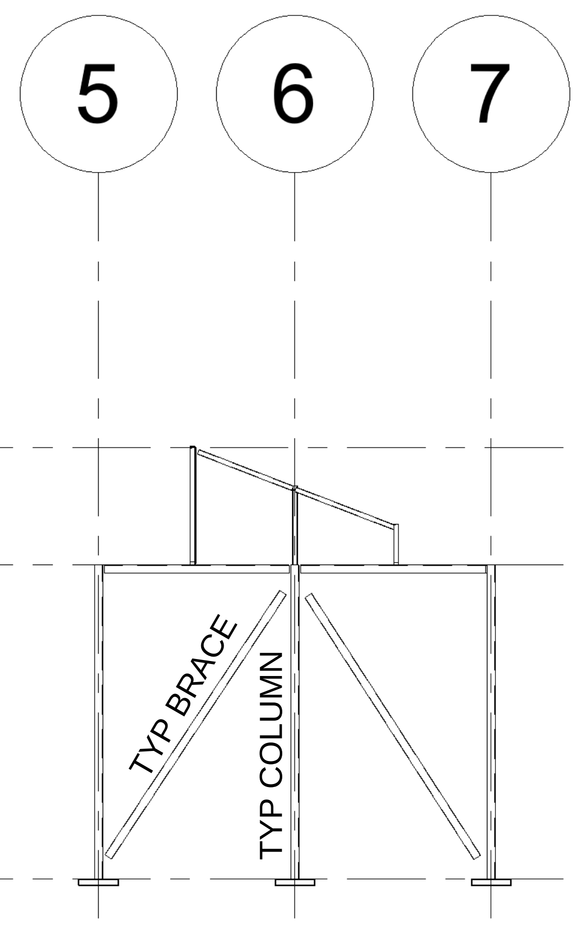
The model uses the same member type throughout and is modeled under worst case conditions and a partially closed wind load. All connections are modeled as pinned though they will have more rigidity when constructed.
Dead loads are applied at worst case conditions and live as uniformly distributed based off of tributary area. Wind load is applied windward, leeward and as uplift pressure. LRFD load combinations were ran for design code checks and ASD combinations were ran for foundation design.

Key Plans



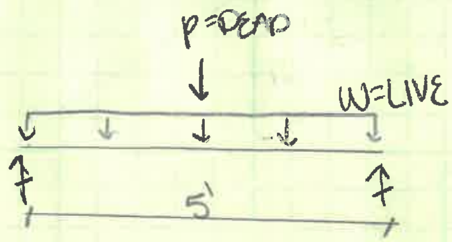

4
3
2
1
TYP BRACE
TYP COLUMN


8
9
10
TYP BRACE
TYP COLUMN


5
6
7
TYP BRACE
TYP COLUMN

Rachel Jakel	In Bloom for WHP	Dec 6 2019

SAMPLE BM CALC



LIVE = 10PSF × 5' TRIB WIDTH
ω = 50PLF

P = 150# CONSERVATIVE LOAD FROM SHELL

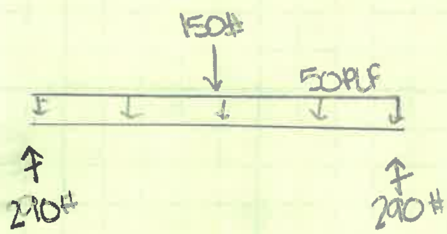
LOAD COMBOS (ASCE 7-16 2.3.1)

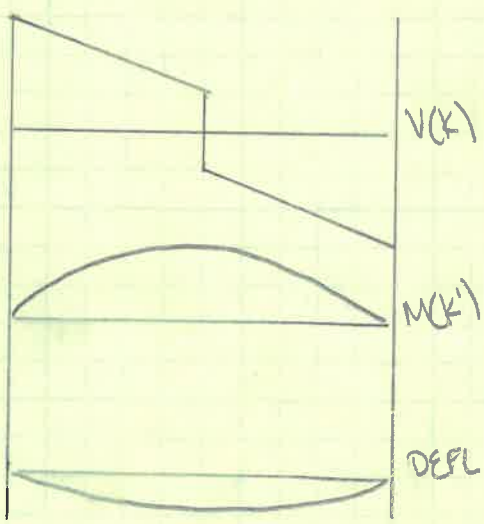
1. 1.4D = 1.4(150) = 210#

2. 1.2D+1.6L = 1.2(150) + 1.6(50 × 5' LENGTH) = 580# ← CONTROLS

[HSS 3×2.5×3/16]

E = 29000 ksi, I = 1.59 in^4





$V_{MAX} = .58^k/2 = \underline{.29k}$

$M_{MAX} = \frac{wL^2}{8} + \frac{PL}{4}$

$1.6\left(\frac{50(5)^2}{8}\right) + 1.2\left(\frac{150(5)}{4}\right)$

$= \underline{.475k' = 5.7k''}$

DEFL (UNFACTORED)

$\frac{5wL^4}{384EI} + \frac{PL^3}{48EI}$

$\frac{5(.0042)(5\times12)^4}{384(29000)(1.59)} + \frac{.15(5\times12)^3}{48(29000)(1.59)}$

$.015 + .015$

$= \underline{.03 in}$

Rachel Jakel	In Bloom for WHP	Dec 6 2019

SAMPLE BM CALC CONT'D

BENDING CHECK:

$\phi M_n = \phi F_y Z$ (AISC 360-10F)

$\phi M_n = (.9)(50ksi)(1.73in^3)$

$\phi M_n = 77.85k'' > 5.7k''$

$\frac{d}{c} = \frac{5.7}{77.85} = .073 < 1.0$ ✓

SHEAR CHECK:

$\phi V_n = \phi_v (.6 F_y A_w C_v)$ (AISC 360-G1)

$\phi V_n = .9(.6)(50ksi)(1.0)(1.71)$

$\phi V_n = 46.17k > .29k$

$\frac{d}{c} = \frac{.29}{46.17} = .0063 < 1.0$ ✓

DEFLECTION CHECK:

ROOF MEMBER NOT SUPPORTING CEILING (IBC 2018 T1604.3)

LIVE

$\Delta_{ALLOW} = l/180 = 5x12/180 = 0.33in$

$\Delta_{ACTUAL} = \frac{5wl^4}{384EI} = .015in$

.015in ACTUAL < .33in ALLOW ✓

DEAD + LIVE

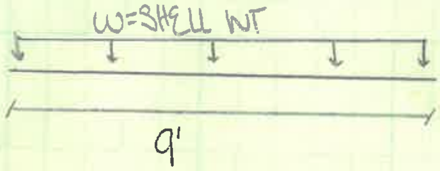
$\Delta_{ALLOW} = l/120 = 5x12/120 = 0.5in$

$\Delta_{ACTUAL} = .03in$

.03in ACTUAL < .5in ALLOW ✓

SHELL CHECK:

P1.5 X-STRONG I = .372

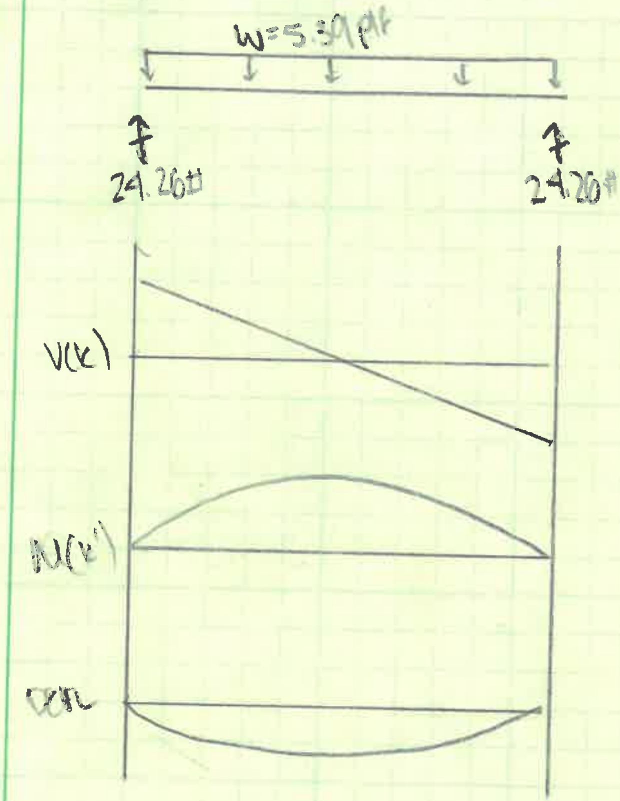


W = WEIGHT OF SHELL (SHEET METAL/ CANVAS) USE SHEET METAL, CONSERVATIVE

W = (2.156 psf)(2.5' TRIB WIDTH)

W = 5.39 plf

L = 9' LENGTH CONSERVATIVE



$V_{max} = 5.39(9')/2 = 24.26\#$

$M_{MAX} = \frac{WL^2}{8} = \frac{5.39(9^2)}{8}$

$= .055\ k'$

$DEFL = \frac{5wl^4}{384EI}$

$\frac{5(.0005 K/i)(9 \times 12)^4}{384(29000 ksi)(.372)}$

$\Delta = .053 in$

Rachel Jakel	In Bloom for WHP	Dec 6 2019

SHELL CHECK CONT'D:

BENDING:

$\phi M_n = \phi F_y Z$ (AISC 360 -10F)

$\phi M_n = .9(35ksi)(.549in^3)$

$\phi M_n = 17.29 k'' = 1.44k' > .055k'$

$\frac{d}{C} = \frac{.055k'}{1.44k'} = .04 < 1.0$ ✓

SHEAR:

$\phi V_n = \phi_v(.6F_y A_w C_v)$ (AISC 360-G1)

$\phi V_n = .9(.6)(35ksi)(1.0in^2)(1.0)$

$= 18.9k > .024k$

$\frac{d}{C} = \frac{.024k}{18.9k} = .001 < 1.0$ ✓

DEFLECTION CHECK:

DEAD+LIVE (IBC 2018 T1604.3)

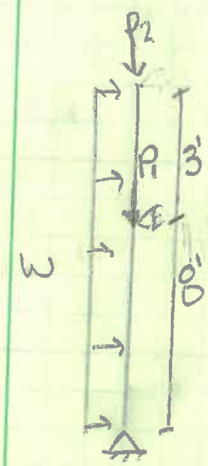
$\Delta_{ALLOW} = l/120 = 9x12/120 = 0.9in$

$\Delta_{ACTUAL} = 0.53in$

.53in ACTUAL < .9in ALLOW ✓

Rachel Jakel	In Bloom for WHP	Dec 6 2019

SAMPLE COLUMN CHECK



W = WIND = 18.53 PSF (5' TRIB WIDTH) = 92.65 PLF

P = LIVE = 10PSF (5'x5' TRIB AREA) = 250#
DEAD = 150/2 = 75#

↳ LOAD COMBO #2 CONTROLS R_{BM} = 290# (SEE BM CALC R)
P_1 = 4 BMS x 290 = 1160#

P_2 = 150 # CONSERVATIVE LOAD FROM SHELL

HSS 2½ x 2½ x ⅛

COMBINED AXIAL & BENDING (AISC 360 CH H)

$\frac{P_r}{P_c} = \frac{1.31k}{12.9k}$ ← (AISC 360 T4-4) = 0.1 < .2

$M_{MAX} = \frac{wl^2}{8} = \frac{92.65(11)^2}{8} = 1.4k' = 16.82k''$

V_{MAX} = .701 k

A_{MAX} = 1.31 k

Rachel Jakel | In Bloom for WHP | Dec 6 2019

SAMPLE COLUMN CHECK CONT'D

$\frac{P_r}{P_c} < 0.2$ (USE AISC EQN H1-1b)

$\frac{P_r}{2P_c} + \left(\frac{M_r}{M_c}\right) \leq 1.0$

$\frac{1.31}{2(12.9)} + \frac{16.82k''}{3.55k'' \times 12^{in/ft}}$ ← AISC T3-13

$= 0.45 < 1.0$ ✓

LATERAL WIND LOADS

PARTIALLY ENCLOSED BLDG, LOW RISE BLDG h<60'

ASCE 7-16 CH 28

1. RISK CATEGORY: II (ASCE 7-16 T1.5-1)
2. BASIC WIND SPEED V=95MPH (ASCE 7-16 FIG 26.5-1B)
3. EXPOSURE CATEGORY: C (ASCE 26.7)

   TOPOGRAPHIC FACTOR K_{zt}: 1.0 (FLAT) (ASCE 7-16 26.8.1)

   ENCLOSURE: PARTIALLY ENCLOSED → HIGH INTERNAL PRESSURE (ASCE 26.13-1)

   WIND DIRECTIONALITY K_d: .85 (ASCE 7-16 T.26.6-1)

   GROUND ELEVATION FACTOR K_e: 1 (ASCE 7-16 26.9)

   INTERNAL PRESSURE COEFFICIENT GC_{pi}: ±.55 (ASCE 7-16 T26.13-1)

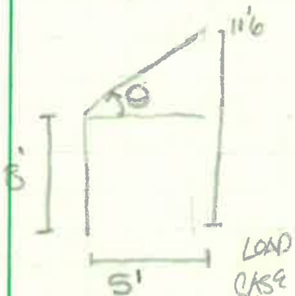
4. VELOCITY PRESSURE EXPOSURE COEFFICIENT K_h/K_z: .85 (ASCE 7-16 T26.10-1)
5. VELOCITY PRESSURE q_z/q_h: (ASCE 7-16 EQN 26.10-1)

$$q_z = .00256 K_z K_{zt} K_d K_e V^2 \ (\#/ft^2)$$

$$= .00256(.85)(1)(.85)(1.0)(95)^2$$

$$= \underline{16.69 \ \#/ft^2}$$

6. EXTERNAL PRESSURE COEFFICIENT GC_p: (ASCE 7-10 FIG 28.3-1)



$\theta = 35°$

BLDG SURFACE

	1	2	3	4	1E	2E	3E	4E
LOAD CASE A	.56	.21	-.43	-.37	.69	.27	-.53	-.48

BLDG SURFACE

	1	2	3	4	5	6	1E	2E	3E	4E	5E	6E
LOAD CASE B	-.45	-.69	-.37	-.45	.4	-.29	-.48	-1.07	-.53	-.48	.61	-.43

7. WIND PRESSURE p (ASCE 7-16 EQN 28.3-1)

$p = q_h(GC_{pf} - GC_{pi})$ #/ft²

$p_1 = 16.69(.56 + .55) = 18.53$ psf
$p_2 = 16.69(.21 + .55) = 12.68$ psf
$p_3 = 16.69(-.43 - .55) = -16.36$ psf
$p_4 = 16.69(-.37 - .55) = -15.35$ psf

} LOAD CASE A

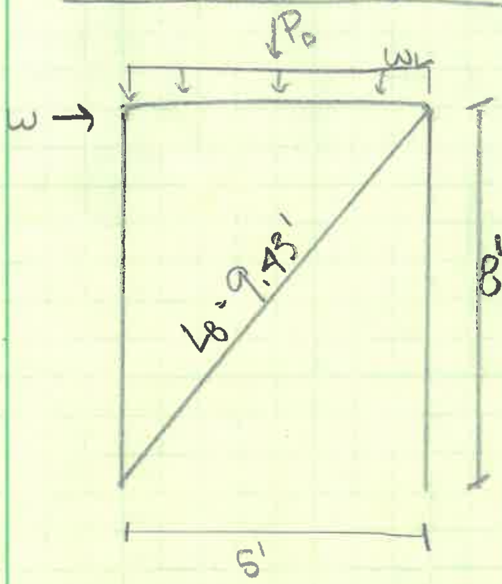
$p_1 = 16.69(-.45 - .55) = -16.69$ psf
$p_2 = 16.69(-.69 - .55) = -20.69$ psf
$p_3 = 16.69(-.37 - .55) = -15.35$ psf
$p_4 = 16.69(-.45 - .55) = -16.69$ psf
$p_5 = 16.69(.40 + .55) = 15.85$ psf
$p_6 = 16.69(-.29 - .55) = -14.02$ psf

} LOAD CASE B

* P NOT TO BE LESS THAN 16 psf ON WALLS & 8PSF ON ROOF
(ASCE 7-16 28.3.4)

Rachel Jakel	In Bloom for WHP	Dec 6 2019

SAMPLE BRACE CALCULATION



$W = 18.53\ PSF\ (5' \times 8') = \underline{741.2\ \#}$

$F_{BRACE} = \frac{W}{5} = \frac{F_B}{9.43}$

$\underline{F_B = 1.4K}$ T & C FOR W BOTH DIRECTIONS

$P_D = 150\#$ (FROM BM CALCS)

$W_L = 50PLF$ (FROM BM CALCS)

LOAD COMBOS (ASCE 7-16 2.3.1)

4. $1.2D + 1.0W + 1.0L = 1.2(^{.15}/_2) + 1.4k + .05(2.5') = \underline{1.52k\ (C)}$

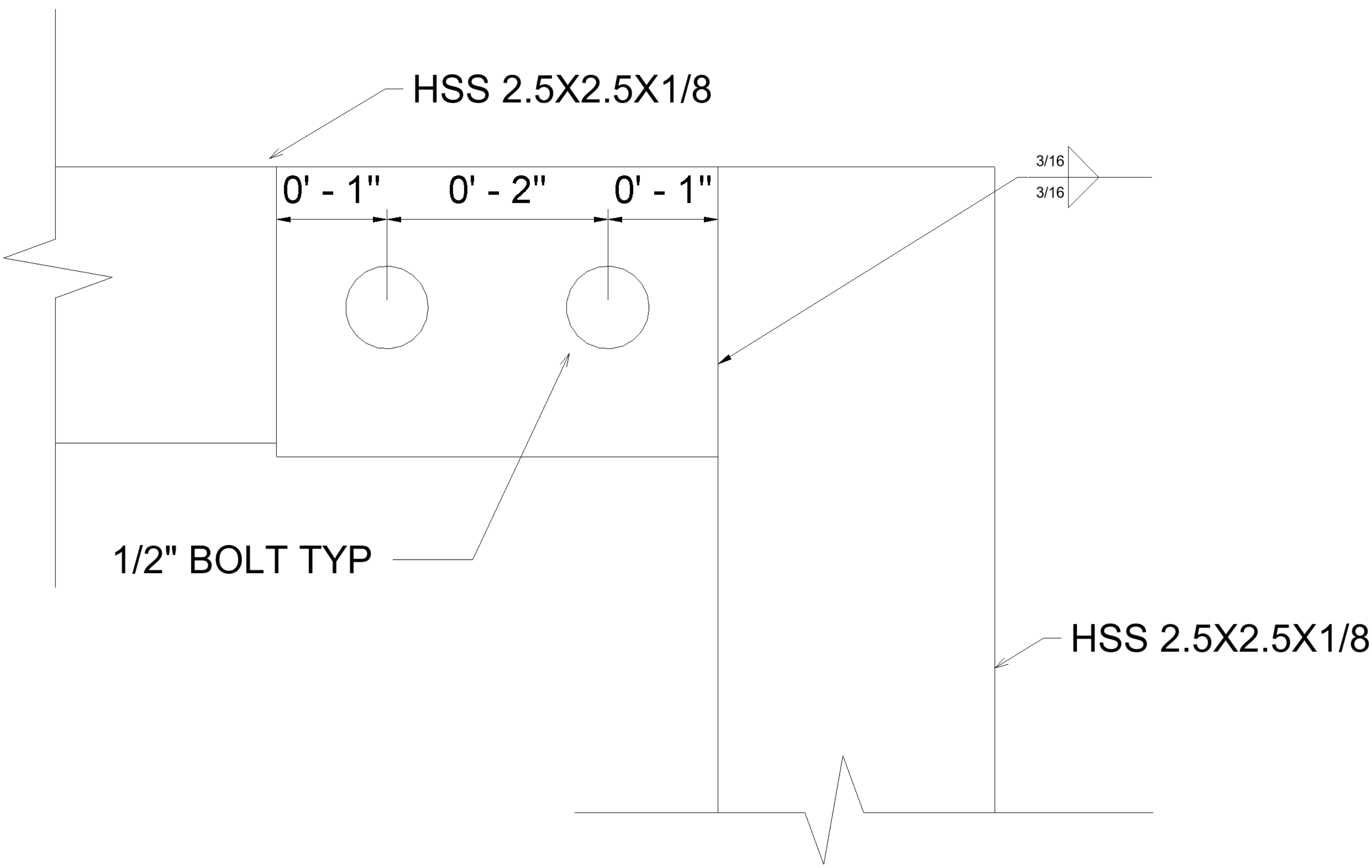
$1.2(^{.15}/_2) - 1.4k + .05(2.5') = -\underline{1.29k\ (T)}$

$P_U = 1.52k$ C CONTROLS

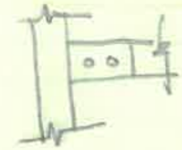
$\phi P_n = 15.6K$ CONSERVATIVE @ 10' (AISC 360 T4-4)

$\frac{d}{c} = \frac{1.52}{15.6} = \underline{.1 < 1.0} \checkmark$

BEAM TO COLUMN DETAIL



BEAM TO COL CONNECTION:



RXN FROM BM → SEE BM CALS (WORST CASE)

$R_B = 150\#$

RUPTURE ON HSS:

$\phi R_n = \phi .6 F_u A_{nv}$ (AISC EQN J4-4)

$.75(.6)(62)(2.5 - (1/2 + 1/8))(.116)$

$\phi R_n = 6.07k > .15k$

$d/c = \frac{.15}{6.07} = .024 < 1.0$ ✓

YIELD ON HSS:

$\phi R_n = \phi .6 F_y A_g$

$(1.0)(.6)(50)(2.5)(.116)$

$\phi R_n = 8.7k$

$d/c = .15k/8.7k = .02 < 1.0$ ✓

RUPTURE ON FLANGE

$\phi R_n = \phi .6 F_u A_{nv}$

$.75(.6)(58ksi)(2.5 - (1/2 + 1/8))(.125)$

$\phi R_n = 6.12k$ $d/c = \frac{.15}{6.12} = .025 < 1.0$ ✓

YIELD ON FLANGE

$\phi R_n = \phi F_y A_{gv} .6$

$1.0(.6)(36ksi)(2.5)(.125)$

$\phi R_n = 6.75k$

$d/c = .15/6.75 = .02 < 1.0$ ✓

BEAM TO COL CONT'D

BEARING:

DIMENSIONAL LIMITATIONS PER AISC CH 10

$L_{EH} \geq 2d = 2(1/2) = 1 \text{ in}$

$L_{EH} = 1 \text{ in}$

$t_p \leq \frac{d_{bolt}}{2} + 1/16 = 1/2 / 2 + 1/16 = .3125$

1/8" PL .125 < .3125 ✓

BEARING OF BOLT ON SHEAR TAB:

AISC EQ J3-6A

$\phi R_n = \phi 2.4 d t F_u$ ← SHEAR TAB SMALLER THAN HSS, CONTROLS

$= .75(2.4)(1/2)(1/8)(58 \text{ ksi})$

$\phi R_n = 65.25 \text{ k}$ $d/c = .15/65.25 = .002 < 1.0$ ✓

WELD: (FILLET STRENGTH)

$\phi R_n = \phi F_{nw} A_{we}$ (AISC J2.4)

$.75(.707)(1/16")(1.0)(.6)(70 \text{ ksi})$

$\phi R_n = 1.392 \text{ k/in}/\frac{1}{16}"$ OF FILLET

USE MIN 3/16" WELD $\phi R_n = 1.392(3)(2.5 \text{ long}) = 10.44 \text{k}$

3/16" WELD 2.5" LONG

Rachel Jakel	In Bloom for WHP	Dec 6 2019

BEAM TO COL CONN'D:

WELD CONN'D:

IN DIRECTION OF LOADING →

YIELD:

$\phi R_n = \phi F_{nBm} A_{Bm}$

$= 1.0(.6F_y)(t_L)$

$= 1.0(.6)(36ksi)(1/8")(2.5)$

$\phi R_n = 6.75k$ $d/c = .15/6.75 = .02 < 1.0$ ✓

RUPTURE:

$\phi R_n = \phi F_{nBm} A_{Bm}$

$= .75(.6)(58ksi)(1/8")(2.5")$

$\phi R_n = 8.156k$ $d/c = .15/8.156 = .02 < 1.0$ ✓

GRAVITY ON WELD ↓, SHEAR

A36 1/8" PL SHEAR TAB

YIELD:

$\phi R_n = .6F_y A_{Bm}$

$= .6(36\ ksi)(2.5")(.125")$

$\phi R_n = 6.75k$ $d/c = .15/6.75k = .02 < 1.0$ ✓

RUPTURE:

$\phi R_n = .75(.6)(58\ ksi)(2.5")(.125")$

$\phi R_n = 8.156k$ $d/c = .15/8.156 = .02 < 1.0$ ✓

Rachel Jakel | In Bloom for WHP | Dec 6 2019

BEAM TO COL CONN'D

1/2" BOLT IN SHEAR (A307)

$\phi R_n = \phi F_n A_b$

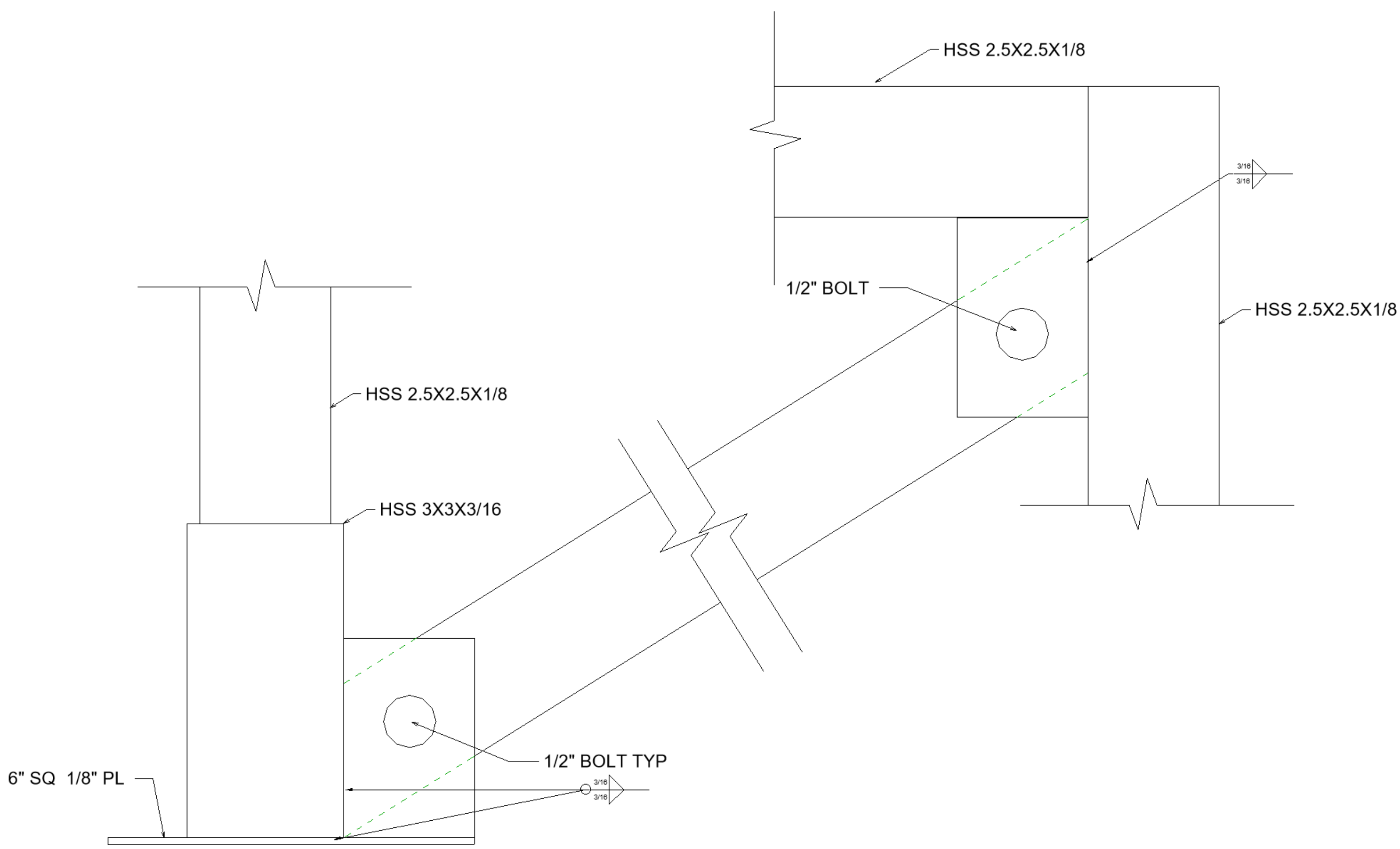
$.75(27ksi)(\pi)(1/2 / 2)^2$

$\phi R_n = 3.98k$ $d/c = .15/3.98 = .04 \leq 1.0$ ✓

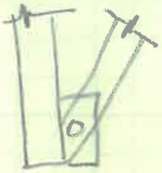
1/2" A307 BOLT IN 2 1/2 x 2 1/2 x 1/8 HSS W/ 1/8 PL OKAY ✓

1 BOLT SUFFICIENT, USE TWO TO CREATE A MORE RIGID CONNECTION

BRACE DETAIL



BRACE CONNECTION:



FROM BRACE CALC

$F_b = 1.4k \quad \theta = \tan^{-1}(8/5) = 58°$

$F_x = 1.4\cos 58 = .74k$

$F_y = 1.4\sin 58 = 1.19k$

CHECK BOLT FOR SHEAR:

RUPTURE ON HSS: (AISC EQN J4.4)

$\phi R_n = \phi .6 F_u A_{nv}$

$= .75(.6)(62)(2.5 - (1/2 + 1/8))(.116)$

$\phi R_n = 6.07k \quad d/c = 1.4/6.07 = .23 < 1.0$ ✓

YIELD ON HSS:

$\phi R_n = \phi .6 F_y A_g$

$1.0(.6)(50ksi)(2.5)(.116)$

$\phi R_n = 8.7k \quad d/c = 1.4/8.7 = .16 < 1.0$ ✓

RUPTURE ON FLANGE:

$\phi R_n = \phi .6 F_u A_{nv}$

$(.75)(.6)(58ksi)(2.5 - (1/2 + 1/8))(.125)$

$\phi R_n = 6.12k \quad d/c = 1.4/6.12 = .23 < 1.0$ ✓

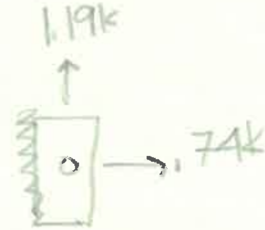
YIELD ON FLANGE:

$\phi R_n = \phi .6 F_y A_{gv}$

$(1.0)(.6)(36ksi)(2.5)(.125")$

$\phi R_n = 6.75k \quad d/c = 1.4/6.75 = .21 < 1.0$ ✓

BRACE CONNECTION CONT'D



WELD:

FILLET WELD STRENGTH

$\phi R_n = \phi F_{nw} A_{we}$ (AISC J2.4)

$\Rightarrow \phi R_n = 10.44k$ FOR 3/16" FILLET WELD 2.5" LONG

↳ SEE BM TO COL FOR FULL CALC

IN DIRECTION OF LOADING →

YIELD

$\phi R_n = \phi F_n B_m A_{BM}$

$(1.0)(.6)(36ksi)(1/8")(2.5)$

$\phi R_n = 6.75 > .74k$ $\quad d/c = \frac{.74}{6.75} = .11 < 1.0$ ✓

RUPTURE

$\phi R_n = \phi F_n B_m A_{BM}$

$.75(.6)(58ksi)(1/8")(2.5")$

$\phi R_n = 8.156k > .74k$ $\quad d/c = .74/8.156 = .1 < 1.0$ ✓

SHEAR, GRAVITY ON WELD ↓

FLANGE PLATE A36 1/8" PL

YIELD

$\phi R_n = .6 F_y A_{BM}$

$= .6(36ksi)(2.5")(.125")$

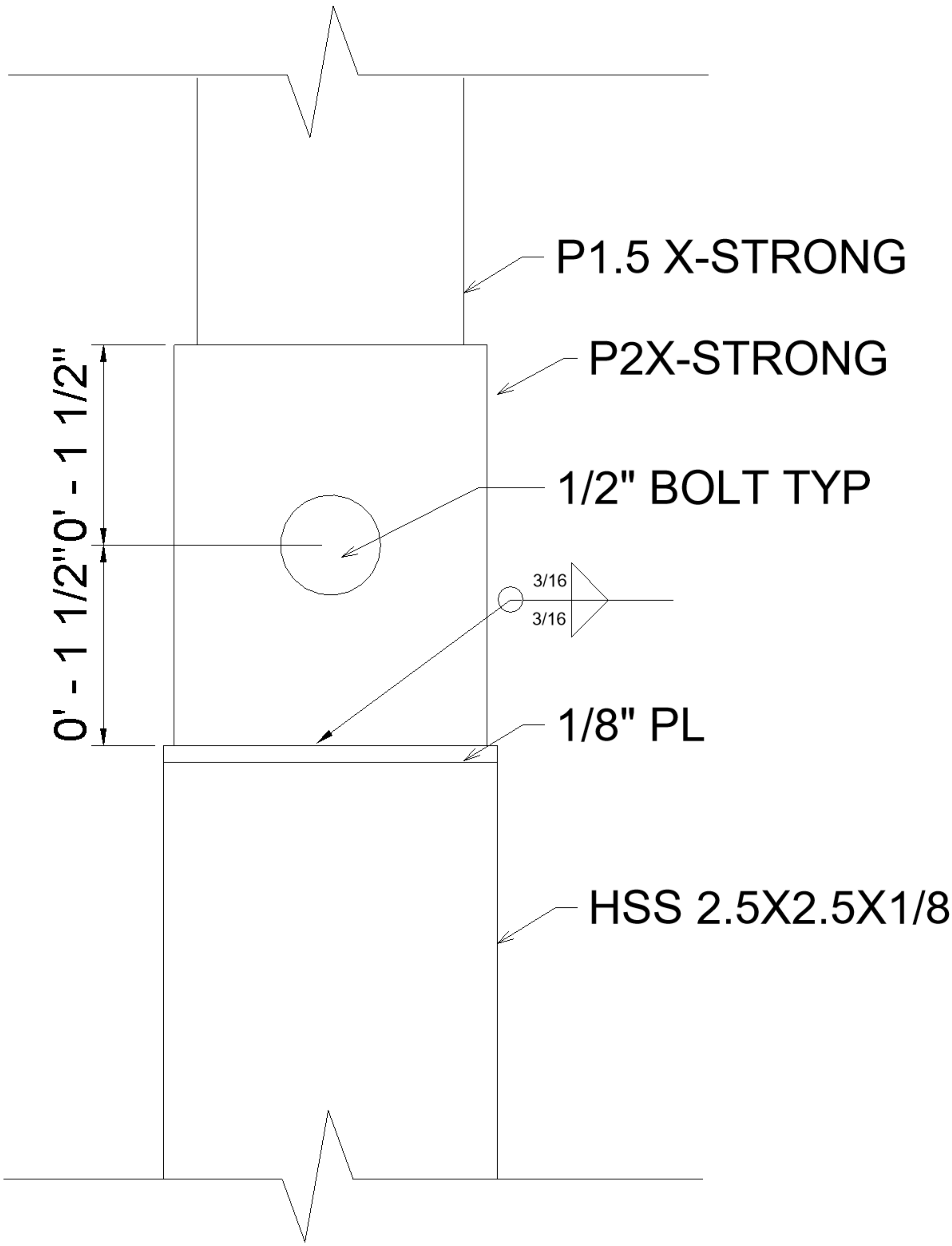
$\phi R_n = 6.75k > 1.19k$ $\quad d/c = 1.19/6.75 = .18 < 1.0$ ✓

RUPTURE

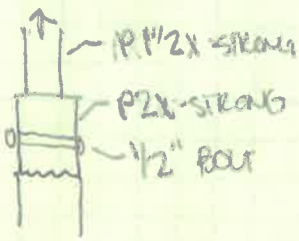
$\phi R_n = .75(.6)(58ksi)(2.5")(.125")$

$\phi R_n = 8.156k > 1.19k$ $\quad d/c = \frac{1.19}{8.156} = .15 < 1.0$ ✓

SHELL TO COLUMN DETAIL



SHELL TO STRUCTURE CONNECTION:



P1 1/2X OUTSIDE DIA 1.9"

P2X INSIDE DIA = 1.94"

1.94 > 1.9" SNUG FIT

WIND UPLIFT = 20.69 PSF

WORST CASE - (20.69 PSF)(5x5 SQFT) = 517.25 # ⇒ USE 600# T

CHECK BOLTS (1/2") TEAROUT

SPACING & EDGE DISTANCE

MIN EDGE DISTANCE = 3/4" (AISC J3.4)

1/2" A307 BOLT IN DOUBLE SHEAR (PIPE W/ THREADS EXCLUDED)

$\phi R_n = \phi F_n A_b$ (AISC J3-1)

$\phi R_n = .75(27\ ksi)(1/2/2^2 \pi)$ (27 ksi FROM T J3.2 AISC)

$\phi R_n = 3.98k > 600\#$

$d/c = .6/3.98 = .15 < 1.0$ ✓

MIN SPACING

$2\frac{2}{3} d = 2\frac{2}{3}(1/2) = 1.33"$ ⇒ USE 1.5" (N/A, ONE BOLT)

Rachel Jakel	In Bloom for WHP	Dec 6 2019

SHELL TO STRUCTURE CONT'D:

YIELD OF PIPE:

$\phi P_n = \phi F_y A_g$

$\phi P_n = .9(35\ ksi)(10)$

$\phi P_n = 31.5k > .6k$

$d/c = .02 < 1.0$ ✓

RUPTURE OF PIPE:

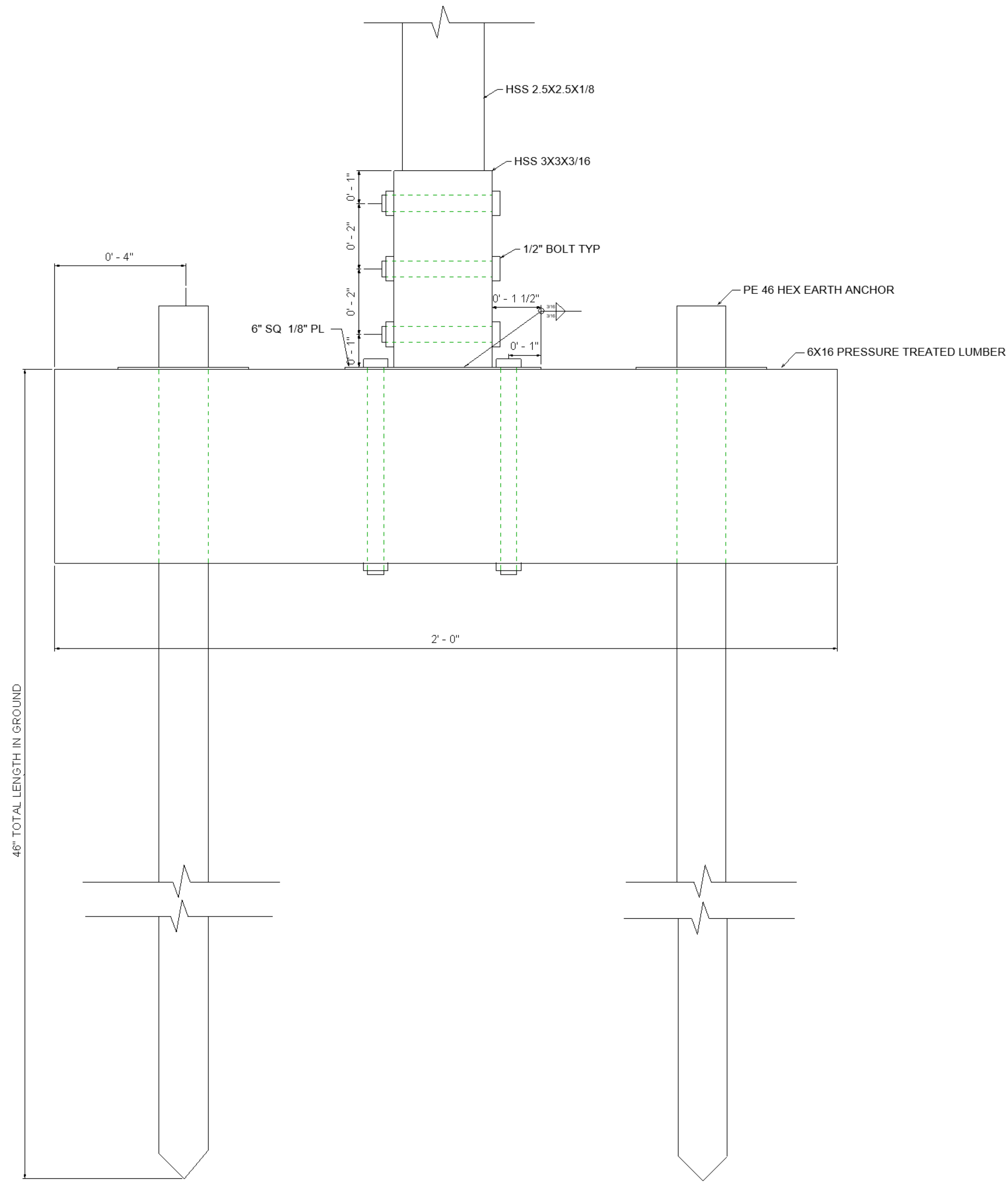
$\phi P_n = \phi F_u A_g$

$.75(60ksi)(1.0 - 1/2 + 1/8)$

$\phi P_n = 16.88k > .6k$

$d/c = .6/16.88 = .05 < 1.0$ ✓

FOOTING DETAIL



FOOTING DESIGN

WORST GRAVITY CASE ↓:

6.2k ↓ FROM SAP ANALYSIS

USE SOIL BEARING PRESSURE F_{brg} = 1000 PSF (WORST CASE)

$\sigma = P/A = 6200/A$

$A = 6.2 ft^2$

2' x 1.3' FTG FOR BEARING

USE 6x16 PRESSURE TREATED LUMBER w/ 6" SQ PL

A 2' x 1.3' = 2.6 ft^2 < 6.2 BUT BEARING FROM EARTH ANCHORS IS AT LEAST TEAROUT VALUE, WILL COVER DIFFERENCE

CHECK $F_{c\perp}$ ON TIMBER

$F_{c\perp} = \frac{RXN}{A_{BEARING}}$

$= \frac{6200\#}{6 \times 6 in}$

= 172.2 psi

$C_{\perp}$ GRADE 20FL = 625 PSI (NDS 2015 T4A)

$F_{c\perp}$ ALLOW 625 psi > $F_{c\perp}$ ACTUAL 172.2 psi ✓

FOOTING CONT'D

WORST UPLIFT CASE:

4.2k ↑ FROM SAP ANALYSIS (APPENDIX)

UNKNOWN SOIL CLASSIFICATIONS

ASSUME SILTY/CLAYEY SAND

USE AMERICAN EARTH ANCHORS, SEE CAPACITIES IN APPENDIX

46" P46-HEX

TENSION CAPACITY ~3.3k PER THIS SOIL CONDITION

USE TWO

CAPACITY 3.3(2) = 6.6 k $d/c = 4.2/6.6 = .6 < 1.0$ ✓

CHECK SLIDING:

$P_{wind} < .3D$ .3 COEFFICIENT OF FRICTION

VERT RXN FROM SAP = .06 k ← GRAVITY

X RXN = .00098k } WIND

Y RXN = .0008k }

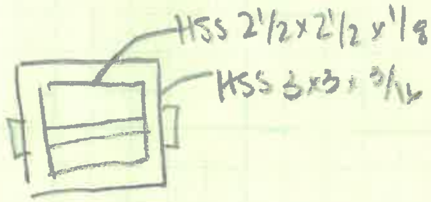
.03(.06) = .018k > .00098k ✓

.018k > .0008k ✓

COL TO FTG

UPLIFT ⇒ SEE SAP RESULTS

SAP RXN = −4.3k WORST CASE



COL DIM = 2.5"

FTG CASE DIM = $3-2(3/16) = 2.625"$

$2.625" > 2.5"$ → SNUG BUT FITS

CHECK BOLTS (1/2") TEAROUT:

SPACING & EDGE DISTANCE

MIN EDGE DIST = 3/4" (AISC J3.4)

1/2" BOLT IN DOUBLE SHEAR (HSS) THREADS EXCLUDED

$\phi R_n = \phi F_n A_b$ (AISC J3-1)

$\phi R_n = .75(27\text{ ksi})(\tfrac{1/2}{2})^2 \pi$ (27 ksi FROM T J3.2)

$\phi R_n = 3.98k$ $\quad d/c = 4.3/3.98 = 1.08 > 1.0$ N.G.

USE 3 BOLTS TO CREATE MORE RIGID CONNECTION W/ 2" SPACING

∴ $4.3^k / 3\text{ BOLTS} = 1.43k$

$d/c = 1.43k / 3.98k = .36 < 1.0$ ✓

MIN SPACING

$2\tfrac{2}{3} d = 2\tfrac{2}{3}(1/2) = 1.33"$

⇒ USE 2" W/ 3 BOLTS FOR MORE RIGID CONNECTION

FOOTING CONT'D

COL ON FTG

COL ON 6" x 6" BASE PL BEARING

$t_{min} = L\sqrt{\frac{2P_u}{.9F_y NB}}$ (AISC 14-7a)

$1.25\sqrt{\frac{2(6.2k)}{.9(36ksi)(6\times6)}}$

$t_{min} = .157"$ ⇒ USE 1/4" PL BEARING

CHECK BOLT THROUGH PL & WOOD

6.2K IN TENSION

1/2" A307 BOLT $F_{nt} = 45ksi$ (AISC TJ3.2)

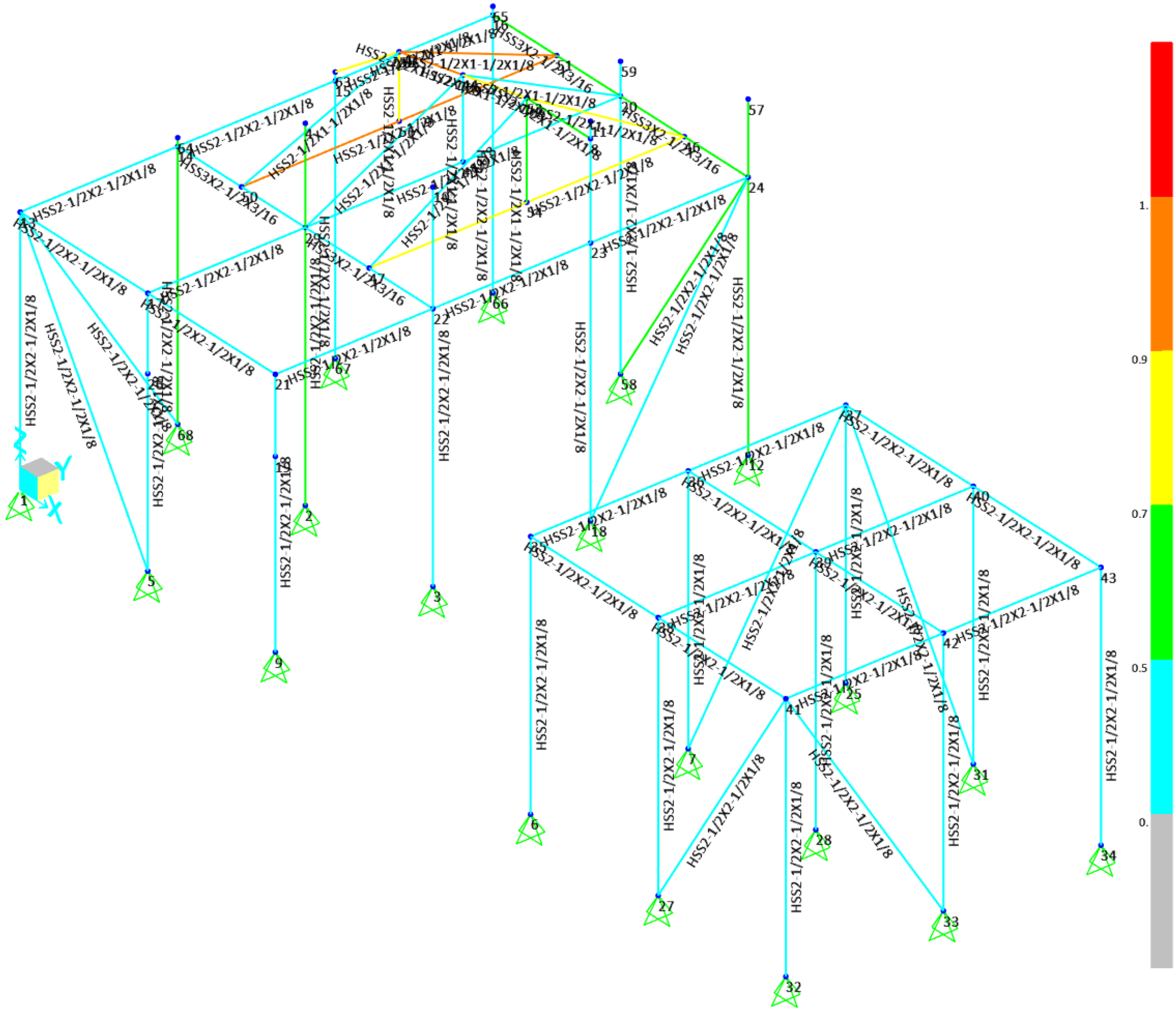
$\phi R_n = \phi F_n A_b$ (J3-1)

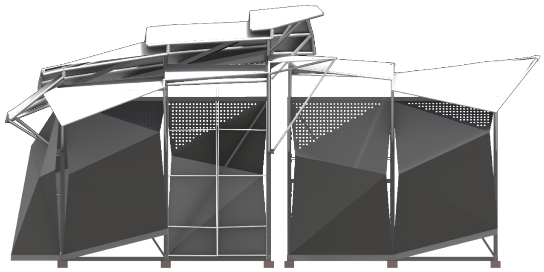
$.75(45ksi)(\frac{1}{2}/2)^2\pi$

6.62k $d/c = 6.2/6.62 = .9 < 1.0$ ✓

CLOSE TO 1.0,

USE TWO BOLTS FOR EVEN DISTRIBUTION ANYWAY

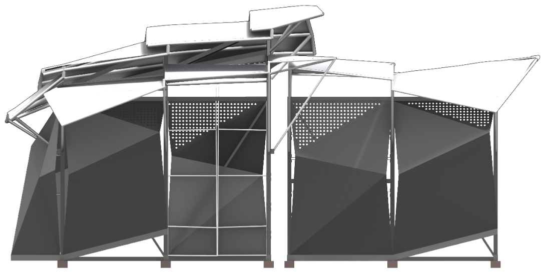

HSS2-1/2X2-1/2X1/8
HSS3X2-1/2X3/16
HSS2-1/2X1-1/2X1/8
1.
0.9
0.7
0.5
0.



Project: In Bloom
Client: Wine History Project
Calculated by: Rachel Jakel
Date: 11/27/2019 Sheet No. A1

TABLE: Joint Reactions

Joint	OutputCase	CaseType	F1	F2	F3	M1	M2	M3
Text	Text	Text	Kip	Kip	Kip	Kip-in	Kip-in	Kip-in
9	COMB4asdx	Combination	-0.116	-0.001277	-0.0046	0	0	0
12	COMB1asd	Combination	-0.000765	-0.001272	0.395	0	0	0
12	COMB2ASDx	Combination	-0.092	-0.014	6.222	0	0	0
12	COMB3ASDy	Combination	-0.002446	-0.069	1.812	0	0	0
58	COMB2asdy	Combination	0.022	-0.209	0.13	0	0	0
58	COMB3asdx	Combination	-1.941	0.017	-2.753	0	0	0
58	COMB4asdx	Combination	-2.588	0.026	-4.298	0	0	0
66	COMB1asd	Combination	-5.383E-05	-0.001143	0.34	0	0	0
66	COMB2ASDx	Combination	-0.109	0.002051	-0.129	0	0	0



Project: In Bloom
Client: Wine History Project
Calculated by: Rachel Jakel
Date: 11/27/2019 Sheet No. A2

Penetrator Load Capacity Chart - US lbs

Penetrators

PENETRATORS®

LOAD CAPACITY
Pounds

Field-tested pullout resistance

SOIL CLASSIFICATION per ASTM D-2487/2488

Soil classification	9" PE9 PE-T9	10" PE10	14" PE14 PE14-STD / 18" PE18 PE18-SQ	26" PE26	36" PE36	46" PE46-Hex PE46-Hex8 PE46-Guy
1 Hardpan, Asphalt	400	1,000	2,500	4,500	8,400	14,000
2 Sandy gravel, Very dense sand	200	700	1,700	3,100	6,000	9,500
3 Silty or clayey sand, Silty gravel	100	350	600	1,100	2,100	3,300
4 Loose to med dense sands, Loose sands, Firm clays	Less than 100	200	350	630	1,000	2,000
5 Uncompacted fill	Less than 100	100	200	360	550	750

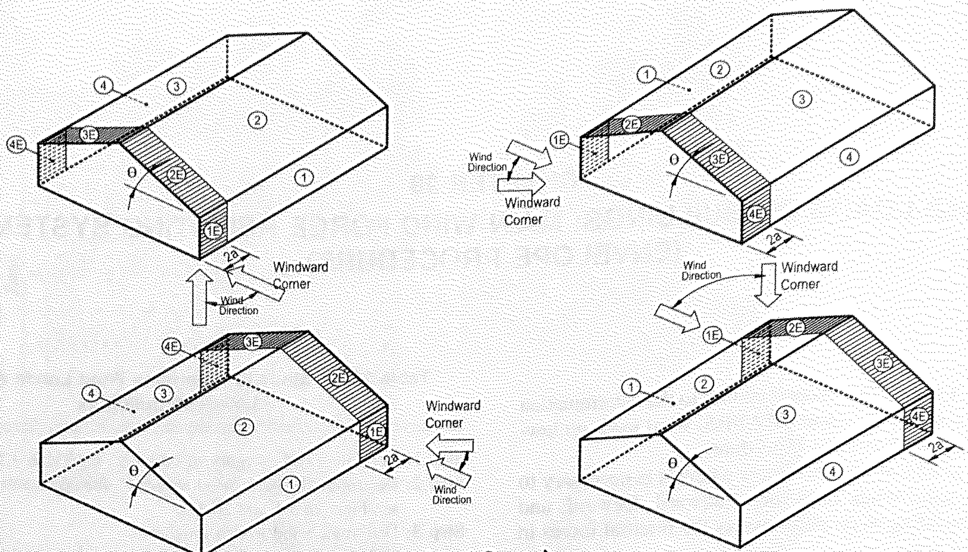
Notes about Penetrator Load Capacity

- Field-tested vertical PULLOUT strength
- PUSHDOWN strength (as when Penetrators are used for footings) is typically equal to or greater than pullout strength because of unlimited undisturbed soil below the Penetrator
- When installed through asphalt, pullout strength is increased because of the Penetrator's grip in the asphalt and in the compacted soil directly below the asphalt

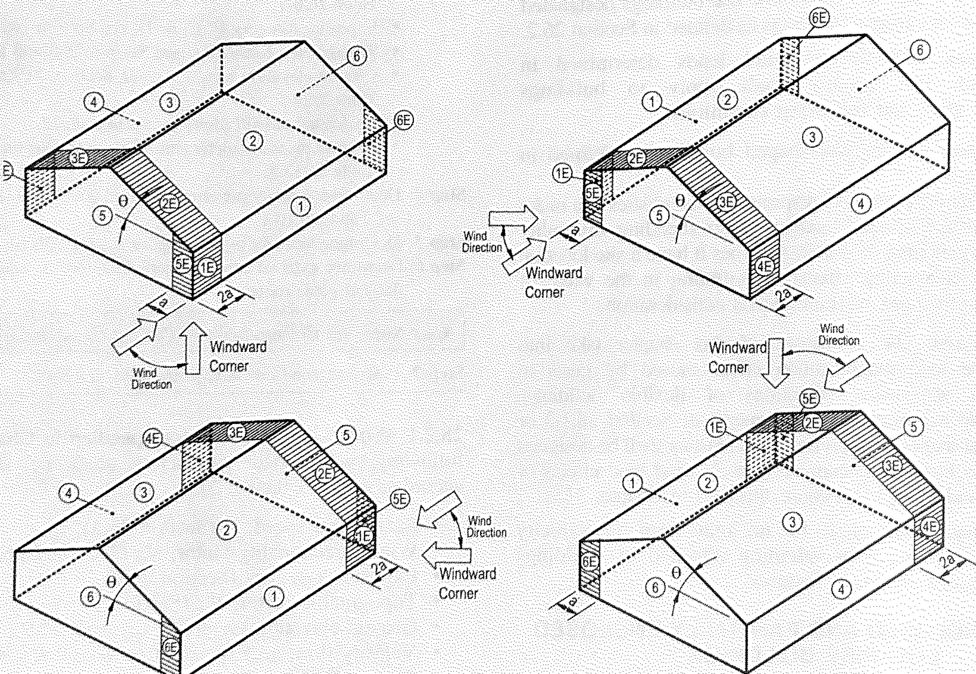
Project: In Bloom
Client: Wine History Project
Calculated by: Rachel Jakel
Date: 11/27/2019 Sheet No. A3

Basic Load Cases

Diagrams



Load Case A



Load Case B

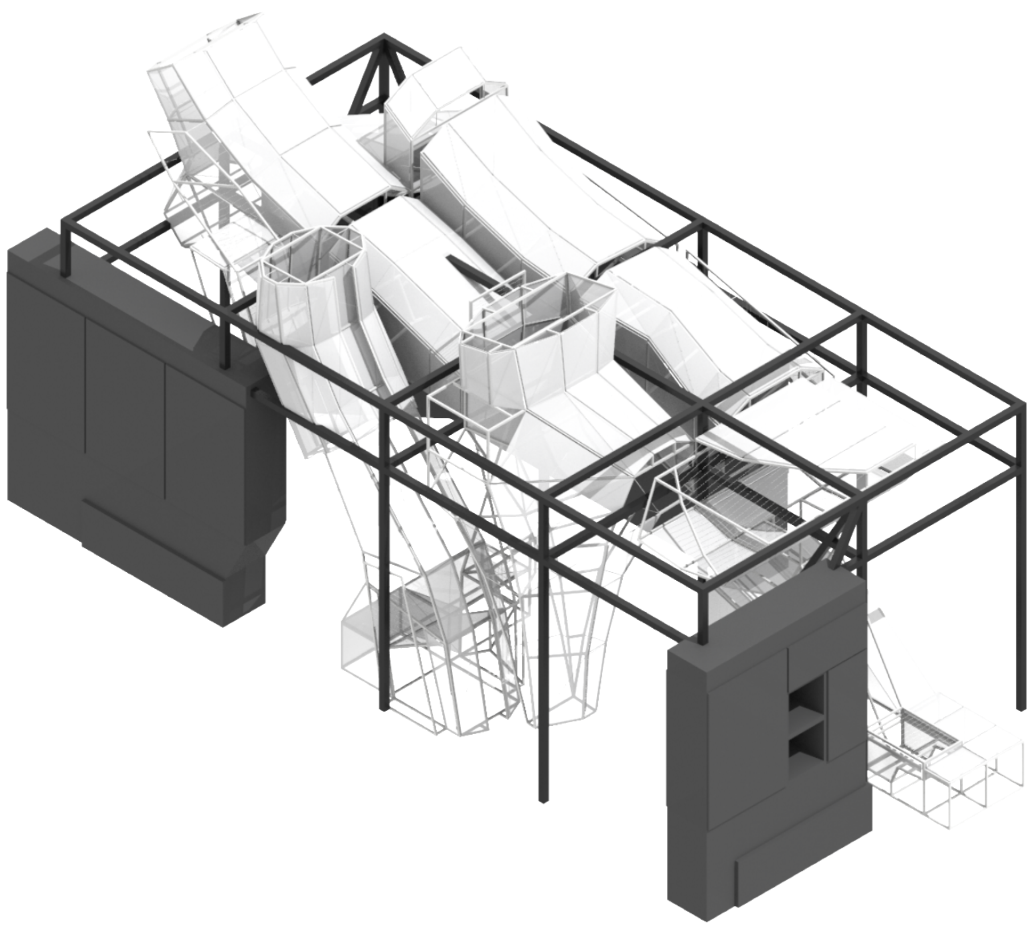
Notation

a 10% of least horizontal dimension or 0.4 *h*, whichever is smaller, but not less than either 4% of least horizontal dimension or 3 ft (0.9 m).
Exception: For buildings with θ = 0 to 7° and a least horizontal dimension greater than 300 ft (90 m), dimension *a* shall be limited to a maximum of 0.8 *h*.
h Mean roof height, in feet (meters), except that eave height shall be used for θ ≤ 10°.
θ Angle of plane of roof from horizontal, in degrees.

FIGURE 28.3-1 Main Wind Force Resisting System, Part 1 [$h \leq 60$ ft ($h \leq 18.3$ m)]: External Pressure Coefficients, (GC_{pf}), for Enclosed and Partially Enclosed Buildings—Low-Rise Walls and Roofs

continues

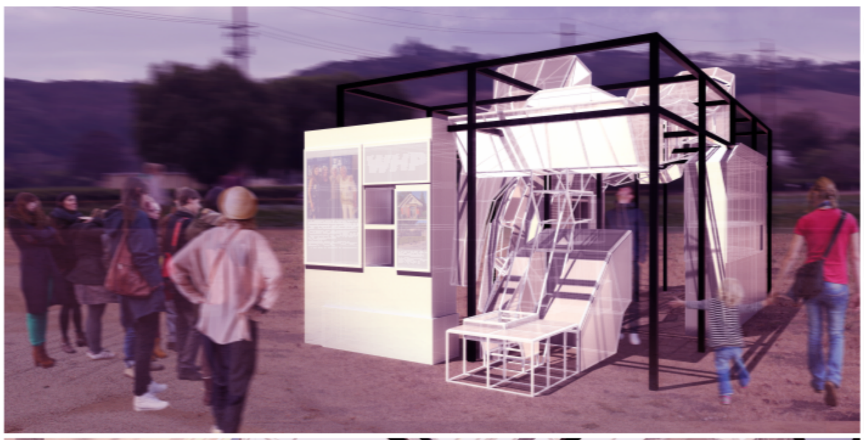
[BI]VOUAC(k)y SHACK
[BI]VOUAC(k)y SHACK
[BI]VOUAC(k)y SHACK
[BI]VOUAC(k)y SHACK

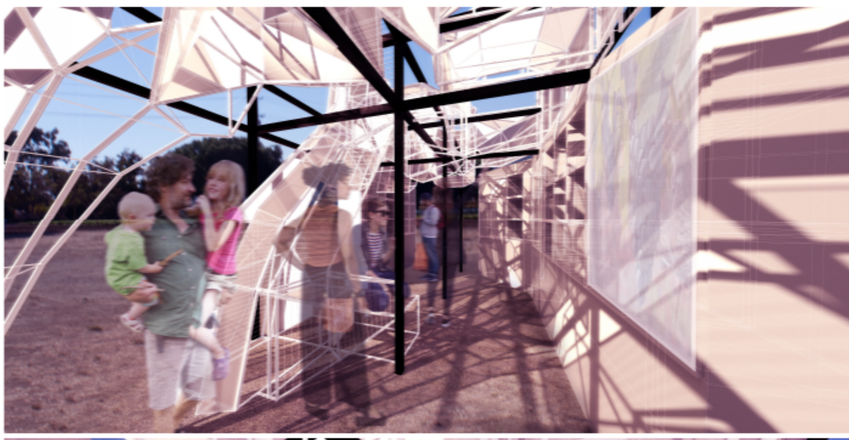


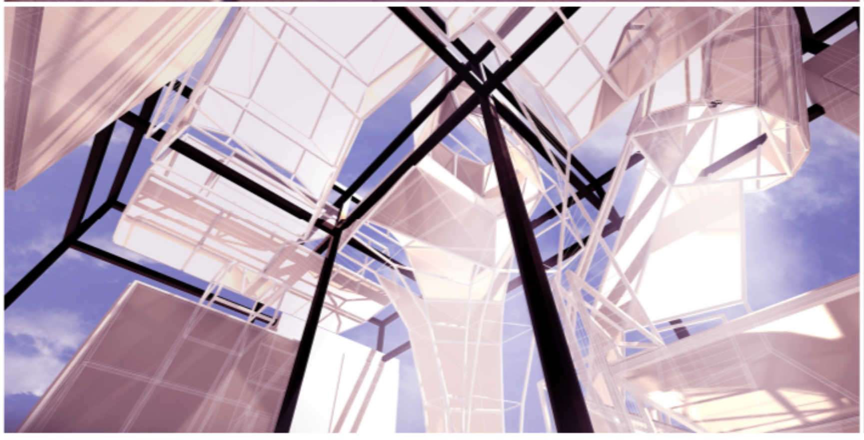
Architectural Renders and Site Plan

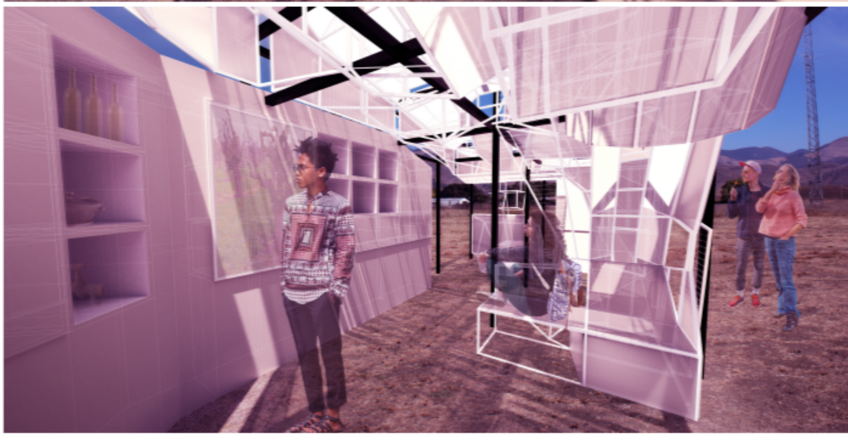
[BI]VOUAC(k)y SHACK

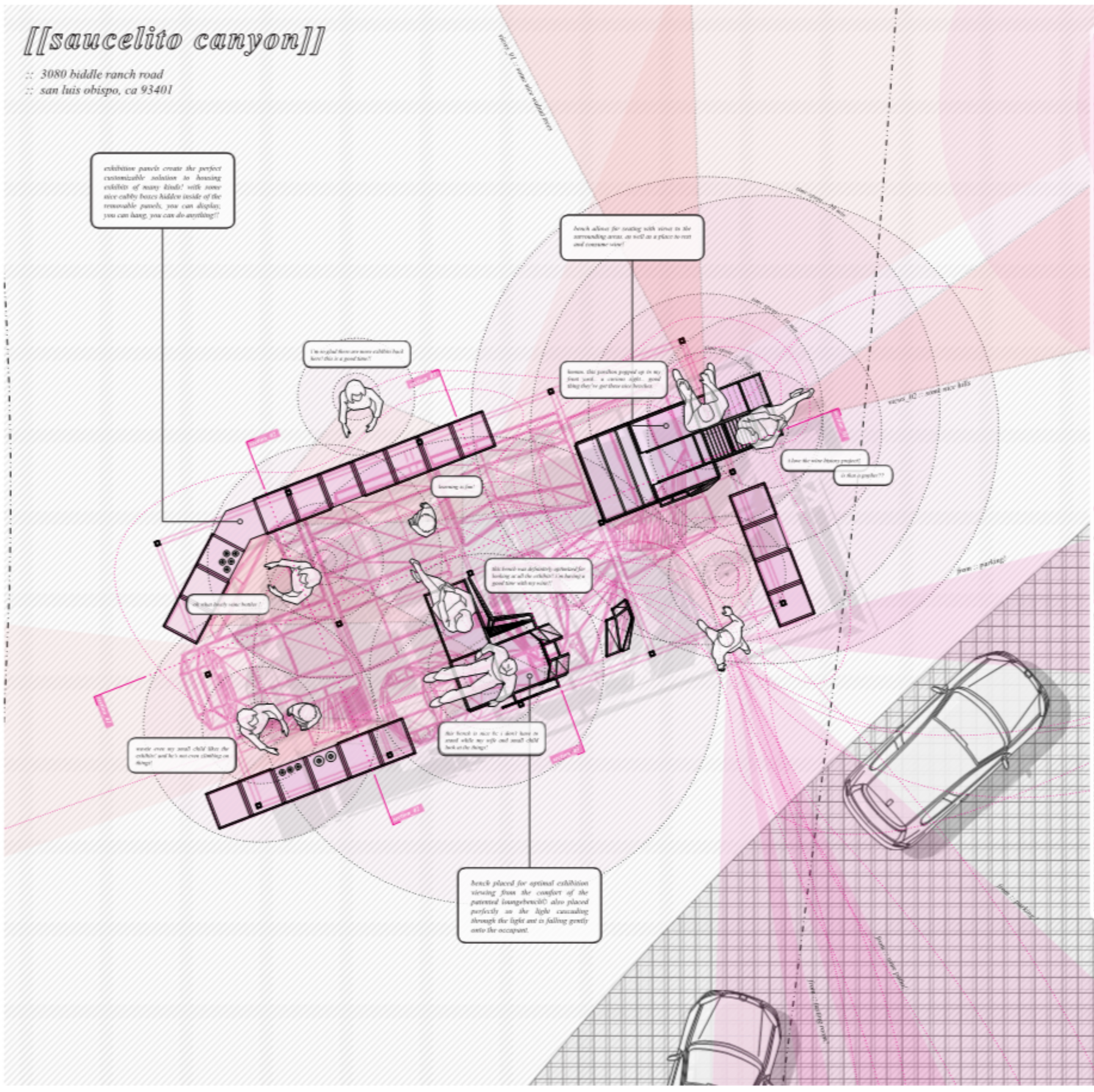
THIS PAVILION IS AN ADAPTABLE MODULAR STRUCTURE THAT CAN EXPAND, CONTRACT, AND BE REARRANGED IN ORDER TO FIT THE NEEDS OF THE EXHIBITION, AND THE STORY IT TELLS. THE PROJECT ACCOMPLISHES THIS THROUGH CHANGING THE EXPERIENCE OF THE PAILION TO ACT DIDACTICALLY, PASSIVELY ENHANCING THE EDUCATIONAL EXPERIENCE.

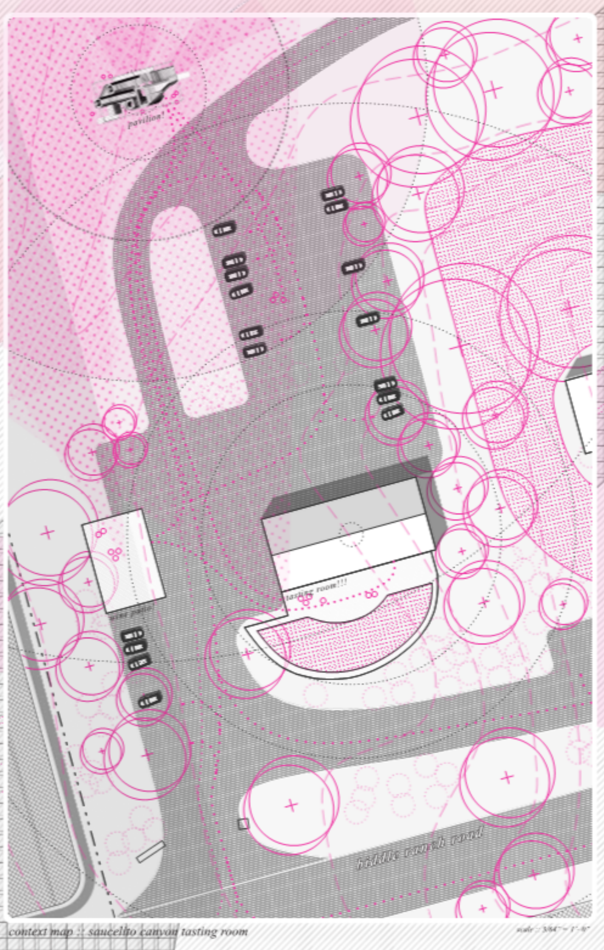


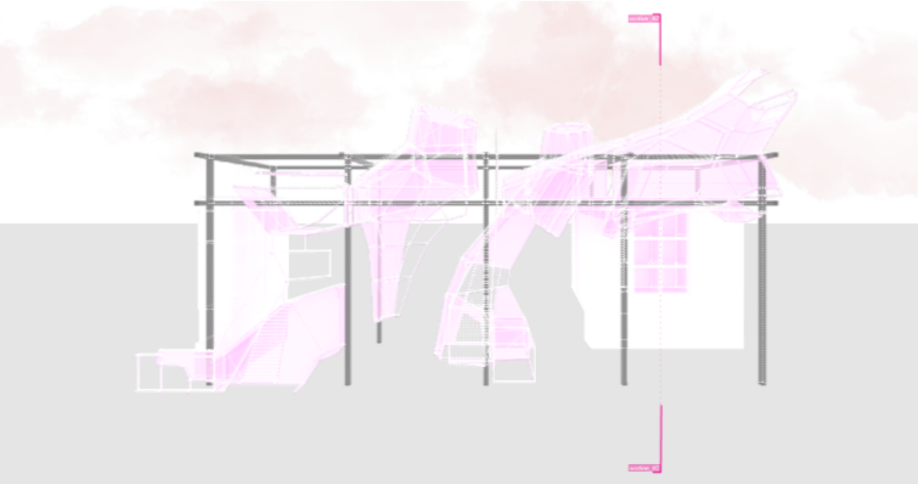


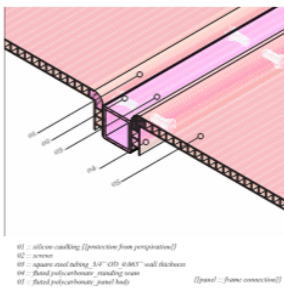












Assembly, Transportation and Cost Estimate

Module 1 - 4 Bay

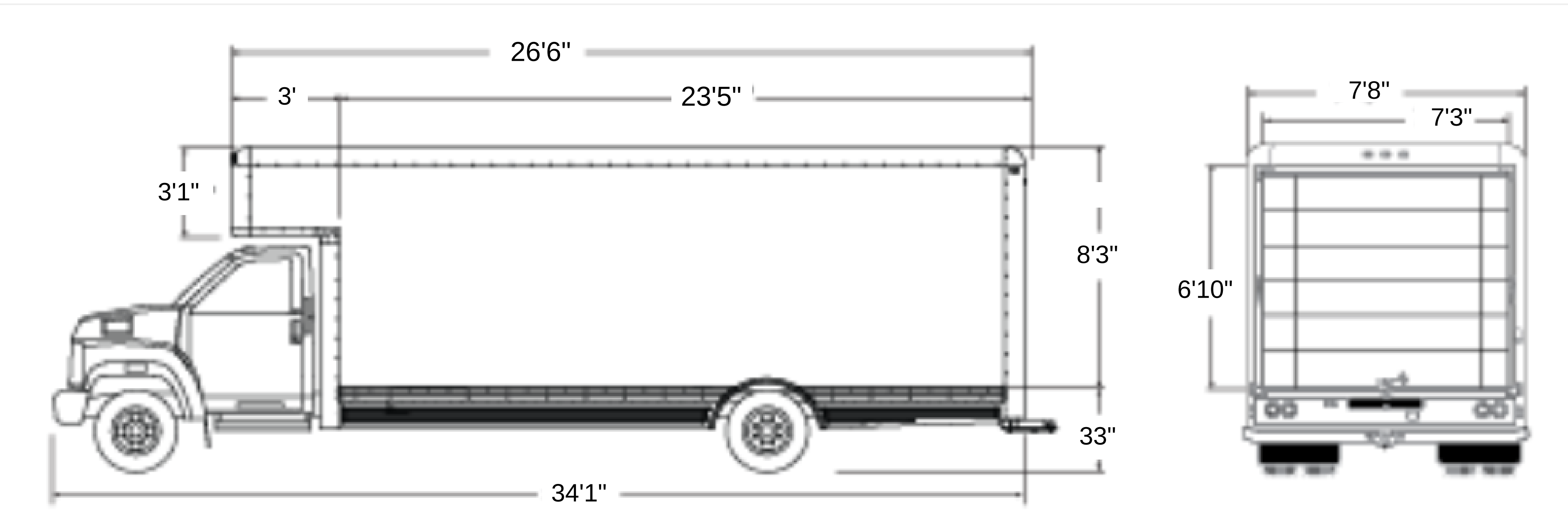
Material	Qty	Unit	Unit Price		Total
HSS Super Strucuture					
2 1/2"x1/8" HSS	300	LF	$69.00	per 20'	$1,035.00
2"x 1/8" HSS	40	LF	$55.00	per 20'	$110.00
1/2 in.-13 x 4 in. Galvanized Hex Bolt	168	Count	$2.16	each	$362.88
6 in. x 16 in. x 8 ft. Hem-Fir Brown Stain Ground Contact Pressure-Treated Lumber	104	LF	$18.27	per 8'	$237.51
1/2 in.-13 x 4 in. Galvanized Hex Bolt	336	count	$0.46	each	$154.56
1/2 in. Galvanized Lock Washer	336	count	$0.31	each	$104.16
4"x8"x1/4" Plate Steel (A36)	5	counts	$258.76	each	$1,293.80
				SUM	**$3,297.91**

Form	Qty	Unit	Unit Price		Total
1"x 1/16" Square Steel Tube	2600	LF	$11.00	per 20'	$1,430.00
1/4" Sqaure Bar	60	LF	$5.00	per 20'	$15.00
Stainless Steel Uncoated Wire Rope 3/32 in. x 200 ft	200	LF	$53.98	per 200'	$53.98
48 in. x 96 in. x 0.157 in. Clear Corrugated Plastic Sheet (10-Pack)	6	Count	$208.49	per pack	$1,250.94
Stainless Steel Hook and Eye Turnbuckle (5-Pack)10-24 x 5-5/8 in.	1	Count	$1.68		$1.68
3/8 in. x 4 in. Zinc-Plated Eye Bolt with Nut	4	Count	$0.95		$3.80
3/8 in. Zinc-Plated Flat Washer	6	Count	$0.17		$1.02
3/8 in.-16 Zinc Plated Hex Nut	5	Count	$0.15		$0.75
3/32 in. Aluminum Ferrule and Stop Set	4	Count	$1.62	2 per pack	$6.48
Spray Paint/Primer	25	Count	$12.00		$300.00
Caulking	5	Count	$5.00		$25.00
				SUM	**$3,088.65**

Wall	Qty	Unit	Unit Price		Total
1/2 4 ft. x 8 ft. Oriented Strand Board	10	Count	$17.55		$175.50
2"x4"x96" Stud	400	LF	$3.00	per 8'	$150.00
3 in. Construction Screw (10 lb.-Box)	2	Count	$33.57	per 10lb box	$67.14
4'x8' x 5/8" Dens Deck	10	Count	$49.00		$490.00
Thermo Plastic Membrane	120	SF	$6.00	Per SF	$720.00
				SUM	**$1,602.64**

Module 1 Total	**$7,989.20**	4 Bays
Module 2 Total	**$3,994.60**	6 Bays
Module 3 Total	**$3,994.60**	8 Bays
TOTAL With 8 bays	**$15,978.40**	

PORTABILITY DIAGRAM



INSIDE USEABLE DIMENSIONS

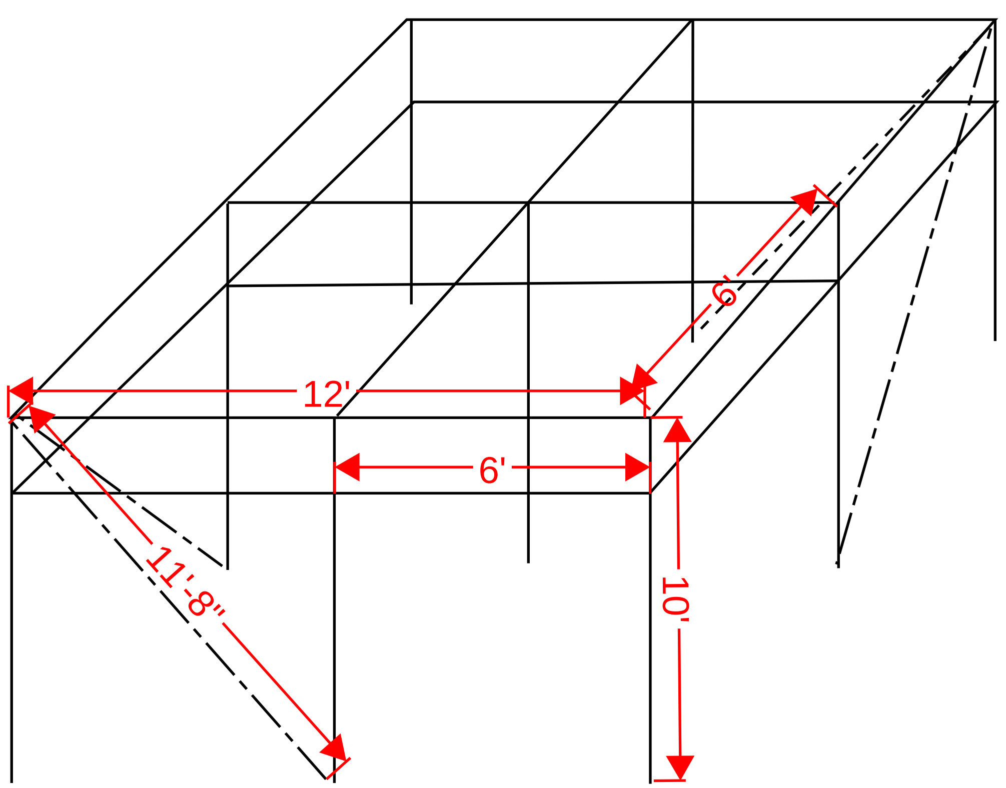
Length: 23'5"

Width: 7'3"

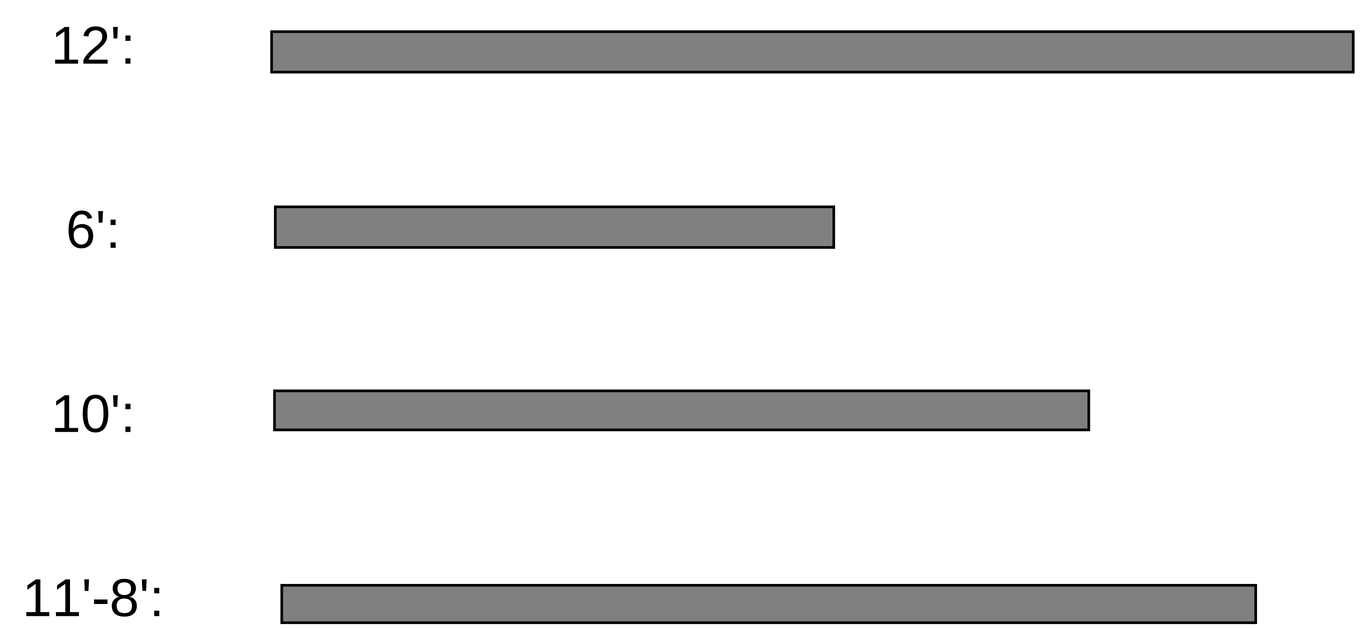
Inside Height: 8'3"

Door Height: 6'10"

STEEL FRAME PORTABIITY

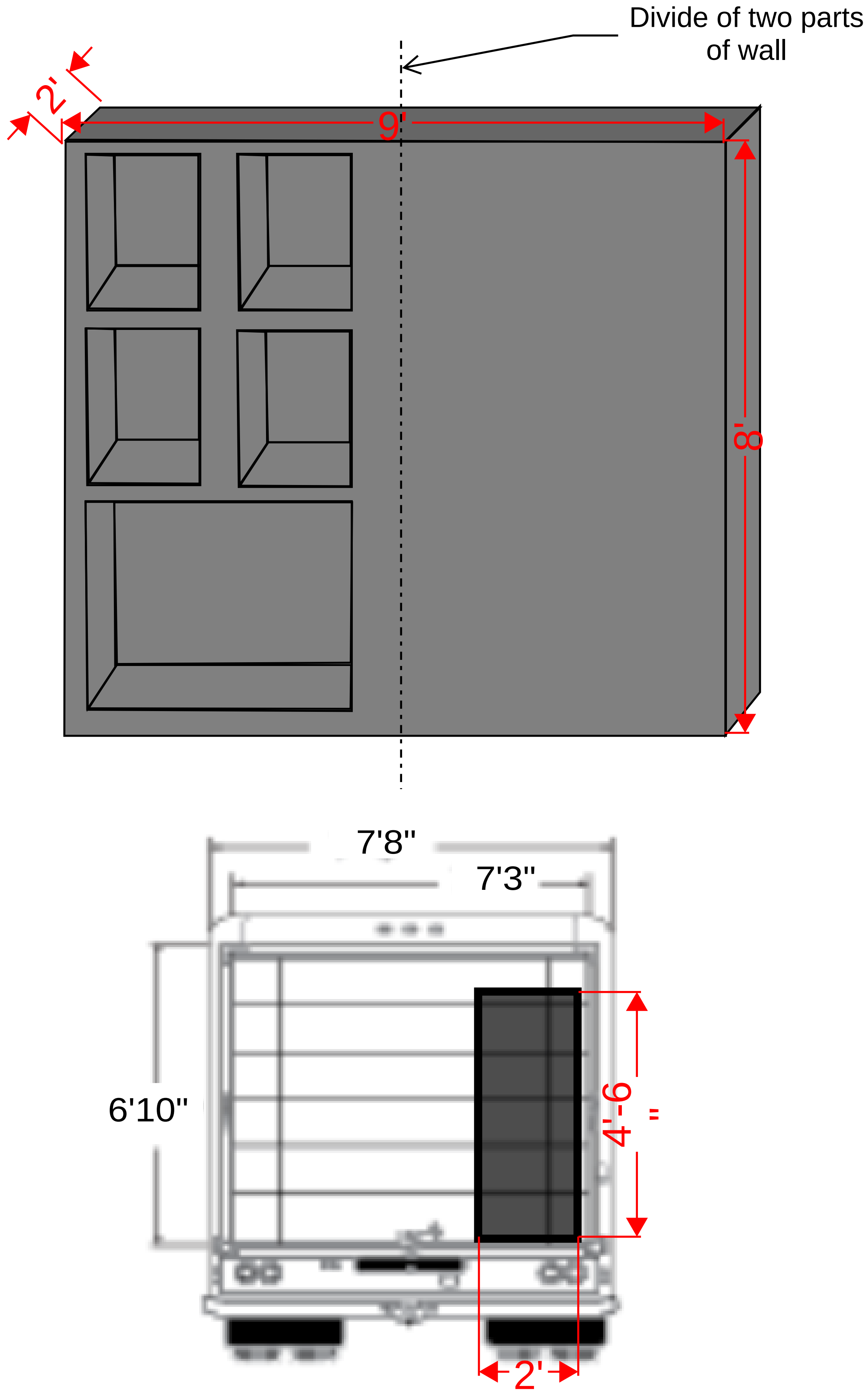


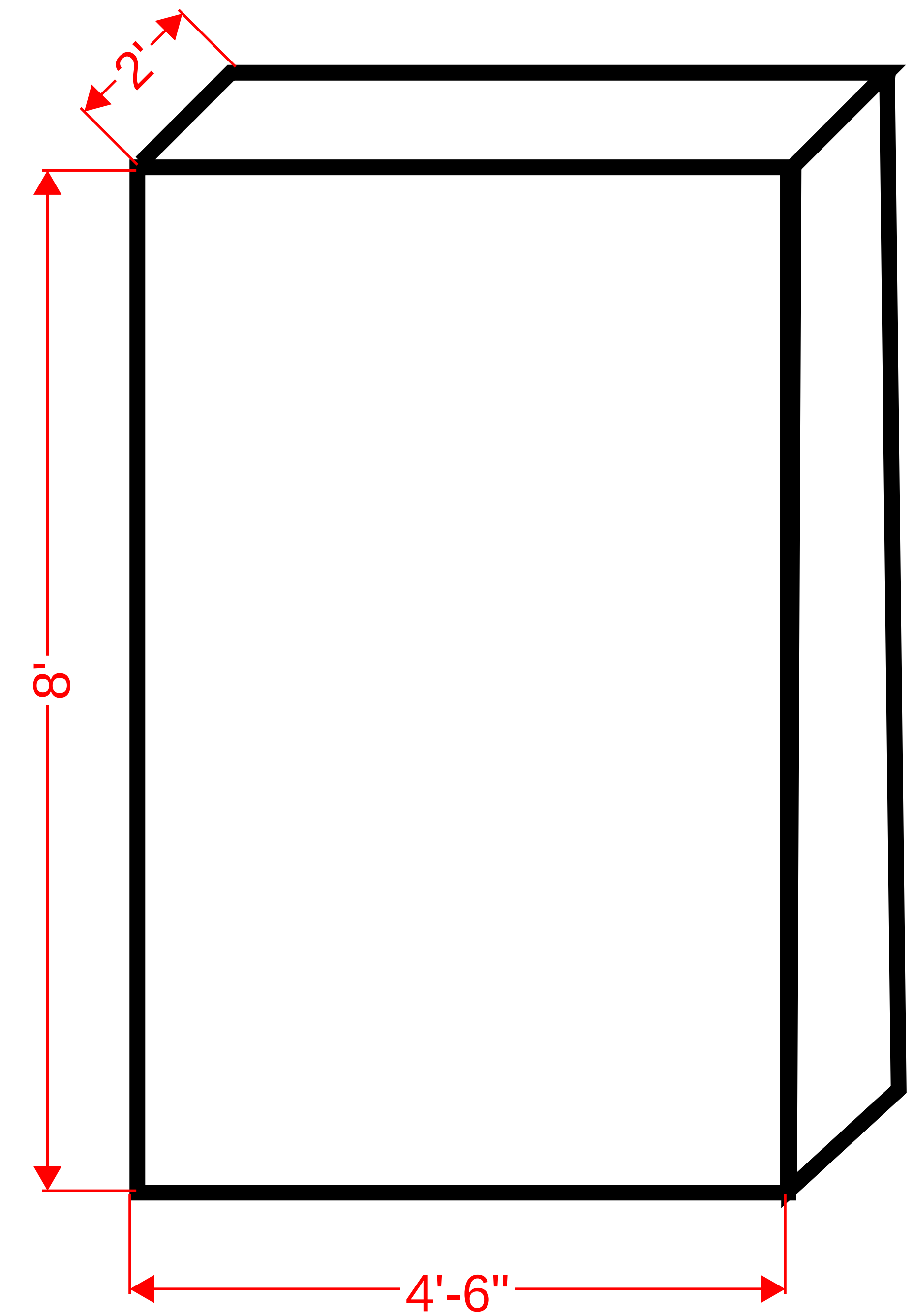
Members:



NOTE
1. Heaviest Steel Member is 60#

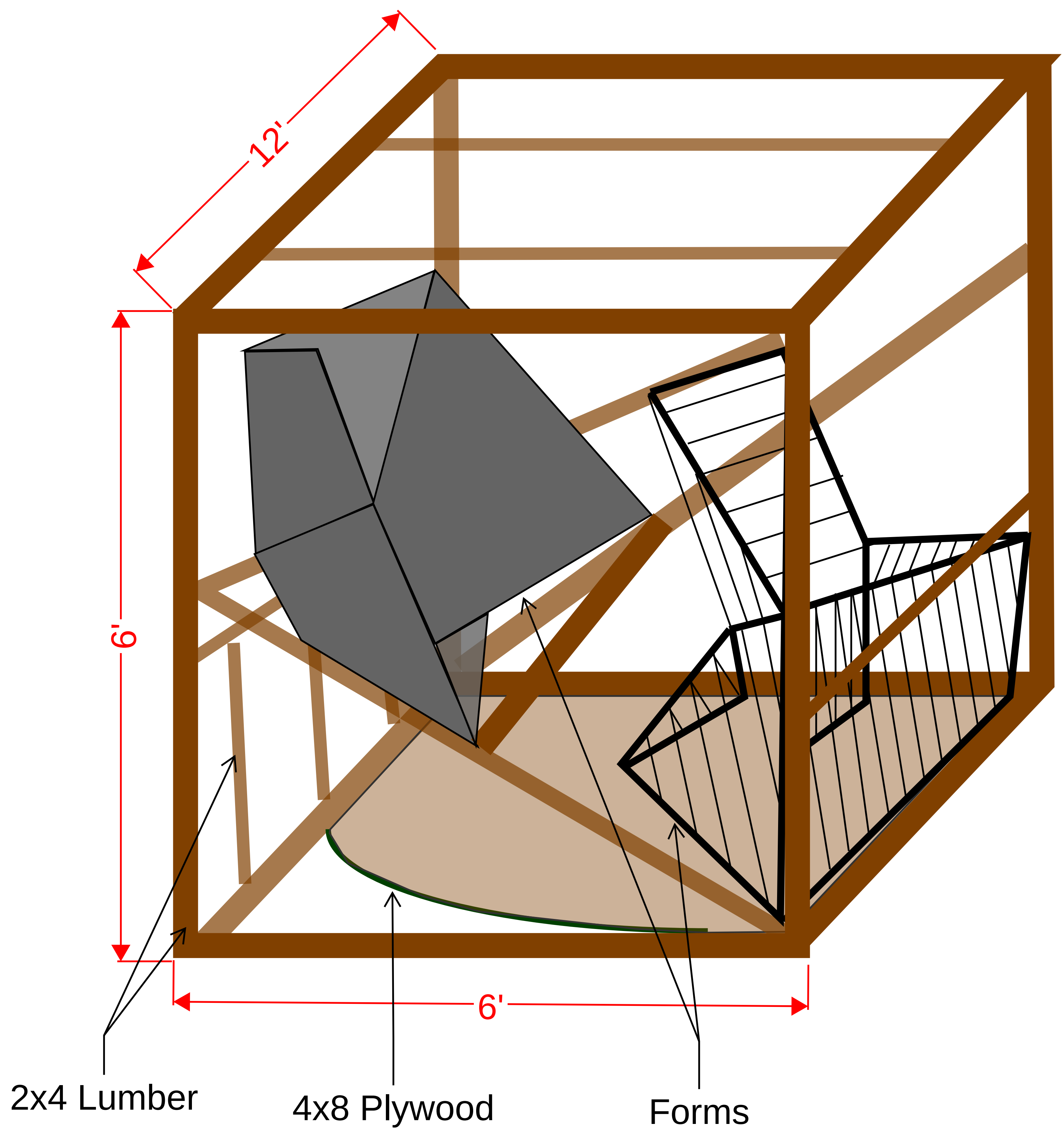
WALL PORTABILITY





DEMENSION OF MODULAR WALL

FORM PORTABILITY



DESRIPTION

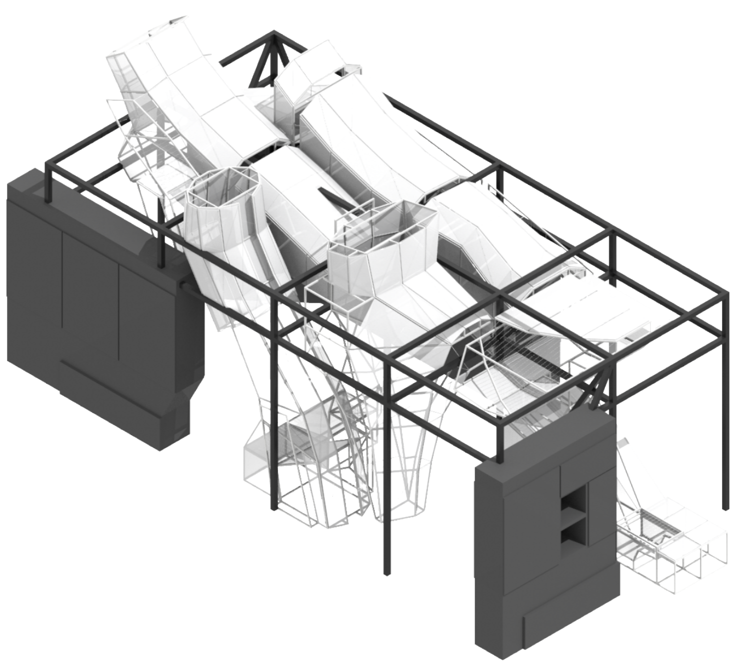
This is depicting the mobility of the form. The plan is to build wood framed structures that hold and protect forms for transportation. There are 8 different frames that will be built for the different parts of the form. This form shows the largest shipping size, which can fit within the U haul. The heaviest mobility structure including the form is 120#.

Structural Calculation Package for

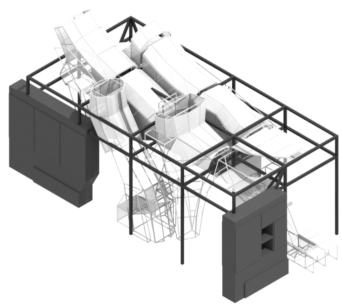
Wine History Project Moving Pavilion: Bivouacky Shack

Site 1: Saucelito Canyon Winery Tasting Room

3180 Biddle Ranch Rd, San Luis Obispo, CA 93401



Rachel Jakel



Project: Bivouacky Shack
Client: Wine History Project
Calculated by: Rachel Jakel
Date: Dec 6 2019 Sheet No. D1

Table of Contents

Description Page Number

Project Description

The Wine History Project documents and preserves the unique food and wine history of San Luis Obispo County. This pavilion made for them will house their exhibits and travel from winery to winery in the San Luis Obispo County. The first site it will see is at the tasting room of Saucelito Canyon Winery. The design of the pavilion stemmed from a biomimetic relationship of the army ant and how they create shelter- the bivouac. The use of biomimicry in the design helps it to live and function at any site by adapting the way that the army ant would. Just as the army ant uses each individual member of the colony to create their bivouac, the Bivouacky Shack is made up of several different but similar elements that come together to form the pavilion for the Wine History Project.

The structure of the pavilion stands 10 feet tall and 12 feet wide with a length that can be adjusted to either 12, 18 or 24 feet with total square footage of 144, 216 or 288 respectively to fit the client's desires. It is comprised of hollow structural steel for the gravity as well as lateral systems. From site to site the pavilion will be constructed on relatively flat ground and is connected to the ground via pressure treated wood bearing footings with earth anchors.

Design Criteria

1) Codes used:
    - International Building Code 2018
    - American Society of Civil Engineers 7-16
    - American Institute of Steel Construction 360-16
    - National Design Specification for Wood Construction 2015

2) Design Loads:
    - Dead Loads- weights of all materials as shown per calculations
    - Live Loads- uniformly distributed- assumed as 10 psf uninhabitable attic without storage per ASCE 7-16 Table 4.3-1
    - Wind Loads per IBC, Exposure C and wind speed V of 95 mph based off process in ASCE 7-16.

3) Foundation Design:
    - With no geotechnical report provided and soil class unknown, worst case soil bearing pressure of 1000 psf will be used.

Material Criteria

1) Steel
   - For framing members, HSS SQ A500 used for beams columns and braces
2) Aluminum
   - Auger anchors for foundations
3) Timber
   - Pressure treated lumber for foundation bearing pads.

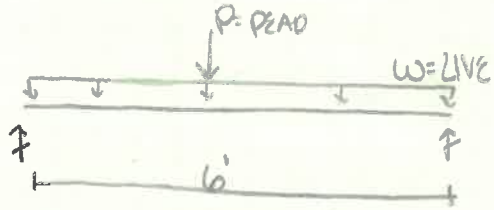
Load Takeoff

Material	Weight
HSS 2.5x2.5x1/8	3.90 plf
1" SQ Steel Tube	1.20 plf
Corrugated Plastic	~.5 psf

SAP2000 Modeling Criteria

The model uses the same member type throughout and is modeled under worst case conditions with point loads at the midpoint of each beam and a partially closed wind load. All connections are modeled as pinned though they will have more rigidity when constructed.
Dead loads are applied at worst case conditions and live as uniformly distributed based off of tributary area. Wind load is applied windward, leeward and as uplift pressure. LRFD load combinations were ran for design code checks and ASD combinations were ran for foundation design.

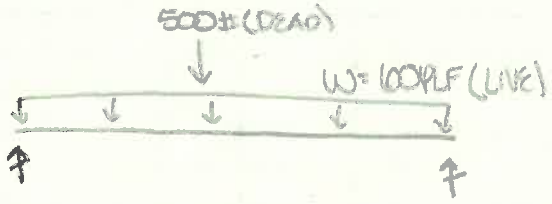
SAMPLE BEAM CALC



LIVE = 10PSF × TRIB WIDTH 6'

W = 60PLF

P = 500# (1/2 OF WORST CASE FORM WT)
↑ VERY CONSERVATIVE



LOAD COMBOS (ASCE 7-16 2.3.1)

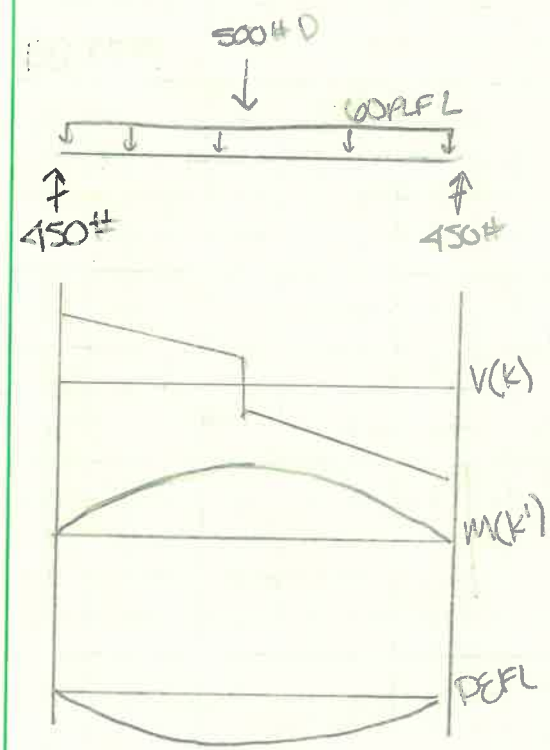
1. 1.4D = 1.4(500) = 700#

2. 1.2D + 1.6L = 1.2(500) + 1.6(60×6) = 1176# ← CONTROLS

HSS 2.5×2.5×1/8

E = 29000 ksi

I = .998 in^4



$V_{MAX} = .45K$

$M_{MAX} = \frac{wL^2}{8} + \frac{PL}{4}$

$1.6\left(\frac{60(6^2)}{8}\right) + \left(\frac{500(6)}{4}\right)1.2$

$= 1.33K' = 15.96K''$

$DEFL = \frac{5wL^4}{384EI} + \frac{PL^3}{48EI}$ (UNFACTORED)

$= \frac{5(.005)(6\times12)^4}{384(.998)(29000)} + \frac{.5(6\times12)^3}{48(.998)(29000)}$

$= .19 \text{ in}$

SAMPLE BM CONT'D

BENDING CHECK:

$\phi M_n = \phi F_y Z$ (AISC 360-10F)

$\phi M_n = .9(50ksi)(.947in^3)$

$\phi M_n = 42.615K'' > 15.96K''$

$\frac{d}{C} = \frac{15.96}{42.615} = .37 < 1.0$ ✓

SHEAR CHECK:

$\phi V_n = \phi_v(.6F_y A_w C_v)$ (AISC 360-G1)

$\phi V_n = .9(.6)(50ksi)(1.0)(1.07in)$

$\phi V_n = 28.89K > .45K$

$\frac{d}{C} = \frac{.45}{28.89} = .015 < 1.0$ ✓

DEFLECTION CHECK:
ROOF MEMBER NOT SUPPORTING CEILING (IBC 2018 T1604.3)

LIVE

$\Delta_{ALLOW} = \ell/180 = 6x12/180 = 0.4in$

$\Delta_{ACTUAL} = \frac{5wL^4}{384EI} = \frac{5(.0054ki)(6x12)^4}{384(29000ksi)(.998in^4)} = .06in$

.06in ACTUAL < .4in ALLOW ✓

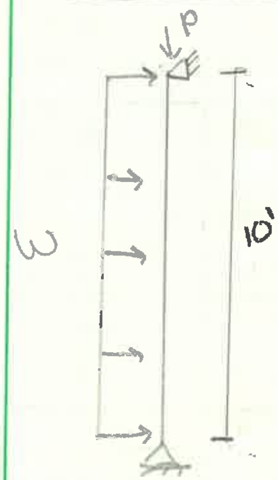
DEAD + LIVE

$\Delta_{ALLOW} = \ell/120 = 6x12/120 = 0.6in$

$\Delta_{ACTUAL} = .19in$

.19in ACTUAL < .6in ALLOW ✓

SAMPLE COLUMN CHECK:



W = WIND = 16.69 PSF (6' TRIB WIDTH) = 100.14 plf

P = LIVE = 10psf (6'×6' TRIB AREA) = 360 #

DEAD = 500#/2 = 250#

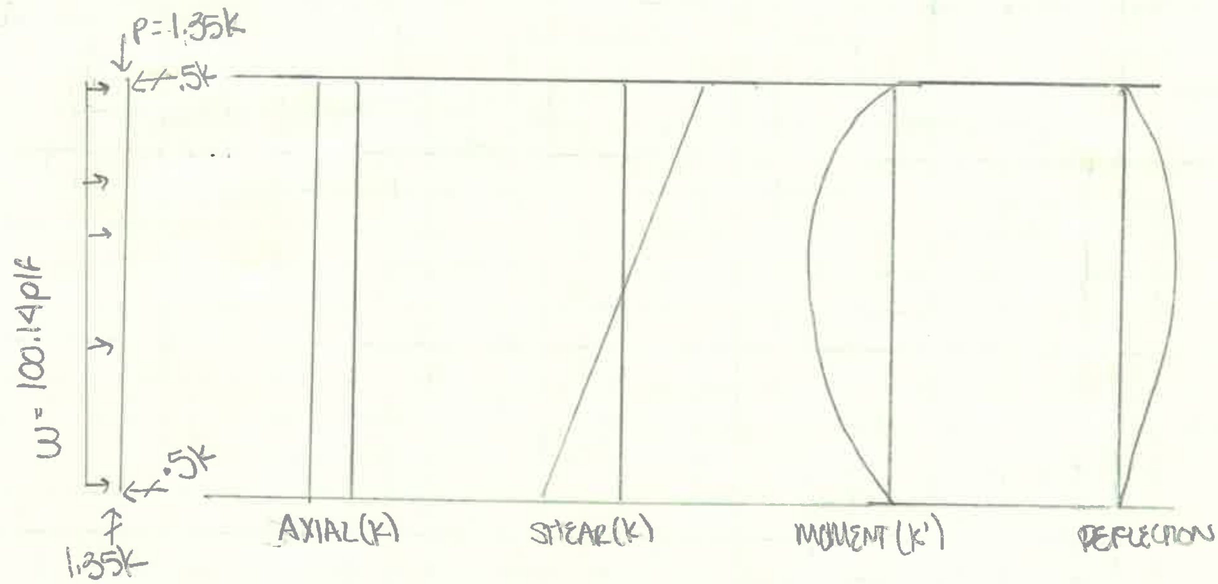
↳ LOAD COMBO #2 CONTROLS. R_{BM} = 450 (SEE BM CALC R)

P = 3 BM'S × 450 = 1.35K

HSS 2½ × 2½ × 1/8

COMBINED AXIAL & BENDING (AISC360 CH H)

$$\frac{P_r}{P_c} = \frac{1.35k}{15.6k} \leftarrow \text{(AISC360 T4-4)} = .09 < .2$$



$$M_{MAX} = \frac{wl^2}{8} = \frac{100.14(10)^2}{8} = 1.25K' = 15\ K''$$

V_{MAX} = .5K

A_{MAX} = 1.35K

SAMPLE BM CALC CONT'D

$\frac{P_r}{P_c} < 0.2$ (USE AISC EQN H1-1b)

$$\frac{P_r}{2P_c} + \left(\frac{M_r}{M_c}\right) \leq 1.0$$

$$\frac{1.35k}{15.6k} + \frac{15.1k''}{(3.55k')\times 12''/ft} \longleftarrow \text{AISC T3-13}$$

$$= 0.44 < 1.0 \checkmark$$

LATERAL WIND LOADS

PARTIALLY ENCLOSED BLDG, LOW RISE BLDG $h<60'$

ASCE 7-16 CH 28

1. RISK CATEGORY: II (ASCE 7-16 T 1.5-1)
2. BASIC WIND SPEED V=95MPH (ASCE 7-16 FIG 26.5-1B)
3. EXPOSURE CATEGORY: C (ASCE 26.7)

   TOPOGRAPHIC FACTOR K_{zt}: 1.0 (FLAT) (ASCE 7-16 26.8.1)

   ENCLOSURE: PARTIALLY ENCLOSED → HIGH INTERNAL PRESSURE (ASCE 26.13-1)

   WIND DIRECTIONALITY K_d: .85 (ASCE 7-16 T. 26.6-1)

   GROUND ELEVATION FACTOR K_e: 1 (ASCE 7-16 26.9)

   INTERNAL PRESSURE COEFFICIENT GC_{pi}: ±.55 (ASCE 7-16 T26.13-1)
4. VELOCITY PRESSURE EXPOSURE COEFFICIENT K_h/K_z: .85 (ASCE 7-16 T26.10-1)
5. VELOCITY PRESSURE q_z/q_h: (ASCE 7-16 EQN 26.10-1)

$$q_z = .00256 K_z K_{zt} K_d K_e V^2 \ (\#/ft^2)$$

$$= .00256(.85)(1)(.85)(1.0)(95^2)$$

$$= \underline{16.69 \ \#/ft^2}$$

6. EXTERNAL PRESSURE COEFFICIENT (GC_p) (ASCE 7-16 FIG 28.3-1)

$\theta = 0°$

LOAD CASE A

BLDG SURFACE	1	2	3	4	1E	2E	3E	4E
	.4	-.69	-.37	-.29	.61	-1.07	-.53	-.43

LOAD CASE B

BLDG SURFACE	1	2	3	4	5	6	1E	2E	3E	4E	5E	6E
	-.45	-.69	-.37	-.45	.40	-.29	-.48	-1.07	-.53	-.48	.61	-.43

7. WIND PRESSURE P (ASCE 7-16 28.3-1)

$P = q_h(GC_{pf} - GC_{pi})$ #/ft²

LOAD CASE A

$P_1 = 16.69(.4+.55) = 15.85$ psf

$P_2 = 16.69(-.69-.55) = -20.69$ psf

$P_3 = 16.69(-.37-.55) = -15.35$ psf

$P_4 = 16.69(-.29-.55) = -14.02$ psf

LOAD CASE B

$P_1 = 16.69(-.45-.55) = -16.69$ psf

$P_2 = 16.69(-.69-.55) = -20.69$ psf

$P_3 = 16.69(-.37-.55) = -15.35$ psf

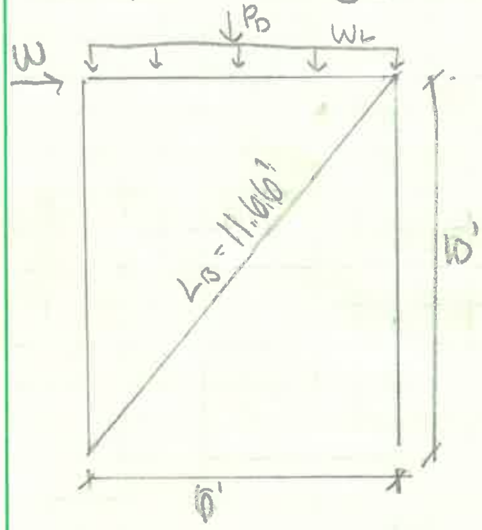
$P_4 = 16.69(-.45-.55) = -16.69$ psf

$P_5 = 16.69(.4+.55) = 15.85$ psf

$P_6 = 16.69(-.29-.55) = -14.02$ psf

* P NOT TO BE LESS THAN 16 PSF ON WALLS & 8 PSF ON ROOF (ASCE 7-16 28.3.4)

SAMPLE BRACE CALCULATION



$W = 16.69\text{plf}(6' \text{ TRIB WIDTH})(10' \text{ HT}) = \underline{1001.4\#}$

$F_{brace} = \frac{W}{6'} = \frac{F_b}{11.66'}$

$\underline{F_b = 1.95k}$ (T & C FOR W BOTH DIRECTIONS)

$P_D = 500\#$ (FROM BM CALC)

$W_L = 60\text{PLF}$ (FROM BM CALC)

LOAD COMBOS (ASCE7-16 2.3.1)

4. $1.2D + 1.0W + 1.0L = 1.2(.5/2) + 1.95k + .06(3') = \underline{2.43K}$ ON BRACE C

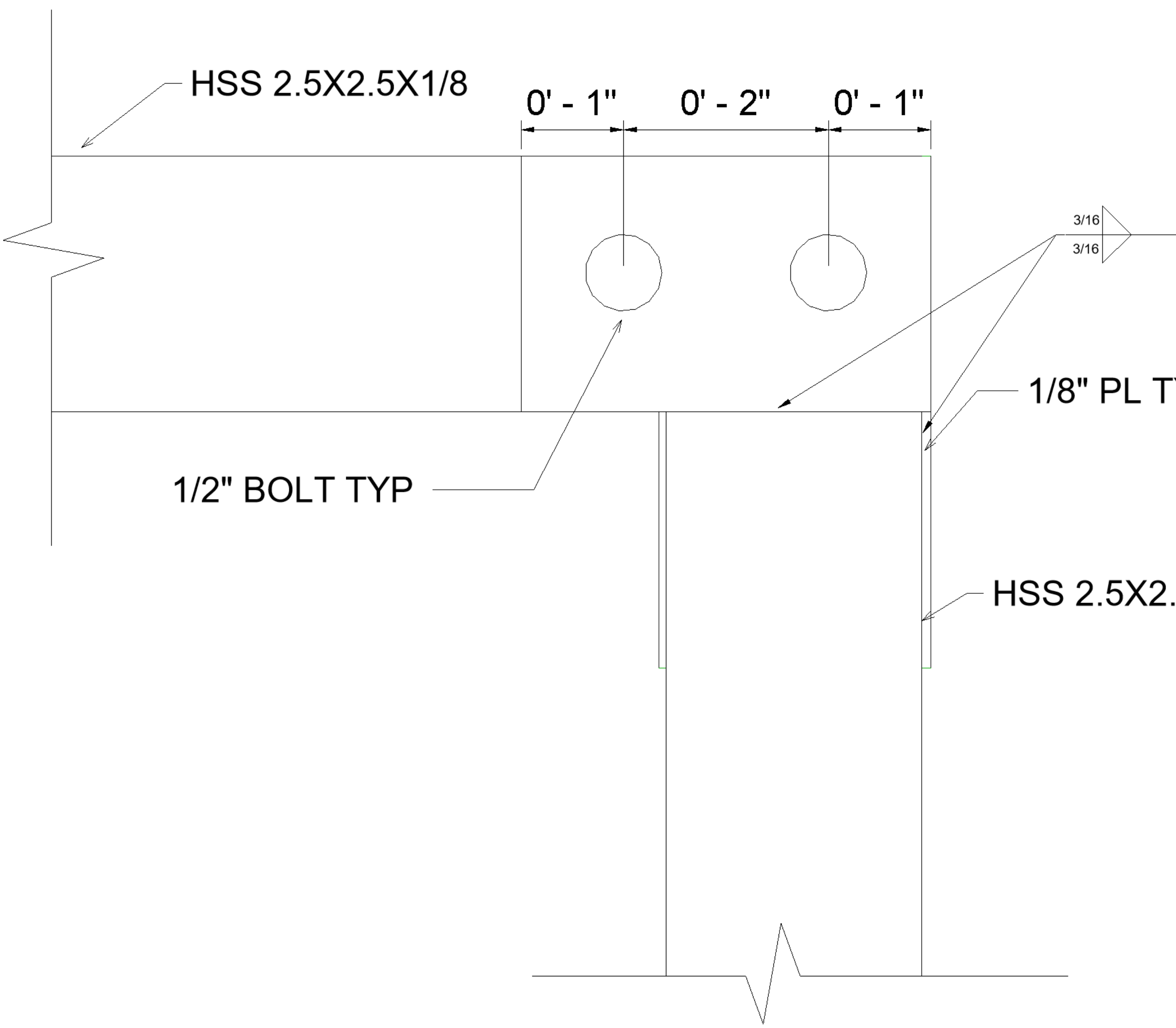
$1.2(.5/2) - 1.95k + .06(3') = \underline{-1.47k}$ ON BRACE T

$\underline{P_u = 2.43k \text{ CONTROLS}}$ (C)

$\phi P_n = 10.9k$ (CONSERVATIVE @12') (AISC 360 T.4-4)

$\frac{d}{c} = \frac{2.43}{10.9} = \underline{.22 < 1.0}$ ✓

BEAM ON TOP OF COLUMN DETAIL



BEAM ON TOP OF COLUMN

RXN FROM BM → SEE BM CALCS

$R_B = 450\#$ WORST CASE, MIDDLE COL = 2 BM RXNS

$P_U = 450\#(2) = .9k$

BEARING:

$\sigma = \frac{P}{A} = \frac{.9k}{1.97in^2} = .45ksi$

$f_{yHSS} = 50ksi > \sigma_{BEARING}$ ✓

BOLTS FOR SHEAR:

WIND ~17PSF FROM WIND CALCS
@BM $(10'/2 \times 6')(17PSF) = 510\#$

USE 1/2" A307 BOLT

RUPTURE ON HSS

$\phi R_n = \phi .6 F_u A_{nv}$

$.75(.6)(62ks)(2.5-(1/2+1/8))(.116)$

$\phi R_n = 6.1k$ $d/c = .51k/6.1k = .08 < 1.0$ ✓

YIELD ON HSS

$\phi R_n = \phi .6 F_y A_{gv}$

$1.0(.6)(50ksi)(2.5")(.116")$

$\phi R_n = 8.7k$ $d/c = .51/8.7 = .06 < 1.0$ ✓

BEAM ON COL CONT'D

SHEAR:

RUPTURE ON SHEAR TAB:

$\phi R_n = \phi .6 F_u A_{nv}$

$= .75(.6)(58ksi)(2.5 - (1/2 + 1/8))(.125")$

$= 6.12k \quad d/c = .51/6.12 = .08 < 1.0$ ✓

YIELD ON SHEAR TAB:

$\phi R_n = \phi .6 F_y A_{gv}$

$1.0(.6)(36ksi)(2.5")(.125")$

$\phi R_n = 6.75k \quad d/c = .51/6.75 = .08 < 1.0$ ✓

1/2" A307 BOLT IN SHEAR

$\phi R_n = \phi F_n A_b$ ← AISC TJ3.2

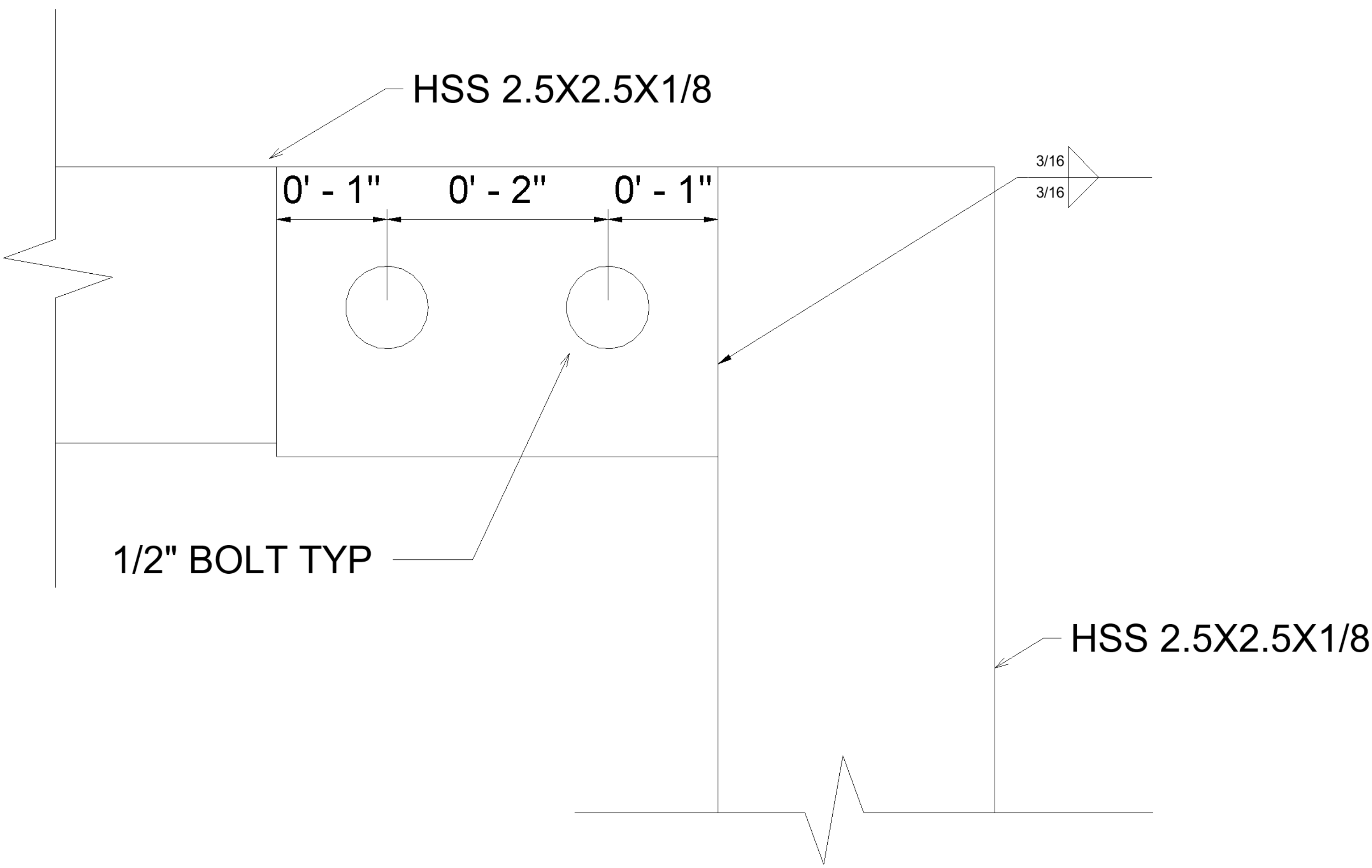
$(.75)(27ksi)(\pi)(1/2 / 2)^2$

$\phi R_n = 3.98k \quad d/c = .51/3.98 = .13 < 1.0$ ✓

1/2" A307 BOLT IN 2½ x 2½ x 1/8 HSS w/ 1/8" PL OKAY ✓

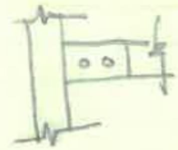
1 BOLT SUFFICIENT, USE TWO TO CREATE A MORE RIGID CONNECTION

BEAM TO COLUMN DETAIL



Rachel Jakel	Bivouacky Shack for WHP	Dec 6 2019

BEAM TO COL CONNECTION:



RXN FROM BM → SEE BM CALCS (WORST CASE)

$R_B = 150\#$

RUPTURE ON HSS:

$\phi R_n = \phi .6 F_u A_{nv}$ (AISC EQN J4-4)

$.75(.6)(62)(2.5 - (1/2 + 1/8))(.116)$

$\phi R_n = 6.07K > .15K$

$d/c = \frac{.15}{6.07} = .024 < 1.0$ ✓

YIELD ON HSS:

$\phi R_n = \phi .6 F_y A_g$

$(1.0)(.6)(50)(2.5)(.116)$

$\phi R_n = 8.7K$

$d/c = .15K / 8.7K = .02 < 1.0$ ✓

RUPTURE ON FLANGE

$\phi R_n = \phi .6 F_u A_{nv}$

$.75(.6)(58ksi)(2.5 - (1/2 + 1/8))(.125)$

$\phi R_n = 6.12K$ $d/c = \frac{.15}{6.12} = .025 < 1.0$ ✓

YIELD ON FLANGE

$\phi R_n = \phi F_y A_{gv} .6$

$1.0(.6)(36ksi)(2.5)(.125)$

$\phi R_n = 6.75K$

$d/c = .15/6.75 = .02 < 1.0$ ✓

BEAM TO COL CONT'D

BEARING:

DIMENSIONAL LIMITATIONS PER AISC CH 10

$L_{EH} \geq 2d = 2(1/2) = 1 \text{ in}$

$L_{EH} = 1 \text{ in}$

$t_p \leq \frac{d_{bolt}}{2} + 1/16 = \frac{1/2}{2} + 1/16 = .3125$

1/8" PL $.125 < .3125$ ✓

BEARING OF BOLT ON SHEAR TAB:

AISC EQ J3-6A

$\phi R_n = \phi 2.4 d t F_u$ ← SHEAR TAB SMALLER THAN HSS, CONTROLS

$= .75(2.4)(1/2)(1/8)(58 \text{ ksi})$

$\phi R_n = 65.25 \text{ k}$ $d/c = .15/65.25 = .002 < 1.0$ ✓

WELD: (FILLET STRENGTH)

$\phi R_n = \phi F_{nw} A_{we}$ (AISC J2.4)

$.75(.707)(1/16")(1.0)(.6)(70 \text{ ksi})$

$\phi R_n = 1.392 \text{ k/in}/\frac{1}{16}"$ OF FILLET

USE MIN 3/16" WELD $\phi R_n = 1.392(3)(2.5 \text{ long}) = 10.44 \text{k}$

3/16" WELD 2.5" LONG

BEAM TO COL CONN:

WELD CONN:

IN DIRECTION OF LOADING →

YIELD:

$\phi R_n = \phi F_n B_m A_{BM}$

$= 1.0(.6 F_y)(t_L)$

$= 1.0(.6)(36ksi)(1/8")(2.5)$

$\phi R_n = 6.75k$ $d/c = .15/6.75 = .02 < 1.0$ ✓

RUPTURE:

$\phi R_n = \phi F_n B_m A_{BM}$

$= .75(.6)(58ksi)(1/8")(2.5")$

$\phi R_n = 8.156k$ $d/c = .15/8.156 = .02 < 1.0$ ✓

GRAVITY ON WELD ↓, SHEAR

A36 1/8" PL SHEAR TAB

YIELD:

$\phi R_n = .6 F_y A_{BM}$

$= .6(36 ksi)(2.5")(.125")$

$\phi R_n = 6.75k$ $d/c = .15/6.75k = .02 < 1.0$ ✓

RUPTURE:

$\phi R_n = .75(.6)(58 ksi)(2.5")(.125")$

$\phi R_n = 8.156k$ $d/c = .15/8.156 = .02 < 1.0$ ✓

BEAM TO COL CONT'D

1/2" BOLT IN SHEAR (A307)

$\phi R_n = \phi F_n A_b$

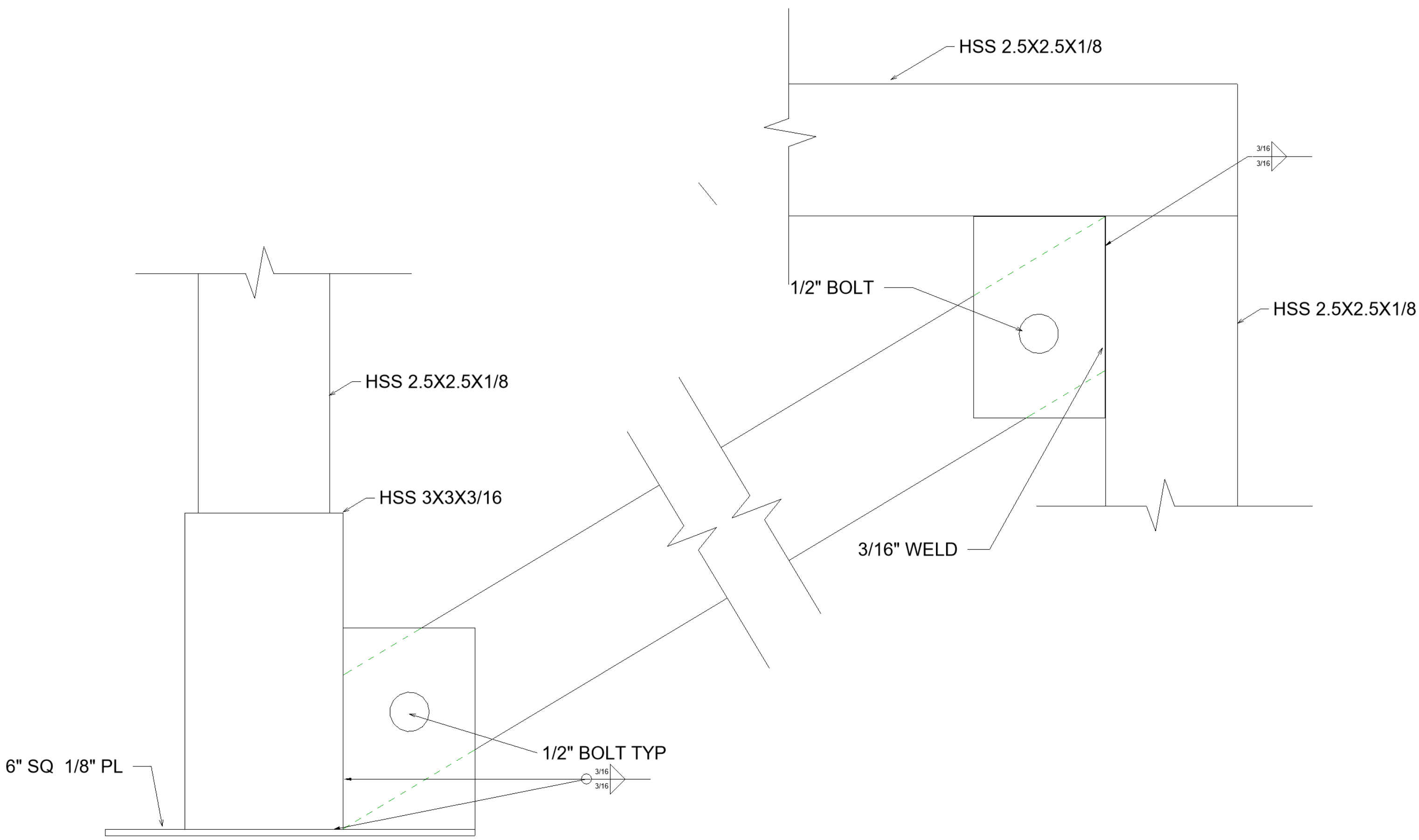
$.75(27ksi)(\pi)(1/2 / 2)^2$

$\phi R_n = 3.98k$ $d/c = .15/3.98 = .04 \leq 1.0$ ✓

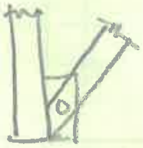
1/2" A307 BOLT IN 2 1/2 x 2 1/2 x 1/8 HSS W/ 1/8 PL OKAY ✓

1 BOLT SUFFICIENT, USE TWO TO CREATE A MORE RIGID CONNECTION

BRACE DETAIL



BRACE CONNECTION



FROM BRACE CALC
$F_b = 1.95k$ $\theta = \tan^{-1}(10/6) = 59°$

$F_x = 1.95\cos 59° = 1.004k$
$F_y = 1.95\sin 59° = 1.67k$

SHEAR:

RUPTURE ON HSS (AISC EQN J4.4)
$\phi R_n = \phi .6 F_u A_{nv}$

$.75(.6)(62ksi)(2.5 - (1/2 + 1/8))(.116")$

$\phi R_n = 10.11k$ $d/c = 1.95/10.11 = .2 < 1.0$ ✓

YIELD ON HSS
$\phi R_n = \phi .6 F_y A_g$

$1.0(.6)(50ksi)(2.5")(.116")$

$\phi R_n = 8.7k$ $d/c = 1.95/8.7 = .22 < 1.0$ ✓

RUPTURE ON SHEAR TAB:
$\phi R_n = \phi .6 F_u A_{nv}$

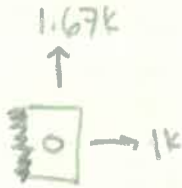
$.75(.6)(58ksi)(2.5 - (1/2 + 1/8))(.125)$

$\phi R_n = 6.1$ $d/c = 1.95/6.1 = .32 < 1.0$ ✓

YIELD ON SHEAR TAB:
$\phi R_n = \phi .6 F_y A_{gv}$

$1.0(.6)(36ksi)(2.5")(.125")$

$\phi R_n = 6.75k$ $d/c = 1.95/6.75 = .3 < 1.0$ ✓



WELD:

FILLET WELD STRENGTH

$\phi R_n = \phi F_{nw} A_{we}$ (AISC J2.4)

$\Rightarrow \phi R_n = 10.44k$ FOR 3/16" FILLET WELD 2.5" LONG

↳ SEE BM TO COL FOR FULL CALC

IN DIRECTION OF LOADING →

YIELD

$\phi R_n = \phi F_{nBM} A_{BM}$

$(1.0)(.6)(36ksi)(1/8")(2.5)$

$\phi R_n = 6.75k > 1k$ $\quad d/c = 1/6.75 = .15 < 1.0$ ✓

RUPTURE

$\phi R_n = \phi F_{nBM} A_{BM}$

$.75(.6)(58ksi)(1/8")(2.5")$

$\phi R_n = 8.16k > 1k$

$d/c = 1/8.156 = .12 < 1.0$ ✓

BRACE CONNECTION CONT'D

↓ GRAVITY ON WELD, SHEAR

FLANGE PLATE

A36 1/8" PL

YIELD

$\phi R_n = .6 F_y A_{gv}$

$.6(36ksi)(2.5")(.125")$

$\phi R_n = 6.75k > 1.67k$

$\frac{d}{c} = \frac{1.67}{6.75} = .25 < 1.0$ ✓

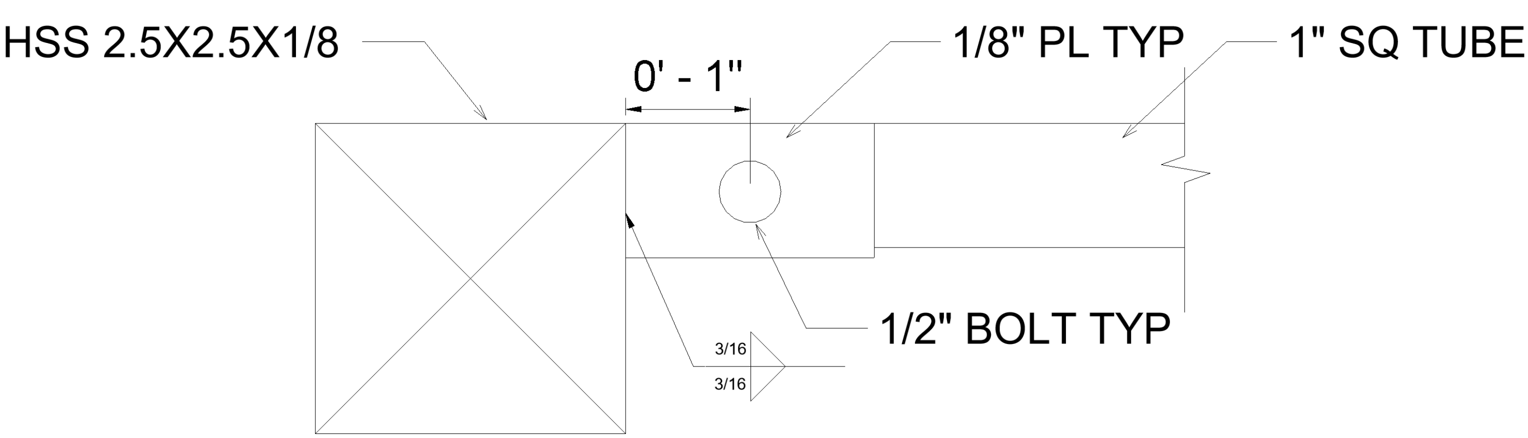
RUPTURE

$\phi R_n = .75(.6)(58 ksi)(2.5")(.125")$

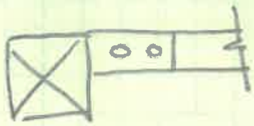
$\phi R_n = 8.156k > 1.67k$

$\frac{d}{c} = \frac{1.67}{8.156} = .2 < 1.0$ ✓

FORM TO BEAM DETAIL



FORM TO BEAM CONNECTION



RXN OF FORM : 500#/2 = 250#
(WORST CASE)
BM RXN = 250#/2 = 125#

SHEAR:

RUPTURE ON TUBE

$\phi R_n = \phi .6 F_u A_{nv}$

$.75(.6)(62ksi)(1-(1/2+1/8))(.0246)$

$\phi R_n = .257k \quad d/c = .125k/.257 = .49 < 1.0$ ✓

YIELD ON TUBE

$\phi R_n = \phi .6 F_y A_{gv}$

$1.0(.6)(50ksi)(1.0)(.0246")$

$\phi R_n = .738k \quad d/c = .125/.738 = .17 < 1.0$ ✓

RUPTURE ON SHEAR TAB:

$\phi R_n = \phi .6 F_u A_{nv}$

$= .75(.6)(58ksi)(1-(1/2+1/8))(.125")$

$\phi R_n = .815k \quad d/c = .125/.815 = .15 < 1.0$ ✓

YIELD ON SHEAR TAB:

$\phi R_n = \phi .6 F_y A_{gv}$

$= 1.0(.6)(36ksi)(1.0)(.125)$

$\phi R_n = 2.7k \quad d/c = .125/2.7 = .05 < 1.0$ ✓

FORM TO BEAM CONNECTION CONTD

1/2" BOLT IN SHEAR

$\phi R_n = \phi F_n A_b$

$.75(54\text{ ksi})(\pi)(1/2 / 2)^2$

$\phi R_n = 7.95k$ $d/c = .125/7.95 = .015 < 1.0$ ✓

BEARING:

DIMENSIONAL LIMITATIONS PER AISC CH10

$L_{EH} \geq 2d = 2(1/2) = 1"$

$t_p \leq \frac{d_{bolt}}{2} + \frac{1}{16}"$

$= 1/2 / 2 + \frac{1}{16} = .3125"$

$1/8" < .3125"$ ✓

1/8" PL OKAY

BEARING OF BOLT ON SHEAR TAB:

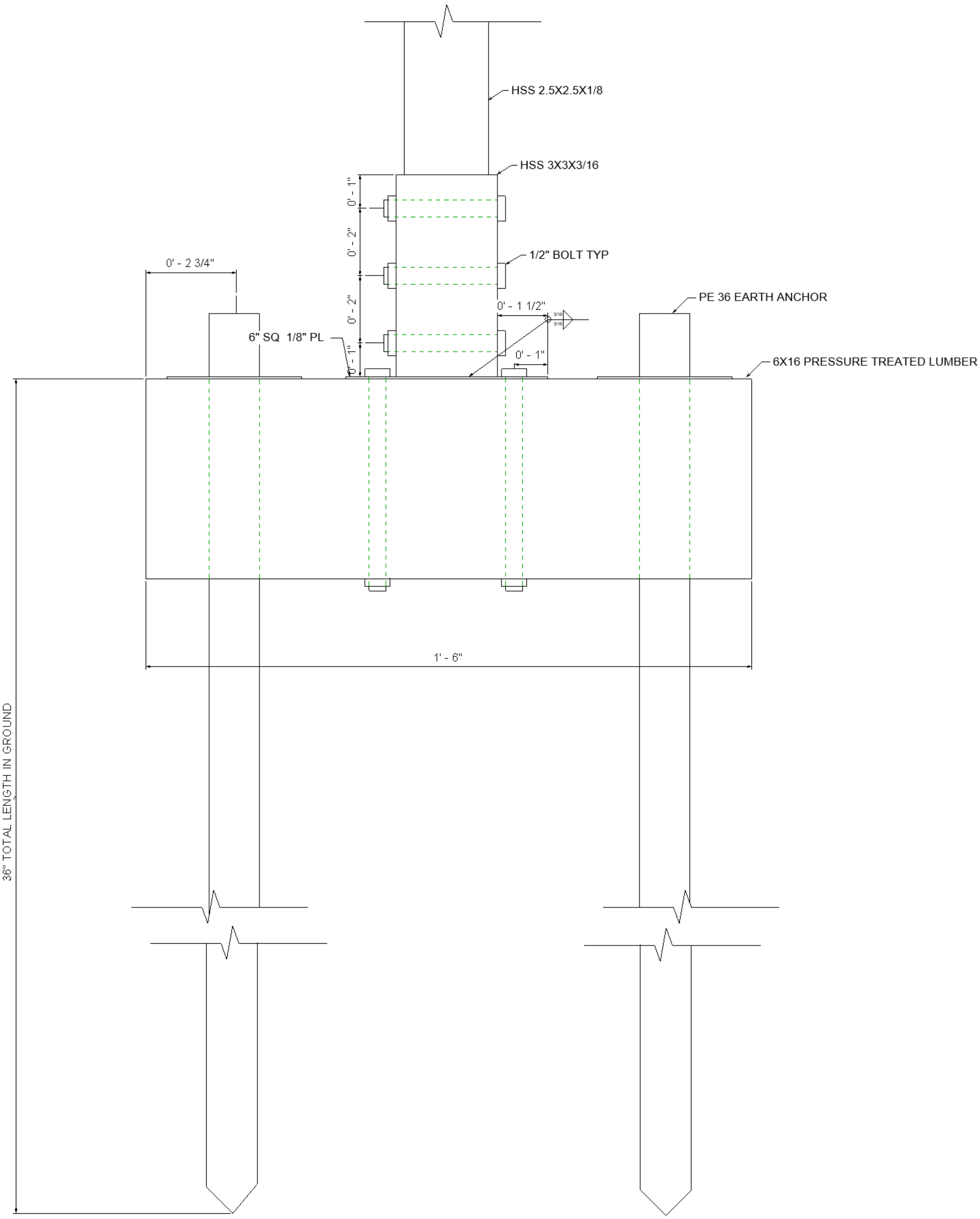
(AISC EQ J3-6A)

$\phi R_n = \phi 2.4 d t F_u$

$= .75(2.4)(1/2)(1/8")(58\text{ ksi})$

$\phi R_n = 6.525k$ $d/c = .125/6.525 = .02 < 1.0$ ✓

FOOTING DETAIL



Rachel Jakel | Bivouacky Shack for WHP | Dec 6 2019

FOOTING DESIGN

WORST GRAVITY CASE:

2.3K ↓ FROM SAP ANALYSIS (SEE APPENDIX)

USE SOIL BEARING PRESSURE F_b = 1000 PSF (WORST CASE)

$\sigma = \frac{P}{A}$ 1000 PSF = $\frac{2300}{A}$

$A = 2.3 ft^2$

USE 1.6' x 1.3' FTG PRESSURE TREATED LUMBER

6x16 W/ 6" SQ BEARING PL

$1.6' \times 1.3' = 2.08 ft^2 < 2.3 ft^2$ BUT BEARING FROM EARTH ANCHORS WILL COVER .22 EXTRA SF.

CHECK $F_{c\perp}$ ON TIMBER

$f_{c\perp} = \frac{RXN}{A_{BEARING}}$

$\frac{2300 \#}{6 in^2}$

= 63.89 psi

$C\perp$ GRADE 2 DFL = 625 psi (NDS 2015 T4A

$F_{c\perp}$ ALLOW 625 psi > $F_{c\perp}$ ACTUAL 63.89 PSI ✓

FOOTING CONT'D

WORST UPLIFT CASE:

1.4K↑ FROM SAP ANALYSIS

UNKNOWN SOIL CLASSIFICATIONS

ASSUME SILTY/CLAYEY SAND

USE AMERICAN EARTH ANCHORS, SEE APPENDIX FOR CAPACITIES

36" PE36

TENSION CAPACITY ~ 2100# PER THIS SOIL CONDITION

USE TWO → OVERESTIMATE FOR UNKNOWN SOIL

CAPACITY ~ 4200#

$D/C = 1.4/4.2 = .33 < 1.0$ ✓

CHECK SLIDING:

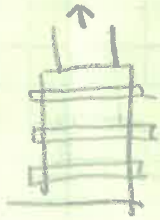
$P_{WIND} < .30$ .3 COEFFICIENT OF FRICTION

VERT RXN FROM SAP .2K ← GRAVITY

XRXN = .0000786 K
YRXN = .0000526 K } WIND

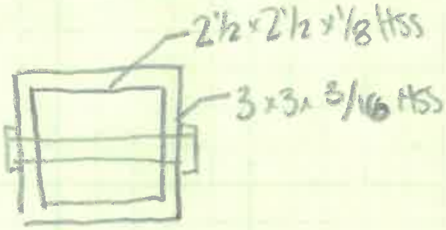
.3(.2) = .06K > .0000786 K ✓

.06K > .0000526K ✓



UPLIFT → SEE SAP RESULTS

SAP RXN = 1.4k WORST CASE



COL DIM = 2.5"

FTG CASE DIM = 3−2(3/16) = 2.625"

2.625" > 2.5" → SNUG FIT

CHECK BOLTS (½") TEAROUT:

SPACING & EDGE DISTANCE

MIN EDGE DIST − 3/4" (AISC J3.4)

½" BOLT IN DOUBLE SHEAR (HSS) THREADS EXCLUDED

$\phi R_n = \phi F_n A_b$ (AISC J3-1)

$\phi R_n = .75(27\text{ ksi})(\frac{1/2}{2})^2\pi$ (27 ksi FROM TJ3.2)

$\phi R_n = 3.98\text{k}$ $\quad d/c = 1.4/3.98 = .35 < 1.0$ ✓

MIN SPACING

$2\frac{2}{3}d = 2\frac{2}{3}(\frac{1}{2}) = 1.33"$

⇒ USE 2" SPACING & 3 BOLTS TO CREATE A MORE RIGID CONNECTION

FOOTING CONT'D

COL ON FTG

COL ON 6"x6" BASE PL BEARING

$t_{min} = L\sqrt{\frac{2P_u}{.9F_yN_B}}$ (AISC 14-7a)

$1.25\sqrt{\frac{2(2.3k)}{.9(36ksi)(6)(6)}}$

$t_{min} = .078$ in ⇒ USE 1/8" PL BEARING

CHECK BOLT THROUGH BEARING PL & WOOD:

1.4k IN TENSION

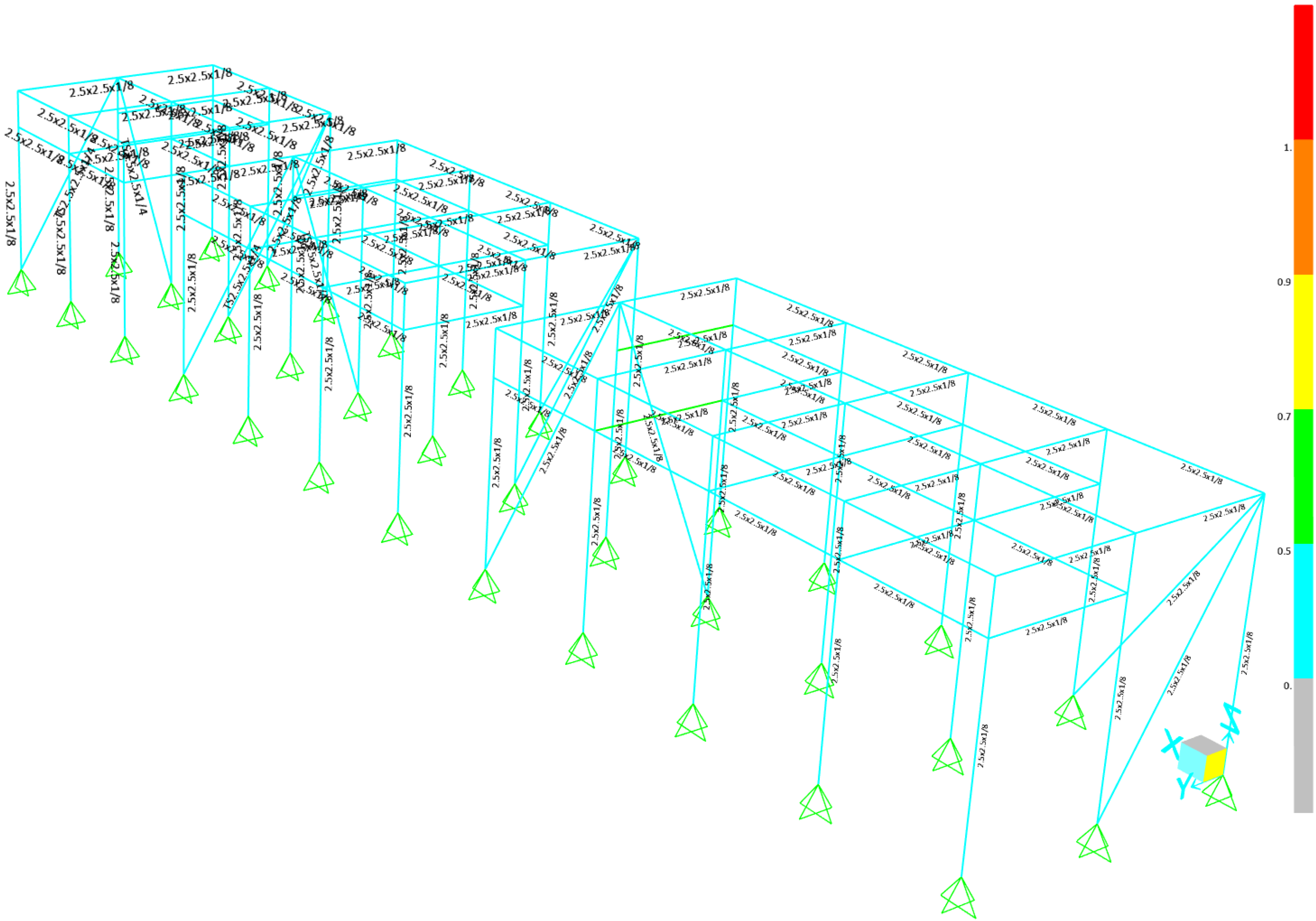
1/2" A307 BOLT $F_{nt} = 45ksi$ (AISC TJ3.2)

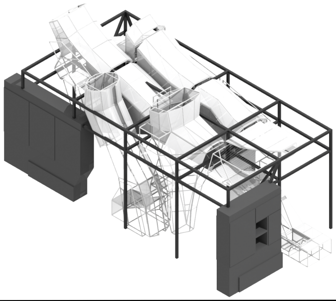
$\phi R_n = \phi F_n A_b$ (J3-1)

$= .75(45ksi)(1/2 / 2)^2 \pi$

$= 6.62k$ $\quad d/c = 1.4/6.62 \approx .2 < 1.0$ ✓

USE TWO BOLTS FOR EVEN DISTRIBUTION

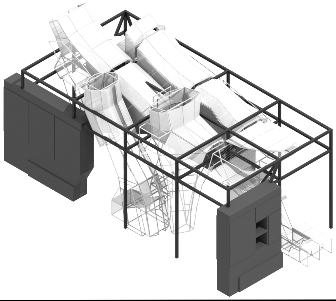

2.5x2.5x1/8
2.5x2.5x1/4
1.
0.9
0.7
0.5
0.



Project: Bivouacky Shack
Client: Wine History Project
Calculated by: Rachel Jakel
Date: 11/27/2019 Sheet No. A1

TABLE: Joint Reactions

Joint	OutputCase	CaseType	F1	F2	F3	M1	M2	M3
Text	Text	Text	Kip	Kip	Kip	Kip-in	Kip-in	Kip-in
58	COMB3asdx	Combination	-0.557	0.008486	0.426	0	0	0
58	COMB3asdy	Combination	-0.066	-0.025	1.304	0	0	0
58	COMB4asdx	Combination	-0.751	0.009184	-1.377	0	0	0
58	COMB4asdy	Combination	-0.096	-0.036	-0.206	0	0	0
36	COMB4asdx	Combination	-0.001999	0.006155	0.353	0	0	0
36	COMB4asdy	Combination	0.0004483	-0.346	0.295	0	0	0
37	COMB1asd	Combination	0.017	0.003015	2.271	0	0	0
37	COMB2asdx	Combination	-0.755	0.008333	-0.652	0	0	0
37	COMB2asdy	Combination	-0.085	-0.059	0.452	0	0	0



Project: Bivouacky Shack
Client: Wine History Project
Calculated by: Rachel Jakel
Date: 11/27/2019 Sheet No. A2

Penetrator Load Capacity Chart - US lbs

Penetrators

PENETRATORS®

LOAD CAPACITY
Pounds

Field-tested pullout resistance

SOIL CLASSIFICATION per ASTM D-2487/2488	9" PE9 PE-T9	10" PE10	14" 18" PE14 PE14-STD PE18 PE18-SQ	26" PE26	36" PE36	46" PE46-Hex PE46-Hex8 PE46-Guy
1 Hardpan Asphalt	400	1,000	2,500	4,500	8,400	14,000
2 Sandy gravel Very dense sand	200	700	1,700	3,100	6,000	9,500
3 Silty or clayey sand Silty gravel	100	350	600	1,100	2,100	3,300
4 Loose to med dense sands Loose sands Firm clays	Less than 100	200	350	630	1,000	2,000
5 Uncompacted fill	Less than 100	100	200	360	550	750

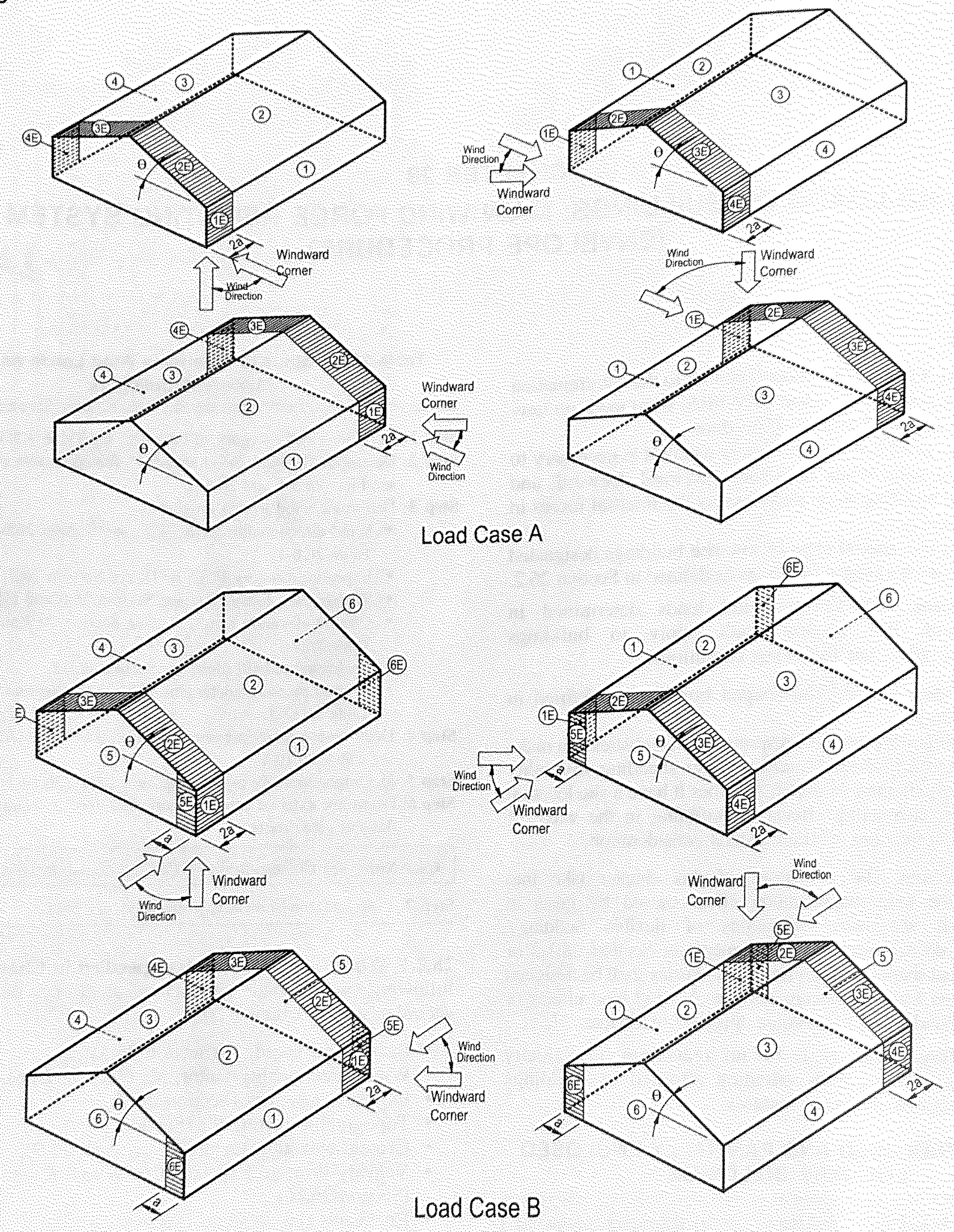
Notes about Penetrator Load Capacity

- Field-tested vertical PULLOUT strength
- PUSHDOWN strength (as when Penetrators are used for footings) is typically equal to or greater than pullout strength because of unlimited undisturbed soil below the Penetrator
- When installed through asphalt, pullout strength is increased because of the Penetrator's grip in the asphalt and in the compacted soil directly below the asphalt

Project: Bivouacky Shack
Client: Wine History Project
Calculated by: Rachel Jakel
Date: 11/27/2019 Sheet No. A3

Basic Load Cases

Diagrams



Notation

a 10% of least horizontal dimension or 0.4 *h*, whichever is smaller, but not less than either 4% of least horizontal dimension or 3 ft (0.9 m).

Exception: For buildings with $\theta = 0$ to 7° and a least horizontal dimension greater than 300 ft (90 m), dimension *a* shall be limited to a maximum of 0.8 *h*.

h Mean roof height, in feet (meters), except that eave height shall be used for $\theta \leq 10°$.

θ Angle of plane of roof from horizontal, in degrees.

FIGURE 28.3-1 Main Wind Force Resisting System, Part 1 [$h \leq 60$ ft ($h \leq 18.3$ m)]: External Pressure Coefficients, (GC_{pf}), for Enclosed and Partially Enclosed Buildings—Low-Rise Walls and Roofs

continues

Credits

Renderings and Site Plan

Project “In Bloom”	Moises De La Cruz
	Mereck Palazzo
Project “Bivouacky Shack”	Erica David
	Jerome Deck
	Alex Urasaki

Assembly, Transportation and Cost Estimate

Project “In Bloom”	Albert Gutierrez
Project “Bivouacky Shack”	Gannon Van Sickle