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

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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.
Architectural Renders and Site Plan
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 senses surrender to the wonder.

— Rumi

PROJECT GOALS

The Wine History Project of San Luis Obispo has outsourced Cal Poly Architecture, Engineering, and Construction Management to assist with the task of designing a pavilion to house a virtual exhibit showcasing thousands of years worth of artifacts showcasing the region’s interlinked cultural traditions in the cultivation and consumption of wine. In an emergent ‘interdisciplinary’ design studio format, students have been tasked with designing a two-component display: 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 use continuous collaboration with local vintners & tasters to curate the tradition forward.

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

Total Weight of HSS: 1135.2 lbs
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

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

Total Weight of HSS: 733.2 lbs
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.
A secondary smaller truck will be needed to transport the remaining prefabricated material.

*All material is to be strapped down and secured during transportation*

Interior of Truck Dimensions
- Volume: 1,583 cu. ft.
- Max Weight: 9,010 lbs
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
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<td>C1-C2</td>
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<td>J1-J9</td>
</tr>
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<td>F1-F3</td>
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**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

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

<table>
<thead>
<tr>
<th>Material</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>HSS 2.5x2.5x1/8</td>
<td>3.90 plf</td>
</tr>
<tr>
<td>Pipe 1 ½ X-strong</td>
<td>3.63 plf</td>
</tr>
<tr>
<td>Architectural Fabric</td>
<td>~3psf</td>
</tr>
</tbody>
</table>

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.
SAMPLE BM CALC

\[ P = \text{DEAD} \quad \downarrow \quad W = \text{LIVE} \]

\[ 5 \quad \downarrow \quad 5 \quad \downarrow \quad 5 \quad \downarrow \quad 5 \quad \uparrow \]

\[ \text{LIVE: } 10 \text{BF} \times 5' \text{ TIEBR WORTH} \]

\[ w = 500 \text{ lb} \]

\[ P = 150 \text{# CONSERVATIVE LOAD FROM SHELL} \]

LOAD COMBOS (ASCE 7-10 2.3.1)

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

2. 1.2D + 1.6L = 1.2(150) + 1.6(50 \times 5' \text{ LENGTH}) = 580# \quad \text{\textit{CONSOLS}}

[HSS 3'x2.5'x3/16]

\[ E = 29000 \text{ ksi}, \quad I = 1.89 \text{ in}^4 \]

\[ 150# \quad \downarrow \quad 500 \text{ lb} \]

\[ \uparrow \quad 210# \quad \uparrow \quad 200# \]

\[ V_{\text{max}} = \frac{.58}{2} = 0.29 \text{k} \]

\[ M_{\text{max}} = \frac{WL^2}{8} + \frac{Pl}{4} \]

\[ 1.0 \left( \frac{50(5)^3}{8} \right) + 1.2 \left( \frac{150(5)}{4} \right) \]

\[ = 475k = 5.7k \]

DEFL (UNFACTORED)

\[ \frac{5WL^4}{384E1} + \frac{Pl^3}{48EI} \]

\[ \frac{5(1000)(5)^4}{384(29000)(1.8)} + \frac{150(5)^3}{48(29000)(1.8)} \]

\[ = 0.015 + 0.015 \]

\[ = 0.03 \text{ in} \]
SAMPLE BI-M CALC CONT

BENDING CHECK:

\[ \phi_{Mn} = \phi_{Fy} \]  (AISC 360-10F)
\[ \phi_{Mn} = (9)(50ksi)(1.73in^3) \]
\[ \phi_{Mn} = 77.85^2 > 3.7K \]
\[ \epsilon = \frac{5.7}{77.85} = 0.073 < 1.0' \]

SHEAR CHECK:

\[ \phi_{Vn} = \phi_c (0.7Fy \cdotAw\cdot c) \]  (AISC 360-61)
\[ \phi_{Vn} = 0.9(1.6)(50ksi)(1.0)(1.71) \]
\[ \phi_{Vn} = 416.17K > 129K \]
\[ \epsilon = \frac{29}{416.17} = 0.069 < 1.0' \]

DEFLECTION CHECK:

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

LIVE

\[ \Delta_{allow} = \frac{l}{180} = \frac{5\times12}{180} = 0.133in \]
\[ \Delta_{actual} = \frac{5\times14^4}{384EI} = 0.015in \]

\[ 0.015in \text{ actual} < 0.13in \text{ allow } \checkmark \]

DEAD + LIVE

\[ \Delta_{allow} = \frac{l}{120} = \frac{5\times12}{120} = 0.5in \]
\[ \Delta_{actual} = 0.03in \]

\[ 0.03in \text{ actual} < 0.5in \text{ allow } \checkmark \]
**SHELL CHECK**

**P.5 x STRONG**  \( I = 0.372 \)

\[
W = \text{SHELL WT}
\]

\[
q'
\]

\[
W = 5.39 \text{ plf}
\]

\[
L = 9 \text{ LENGTH CONSERVATIVE}
\]

\[
V_{\text{max}} = \frac{5.39(9)^{1/2}}{2} = 24.26\text{#}
\]

\[
M_{\text{max}} = \frac{W}{8} = \frac{5.39(9)}{8} = 6.05\text{, k'}
\]

\[
\text{DEFL} = \frac{5wl^4}{384EI}
\]

\[
5(0.005Kli)(9)^{12/4}
\]

\[
\frac{584(2900000}(1.372)
\]

\[
\Delta = 0.053\text{in}
\]
SHELL CHECK COMBO:

BENDING:

\[ \phi_{Mn} = 0.85 F_y \tau \]  
(ASCE 3190 -10F)

\[ \phi_{Mn} = 0.9 (35 \text{ ksi}) (0.549 \text{ in}^2) \]

\[ \phi_{Mn} = 17.29 \text{ k}'' = 1.44 \text{ k} > 0.55 \text{k} \]

\[ \frac{d}{C} = \frac{0.55 \text{k}}{1.44 \text{k}} = 0.39 < 1.0 \checkmark \]

SHEAR:

\[ \phi_{Vn} = \phi_v (0.65 A_w C_y) \]  
(ASCE 3190 -11)

\[ \phi_{Vn} = 0.96 (35 \text{ ksi}) (10 \text{ in}) (\tau) \]

\[ = 18.9 \text{k} > 0.024 \text{k} \]

\[ \frac{d}{C} = \frac{0.024 \text{k}}{18.9 \text{k}} = 0.001 < 1.0 \checkmark \]

DEFLECTION CHECK:

DEAD + LIVE  
(IRC 2018 T1609.3)

\[ \Delta_{allow} = \frac{f}{120} = 9 \times 12/120 = 0.9 \text{ in} \]

\[ \Delta_{actual} = 0.53 \text{ in} \]

\[ \frac{0.53 \text{ in}}{0.9 \text{ in}} \text{ actual} < 0.9 \text{ in allow} \checkmark \]
SAMPLE COLUMN CHECK

\[ W = W_{wind} = 18.53 \text{ psf} (5' \times 5' \text{ trib width}) = 92.105 \text{ psf} \]
\[ P = \text{ Live load} = 10 \text{ psf} (5' \times 5' \text{ trib area}) = 250 \text{#} \]
\[ \text{Dead load} = 150/2 = 75 \text{#} \]
\[ \text{Load combo 1} + 2 \text{ combos} \quad R = 290 \text{#} \quad \text{(see prev calc R)} \]
\[ P_1 = 4 \text{ bus} \times 290 = 1160 \text{#} \]
\[ P_2 = 150 \text{#} \text{ conservative load from shell} \]

HSS 2\frac{1}{2} \times 2\frac{1}{2} \times \frac{1}{8}

COMBINED AXIAL & BENDING (AISC 360 C & H)
\[ \frac{P_r}{P_c} = \frac{1.34k}{12.9k} \quad \leftarrow \text{(AISC 360 T4-4)} = 0.10 \leq 0.2 \]

\[ W = 92.105 \text{#} \]
\[ 1.8k \]
\[ 141k \quad \text{+ 79#} \]
\[ 781\text{#} \]
\[ M_{max} = \frac{WL^2}{8} = \frac{92105(11)^2}{8} = 1.4k = 16.82k'' \]
\[ V_{max} = 301k \]
\[ A_{max} = 1.31k \]
SAMPLE COLUMN CHECK CONT

\[ \frac{P}{P_c} \leq 0.2 \quad \text{(USE AISC EQN H1-1b)} \]

\[ \frac{P}{P_c} + \left( \frac{M_r}{W_c} \right) \leq 1.0 \]

\[ \frac{1.31}{2(12.9)} + \frac{11682k''}{855k'' \times 12\text{ in}^3} \leq \text{AISC T3-13} \]

\[ = 0.45 \leq 1.0 \checkmark \]
LATERAL WIND LOADS

PARTIALLY ENCLOSED BLDG, LOW RISE BLDG, W<600'
ASCE 7-110 CH 28

1. RISK CATEGORY: II (ASCE 7-110 T1.5-1)

2. BASIC WIND SPEED V=95 MPH (ASCE 7-110 FIG 26.5-1B)

3. EXPOSURE CATEGORY: C (ASCE 26.9)

TOPOGRAPHIC FACTOR k24 = 1.0 (FLAT) (ASCE 7-110 26.8.1)

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

WIND DIRECTIONALITY kA = 0.85 (ASCE 7-110 T.26.6-1)

GROUND ELEVATION FACTOR k_e = 1 (ASCE 7-110 26.9)

INTERNAL PRESSURE COEFFICIENT GC Pe = +0.05 (ASCE 7-110 T26.13-1)

4. VELOCITY PRESSURE EXPOSURE COEFFICIENT k_a/k_e = 0.85 (ASCE 7-110 T26.10-1)

5. VELOCITY PRESSURE q_2 = q_20 \cdot \Theta^{3/2} (ASCE 7-110 EQN 26.10-1)

\[ q_2 = 0.00256 \cdot k_a \cdot k_e \cdot k_v \cdot \Theta^{3/2} (\#/ft^2) \]

\[ = 0.00256 \cdot (0.85) \cdot (1) \cdot (0.85) \cdot (1.0) \cdot (95) \]

\[ = 110.69 \, \#/ft^2 \]

6. EXTERNAL PRESSURE COEFFICIENT GC Pe (ASCE 7-110 FIG 26.3-1)

\[ \Delta Q = 35^\circ \]

\[ \begin{array}{cccccccc}
\text{LOAD CASE} & A & & & & & & \\
\text{1} & \text{2} & \text{3} & \text{4} & \text{5} & \text{6} & \text{7} & \text{8} \\
\text{0.50} & -0.21 & -0.43 & -0.37 & 0.03 & -0.77 & -0.33 & -0.48 \\
\end{array} \]

\[ \begin{array}{cccccccc}
\text{LOAD CASE} & B & & & & & & \\
\text{1} & \text{2} & \text{3} & \text{4} & \text{5} & \text{6} & \text{7} & \text{8} \\
-0.43 & -0.61 & 0.37 & -0.45 & -0.12 & -0.18 & -0.07 & -0.18 \\
\end{array} \]
F. Wind Pressure $p$ (ASCE 7-10 28.3-1)

$p = qh \left( 6C_1 + 8C_p \right) \cdot 14^2$

$P_a = 10.69(0.50 + 0.55) = 18.53$ psf

$P_b = 10.69(0.21 + 0.55) = 12.08$ psf

$P_c = 10.69(-0.43 - 0.55) = -10.36$ psf

$P_d = 10.69(-0.37 - 0.55) = -15.35$ psf

Load Case A

$P_e = 10.69(-0.45 - 0.55) = -10.69$ psf

$P_f = 10.69(-0.69 - 0.55) = -20.09$ psf

$P_g = 10.69(-0.37 - 0.55) = -15.35$ psf

$P_h = 10.69(-0.45 - 0.55) = -10.69$ psf

$P_i = 10.69(-0.40 + 0.55) = 15.85$ psf

$P_j = 10.69(-0.29 - 0.55) = -14.62$ psf

Load Case B

* $p$ not to be less than 110 psf on walls & 81 psf on roof (ASCE 7-10 28.3-4)
SAMPLE FRAME CALCULATION

\[ W = 18.5 \text{ psf} \times (5' \times 8') = 711.2 \# \]

\[ F_{\text{max}} = \frac{W}{5} = \frac{F_0}{9.43} \]
\[ F_0 = 140 \# \text{ (from bm calcs)} \]
\[ W_L = 50 \# \text{ (from bm calcs)} \]

LOAD COMBOS (ASCE 7-10 2.3.1)

\[ A = 1.2(\text{1.0W + 1.0L}) + 1.4(\text{1.0W + 0.5(2.5)}) = 1.52 \text{ k(C)} \]
\[ 1.2(\text{1.52}) - 1.4(\text{1.0k + 0.5(2.5)}) = -1.29 \text{ k(T)} \]

\[ P_0 = 1.52 \text{ k C controls} \]
\[ \Phi P_n = 1.5 \text{ k conservative (ISC 360 T4-4) } \]

\[ \frac{P}{C} = \frac{1.52}{150} = 0.1 < 1.0 \]
BEAM TO COL CONNECTION:

RAN FROM BM SEE BM CALS (WOEFULL CASE)
R_B = 150 #

RUPTURE ON HSS:

\[ \phi_{Rn} = \phi_{u} \frac{F_{u}A_{n}}{V} \]  
\[ (1.0)(1.0)(.62)(2.5) - (1/2 + \frac{1}{8})(.116) \]
\[ \phi_{Rn} = 6.07 k > 1.5k \]
\[ \frac{d_{c}}{c_{o}} = \frac{.15}{6.07} = .024 < 1.0v \]

YIELD ON HSS:

\[ \phi_{Rn} = \phi_{u}F_{y,A}g \]
\[ (1.0)(1.0)(.62)(2.5)(.116) \]
\[ \phi_{Rn} = 8.7 k \]
\[ \frac{d_{c}}{c_{o}} = \frac{.15}{8.7k} = .02 < 1.0v \]

RUPTURE ON FLANGE:

\[ \phi_{Rn} = \phi_{u} \frac{F_{u}A_{n}}{V} \]
\[ (1.0)(.6)(.5865)(2.5) - (1/2 + \frac{1}{8})(.128) \]
\[ \phi_{Rn} = 6.12 k \]
\[ \frac{d_{c}}{c_{o}} = \frac{.15}{6.12} = .025 < 1.0v \]

YIELD ON FLANGE:

\[ \phi_{Rn} = \phi_{u}F_{y,A}g \]
\[ (1.0)(.6)(.5865)(2.5)(.128) \]
\[ \phi_{Rn} = 6.75 k \]
\[ \frac{d_{c}}{c_{o}} = \frac{.15}{6.75} = .024 < 1.0v \]
BEAM TO COL COND

BEARING:

DIMENSIONAL LIMITATIONS PER AISC CH 10

\[ L_{bd} = 2d = 2(\frac{1}{2}) = 1 \text{ in} \]

\[ L_{bd} = 1 \text{ in} \]

\[ c_{bd} = \frac{d_{bd}}{2} + \frac{3}{16} = \frac{1}{2} + \frac{3}{16} = \frac{11}{16} \]

\[ \frac{1}{8} \text{ in} \]

\[ 0.125 < 0.375 \]

BEARING OF BOLT ON SHEAR TAB:

AISC EQ J3-60

\[ \phi R_n = \phi _{Ad} f_{T} \]

\[ = 0.75(2.4)(1/4)(1/8)(60 \text{ ksi}) \]

\[ \phi R_n = 65.25 \text{ k} \]

\[ c/L = 0.15/65.25 = 0.002 < 0.01 \]

WELD: (FILLET STRENGTH)

\[ \phi R_n = \phi _{Fm} d_{Aw} \] (AISC J2.4)

\[ = 1.392 \text{ k/in } \text{ in } 3/16\text{ of fillet} \]

USE MIN 3/16" WELD \[ \phi R_n = 1.392(3)(2.5 \text{ in}) = 10.49 \text{ k} \]

3/16" WELD 2.5" LONG
BEAM TO COL

WELD COND:
IN DIRECTION OF LOADING →

YIELD:

\[ \Phi_{kn} = \Phi F_y A_{nm} \]
\[ = 1.0(0.6 F_y)(12) \]
\[ = 1.0(0.6)(30 ksi)(1/8'')(25) \]
\[ \Phi_{kn} = 0.75 k \quad d/c = 0.15/0.75 = 0.2 < 1.0 \]

RUPNRE:

\[ \Phi_{kn} = \Phi F_y A_{nm} \]
\[ = 0.75(0.6)(58 ksi)(1/8'')(25) \]
\[ \Phi_{kn} = 8.150 k \quad d/c = 0.15/8.150 = 0.02 < 1.0 \]

GRAVITY ON WELD + SHEAR

ASO 1/8'' PL. SHEAR TAB

YIELD:

\[ \Phi_{kn} = 0.6 F_y A_{nm} \]
\[ = 0.6(30 ksi)(2.5'')(125) \]
\[ \Phi_{kn} = 6.75 k \quad d/c = 0.15/6.75 = 0.02 < 1.0 \]

RUPNRE:

\[ \Phi_{kn} = 0.75(0.6)(58 ksi)(2.5'')(125) \]
\[ \Phi_{kn} = 8.150 k \quad d/c = 0.15/8.150 = 0.02 < 1.0 \]
BEAM TO COL CONNECTION

1/2" BOLT IN SHEAR (A325)

\[ \phi_{Fn} = \phi_{Fm} A_b \]

\[ 0.75(27Ks)(\pi)(\frac{1}{2})^2 \]

\[ \phi_{Fn} = 3.98k \quad \phi_{Fm} = 1.5Ks \quad \frac{\phi_{Fn}}{\phi_{Fm}} \leq 1.0 \]

1/2" A325 BOLT IN 2" x 2 1/2 x 1/8 HSS W/HFK OKAY

1 BOLT SUFFICIENT USE TWO TO CREATE A MORE RIGID CONNECTION
BRACE DETAIL

HSS 2.5X2.5X1/8

1/2" BOLT

HSS 2.5X2.5X1/8

HSS 3X3X3/16

1/2" BOLT TYP

6" SQ 1/8" PL
BRACE CONNECTION:

From brace calc:
\[ F_0 = 1.9k \quad \theta = \tan^{-1}(\frac{8}{15}) = 58^\circ \]
\[ F_x = 1.4 \cos 58^\circ = 0.74k \]
\[ F_y = 1.4 \sin 58^\circ = 1.19k \]

Check bolt for shear:
Rupture on HSS: (A1x and T4A)
\[ \phi R_n = 0.6 F_y A_n \]
\[ = 0.75(6)(6)(2.5 - (\frac{12}{2} + \frac{1}{8}))(0.116) \]
\[ \phi R_n = 6.07k \quad \frac{d}{c} = 1.41/0.62 = 2.23 < 1.0 \]

Yield on HSS:
\[ \phi R_n = 0.6 F_y A_n \]
\[ = 1.0(6)(5.0)(5.0)(2.5)(0.116) \]
\[ \phi R_n = 8.7k \quad \frac{d}{c} = 1.41/0.87 = 1.62 < 1.0 \]

Rupture on flange:
\[ \phi R_n = 0.6 F_y A_n \]
\[ = 0.75(6)(5)(5)(2.5 - (0.2 + 0.2))(0.125) \]
\[ \phi R_n = 6.12k \quad \frac{d}{c} = 1.41/0.62 = 2.23 < 1.0 \]

Yield on flange:
\[ \phi R_n = 0.6 F_y A_n \]
\[ = 1.0(6)(3.6)(5)(2.5)(0.125) \]
\[ \phi R_n = 6.75k \quad \frac{d}{c} = 1.41/0.62 = 2.24 < 1.0 \]
BEAM CONNECTION CONT'D

WELD:
FILLET WELD STRENGTH

\[ \phi R_n = \phi F_n B_m A_m \]

(\text{AISC J2.4})

\[ \Rightarrow \phi R_n = 10.44 \text{kFt} \]

For 3/16" FILLER WELD 2.5" long

\( 6.582 \text{ BM TO CAL FOR FULL CALL} \)

IN DIRECTION OF LOADING \( \rightarrow \)

YIELD

\[ \phi R_n = \phi F_n B_m A_m \]

\[ (1.0)(1.6)(3600)(\frac{1}{8})(25) \]

\[ \phi R_n = 6.75 > 4.74 \text{kFt} \]

\[ 1/8 = \frac{24}{75} > 1.0 \]

RUPTURE

\[ \phi R_n = \phi F_n B_m A_m \]

\[ 175(6)(5800)(\frac{1}{8})(2.5) \]

\[ \phi R_n = 8.156 \text{kFt} > 4.74 \text{kFt} \]

\[ 1/8 = \frac{24}{75} > 1.0 \]

SHEAR, GRAVITY ON WELD \( \downarrow \)

FLANGE PLATE ADD 1/8" IR

YIELD

\[ \phi R_n = \phi F_n A_m \]

\[ = 1.6(3600)(2.5)(1.25) \]

\[ \phi R_n = 10.75 > 4.74 \text{kFt} \]

\[ 1/8 = \frac{24}{75} > 1.0 \]

RUPTURE

\[ \phi R_n = 175(6)(5800)(2.5)(1.25) \]

\[ \phi R_n = 8.156 \text{kFt} > 4.74 \text{kFt} \]

\[ 1/8 = \frac{24}{75} > 1.0 \]
SHELL TO COLUMN DETAIL

0' - 1 1/2" 0' - 1 1/2"

P1.5 X-STRONG
P2X-STRONG

1/2" BOLT TYP
1/8" PL

HSS 2.5X2.5X1/8
SHELL TO STRUCTURE CONNECTIONS

- 1/4" x 1/2" x 1.9"
- 3/4" x 1.9"
- 2" x 1.9"
- 1/2" Bolt
- 1.9A > 1.9" SNSA fit

WIND UPLIFT = 20.69 PSF

WORST CASE: (20.69 PSF) x (5 x 5 SQFT) = 517.25 # > USE 600# T

CHECK BOLTS (1/2") TEAROUT

SPACING & EDGE DISTANCE

MIN EDGE DISTANCE = 3/4" (AISC J3A)

1/2" AB6T BOLT IN DOUBLE SHEAR (PLATE W/J HOLE EXCLUDED)

\[ \phi_R = \phi_{FA} A_b \] (AISC J3-1)

\[ \phi_R = 0.75(27 ksi) \left( \frac{1}{2} \right)^2 \pi \] (27 ksi from T332 AISC)

\[ \phi_R = 3.98 \text{kips} \geq 600 \text{#} \]

\[ \Delta \frac{C}{C_0} = 0.15 \leq 1.0 \]

MIN SPACING

\[ 2 \times 0.75 \times 1.33" = 1.83" \Rightarrow USE 1.5" (N/A, ONE BOLT) \]

1.5"
Yield of Pipe:

\[ \Phi_P = \Phi_f A_g \]
\[ \Phi_P = 9.85 \text{ ksi} \times 1.0 \]
\[ \Phi_P = 31.5 \text{ kips} > 10 \text{k} \]
\[ d/k = 0.02 < 1.0 \]

Rupture of Pipe:

\[ dP_n = \Phi_f A_g \]
\[ dP_n = 60 \text{ ksi} \times (1.0 - \frac{1}{2} + 1/8) \]
\[ \Phi_P = 16.88 \text{kips} > 10 \text{k} \]
\[ d/k = 0.06/16.88 = 0.0035 < 1.0 \]
FOOTING DESIGN

WORST GRAVITY CASE:

W.2 k from SAP Analysis

Use soil bearing pressure $P_{s} = 1000$ psi (worst case)

\[ P_{s}/A = 10200/ \]

\[ A = 6.2 \text{ ft}^2 \]

2' x 1.3' FTC for bearing

Use lower pressure treated timber w/ 6" SQ RL

A 2' x 1.3' = 2.6 \text{ ft}^2 < 6.2 \text{ but bearing from}

Earth anchors is at least tearout value, will

cover difference

CHECK $F_{cu}$ ON TIMBER

\[ F_{cu} = \frac{R_{y}}{A_{BEARING}} \]

\[ = \frac{6000}{6 \times 6} \]

\[ = 172.2 \text{ psi} \]

C1 Grade 2 OFL = 625 psi (NDS 285 T-44)

$F_{cu}$ allow 625 psi $> F_{cu}$ actual 172.2 psi $\checkmark$
FOOTING CONT

WORST UPLIFT CASE

4.2ft ↑ FROM SAP ANALYZE (APPENDIX)

UNKNOWN SOIL CLASSIFICATIONS
ASSUME SILTY CLAYEY SAND
USE AMERICAN EARTH NUGGETS, SEE CAPACITIES IN APPENDIX

40" P-40-1HC

TENSION CAPACITY ~ 3.3k PER THIS SOIL CONDITION
USE TWO

CAPACITY 3.3(2) = 6.6k

\[
\frac{d}{c} = \frac{4.2}{0.6} = 0.6 < 1.0
\]

CHECK SLIDING:

\[
\text{Wind} < 0.3 \quad \text{COEFFICIENT OF FRICTION}
\]

\[
\begin{align*}
\text{VEXT RXN FROM SAP} & = 0.06k & \text{GRAVITY} \\
\text{X RXN} & = 0.00978k & \text{WIND} \\
\text{Y RXN} & = 0.0008k
\end{align*}
\]

\[
1.03(0.06) = 0.18k > 0.00978k
\]

\[
0.18k > 0.0008k
\]
UPLIFT => SEE SAP RESULTS
SAP RUN = -4.3x WORST CASE

COL DIM = 2.5"
FIT TO CASE DIM = 3-2(3/16)=2.625"
2.625" > 2.5" => SNE BUT FITS

CHECK BOLTS (1/2") TEAR OUT:
SPACING & EDGE DISTANCE
MIN EDGE DIST = 3/4" (AISC J3-4)

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

\[ \Phi \text{Re}_n = \Phi \text{Re}_n A \] (AISC J3-1)
\[ \Phi \text{Re}_n = 7(27 \text{ksi})(1/2)^2 \text{Ti} \quad (27 \text{ ksi FROM T J3.2)} \]

\[ \Phi \text{Re}_n = 3.98k \quad \frac{d}{c} = 9.3/3.98 = 1.08 > 1.0 \text{ N.G.} \]

USE SPACING TO CREATE MORE RIGID CONNECTION WITH 2" SPACING

\[ : 4.3 \frac{k}{3 \text{ studs}} = 1.43k \]

\[ \frac{d}{c} = 1.43k/3.98k \approx 0.36 < 1.0 \]

MIN SPACING

2\( \frac{3}{4} \)" = 2\( \frac{3}{16} \times 12 \) = 1.83"

=> USE 2" W/ 3 BOLTS FOR MORE RIGID CONNECTION
FOOTING, CONT'D

COL ON PFG
COL ON 6" X 6" BOLT & BEARING

\[ t_{min} = \frac{2P}{\sqrt{1.9 t_{uf} N_{p}}} \]  
\[ 1.25 \frac{2(6.25)}{\sqrt{.9 \times 3649 \times 10^6}} \]

\[ t_{min} = .157" \Rightarrow USE \frac{1}{4}" \text{ BEARING} \]

CHECK BOLT THROUH P & NOOD
6A2k IN TENSION

\( \frac{1}{2} \) " A307 BOLT \( f_{tk} = 45 \text{ksi} \) (AISC T-3.2)

\[ \Phi Rn^2 \Phi F_n A_n \]  
\[ .95 (45 \text{ksi}) (\frac{1}{2})^2 \pi \]

\[ .0162k \ \Phi C = 0.12/0.62 = .19 < 1.0 \]

CLOSE TO 1.0,
USE TWO BOLTS FOR EVEN DISTRIBUTION ANYWAY
<table>
<thead>
<tr>
<th>Joint</th>
<th>OutputCase</th>
<th>CaseType</th>
<th>F1</th>
<th>F2</th>
<th>F3</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>COMB4asdx</td>
<td>Combination</td>
<td>-0.116</td>
<td>-0.001277</td>
<td>-0.0046</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>12</td>
<td>COMB1asd</td>
<td>Combination</td>
<td>-0.000765</td>
<td>-0.001272</td>
<td>0.395</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>12</td>
<td>COMB2ASDx</td>
<td>Combination</td>
<td>-0.092</td>
<td>-0.014</td>
<td>6.222</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>12</td>
<td>COMB3ASDy</td>
<td>Combination</td>
<td>-0.002446</td>
<td>-0.069</td>
<td>1.812</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>58</td>
<td>COMB2asdy</td>
<td>Combination</td>
<td>0.022</td>
<td>-0.209</td>
<td>0.13</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>58</td>
<td>COMB3asdx</td>
<td>Combination</td>
<td>-1.941</td>
<td>0.017</td>
<td>-2.753</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>58</td>
<td>COMB4asdx</td>
<td>Combination</td>
<td>-2.588</td>
<td>0.026</td>
<td>-4.298</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>56</td>
<td>COMB1asd</td>
<td>Combination</td>
<td>-5.383E-05</td>
<td>-0.001143</td>
<td>0.34</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>56</td>
<td>COMB2ASDx</td>
<td>Combination</td>
<td>-0.109</td>
<td>0.002051</td>
<td>-0.129</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Penetrator Load Capacity Chart - US lbs

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
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\(^\circ\) 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 \( \theta \leq 10^\circ \).

\( \theta \) Angle of plane of roof from horizontal, in degrees.

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

continues
Architectural Renders and Site Plan
Assembly, Transportation and Cost Estimate
### Module 1 - 4 Bay

<table>
<thead>
<tr>
<th>Material</th>
<th>Qty</th>
<th>Unit</th>
<th>Unit Price</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>HSS Super Structure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 1/2&quot;x1/8&quot; HSS</td>
<td>300</td>
<td>LF</td>
<td>$69.00 per 20'</td>
<td>$1,035.00</td>
</tr>
<tr>
<td>2&quot;x 1/8&quot; HSS</td>
<td>40</td>
<td>LF</td>
<td>$55.00 per 20'</td>
<td>$110.00</td>
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<tr>
<td>1/2 in.-13 x 4 in. Galvanized Hex Bolt</td>
<td>188</td>
<td>Count</td>
<td>$2.16 each</td>
<td>$362.88</td>
</tr>
<tr>
<td>6 in. x 16 in. x 8 ft. Hem-Fir Brown Stain Ground Contact Pressure-Treated Lumber</td>
<td>104</td>
<td>LF</td>
<td>$18.27 per 8'</td>
<td>$182.71</td>
</tr>
<tr>
<td>1/2 in.-13 x 4 in. Galvanized Hex Bolt</td>
<td>336</td>
<td>Count</td>
<td>$0.46 each</td>
<td>$154.56</td>
</tr>
<tr>
<td>1/2 in. Galvanized Lock Washer</td>
<td>336</td>
<td>Count</td>
<td>$0.31 each</td>
<td>$104.16</td>
</tr>
<tr>
<td>4&quot;x8&quot;x1/4&quot; Plate Steel (A36)</td>
<td>5</td>
<td>Counts</td>
<td>$258.76 each</td>
<td>$1,293.80</td>
</tr>
</tbody>
</table>

**SUM** $3,297.91

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

**SUM** $3,088.65

<table>
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<tr>
<th>Wall</th>
<th>Qty</th>
<th>Unit</th>
<th>Unit Price</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2&quot; 4 ft. x 8 ft. Oriented Strand Board</td>
<td>10</td>
<td>Count</td>
<td>$17.55</td>
<td>$175.50</td>
</tr>
<tr>
<td>2&quot;x4&quot;x96&quot; Stud</td>
<td>400</td>
<td>LF</td>
<td>$3.00 per 8'</td>
<td>$150.00</td>
</tr>
<tr>
<td>3 in. Construction Screw (10 lb.-Box)</td>
<td>2</td>
<td>Count</td>
<td>$33.57 per 10lb box</td>
<td>$67.14</td>
</tr>
<tr>
<td>4&quot;x8&quot; x 5/8&quot; Dens Deck</td>
<td>10</td>
<td>Count</td>
<td>$49.00</td>
<td>$490.00</td>
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<tr>
<td>Thermo Plastic Membrane</td>
<td>120</td>
<td>SF</td>
<td>$6.00 per SF</td>
<td>$720.00</td>
</tr>
</tbody>
</table>

**SUM** $1,602.64

### Module 1 Total
- 4 Bays
- $7,989.20

### Module 2 Total
- 6 Bays
- $3,994.60

### Module 3 Total
- 8 Bays
- $3,994.60

### 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 PORTABILITY

Members:

12': 
6':
10':
11'-8':

NOTE
1. Heaviest Steel Member is #60
WALL PORTABILITY

Divide of two parts of wall

DIMENSION OF MODULAR WALL
DESCRIPTION

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
<table>
<thead>
<tr>
<th>Description</th>
<th>Page Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Project Description</td>
<td>D2</td>
</tr>
<tr>
<td>2. Load Takeoff</td>
<td>D3</td>
</tr>
<tr>
<td>3. Key Plan</td>
<td>D4-D5</td>
</tr>
<tr>
<td>5. Column Design</td>
<td>C1-C2</td>
</tr>
<tr>
<td>7. Connections</td>
<td>J1-J9</td>
</tr>
<tr>
<td>8. Footing Design</td>
<td>F1-F3</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Material</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>HSS 2.5x2.5x1/8</td>
<td>3.90 plf</td>
</tr>
<tr>
<td>1&quot; SQ Steel Tube</td>
<td>1.20 plf</td>
</tr>
<tr>
<td>Corrugated Plastic</td>
<td>~.5 psf</td>
</tr>
</tbody>
</table>

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

\[ P = \text{dead} \]
\[ W = \text{live} \]
\[ 60 \text{"} \]
\[ \text{load} \times (\text{dead}) \]
\[ W = \text{dead} + \text{live} \]

LOAD CONDES (CASE 7:10 2.5:1)
1. \( 1.4D = 1.4(300) = 700 \text{ lb} \)
2. \( 1.2D + 1.6L = 1.2(300) + 1.6(60 \times 10) = 11760 \text{ lb} \)

HSS 2.5\text{x2.5} \text{W}

\( E = 29000 \text{ ksi} \)

\( I = 0.998 \text{ in}^4 \)

\[ \Delta = 0.01D \]

\[ W_{\text{dead}} \]

\[ W_{\text{live}} \]

\[ V_{\text{max}} = \frac{45K}{U} \]

\[ M_{\text{max}} = \frac{KL^2}{8} + \frac{PL}{4} \]

\[ 1.1 \left( \frac{500(300)}{8} \right)^{0.5} (\text{sec}6) = 1.2 \]

\[ \text{DEFL} = \frac{5WL^4}{384EI} + \frac{PL^3}{48EI} \text{ (UNFACTORED)} \]

\[ = \frac{5(300)(4)(12)^3}{384(2900)(29000)} + \frac{48(300)(2900)}{48(2900)(29000)} \]

\[ = 0.19 \text{ in} \]
SAMPLE BUM CONTO

BENDING CHECK:
\[ \phi M_n = \phi (F_y \ell) \quad (AISC 360-10F) \]
\[ \phi M_n = 0.9(50ksi)(947in^3) \]
\[ \phi M_n = 42.03k in > 15.91k in \]
\[ \frac{d}{C} = \frac{13.90}{42.03} = 0.37 < 1.0 \checkmark \]

SHEAR CHECK:
\[ \phi V_n = \phi (F_y A_n C_u) \quad (AISC 360-10) \]
\[ \phi V_n = 0.9(5)(50ksi)(1.0)(1.07in) \]
\[ \phi V_n = 28.97k in > 1.45k \]
\[ \frac{d}{C} = \frac{1.45}{28.97} = 0.015 < 1.0 \checkmark \]

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

LIVE
\[ \Delta_{allow} = \frac{l}{180} = \frac{6\times12}{180} = 0.4 in \]
\[ \Delta_{actual} = \frac{5wL^4}{384EI} = \frac{5(600\text{lb})(6\times12)^4}{384(2900\text{ksi})(998\text{in}^4)} = 0.00 in \]
\[ 0.00 in \text{ actual} < 0.4 in \text{ allow} \checkmark \]

DEAD + LIVE
\[ \Delta_{allow} = \frac{l}{120} = \frac{6\times12}{120} = 0.6 in \]
\[ \Delta_{actual} = 0.19 in \]
\[ 0.19 in \text{ actual} < 0.6 in \text{ allow} \checkmark \]
SAMPLE COLUMN CHECK:

\[ W = W_{\text{WIND}} = 10,000 \text{ PSF} (\text{W' TEUS WIDTH}) = 100,144 \text{ lb} \]

\[ P_{\text{LIVE}} = 10 \text{ PSF} (10' \times 10' \text{ TEUS AREA}) = 360 \text{ lb} \]

\[ P_{\text{DEAD}} = 500 \text{ lb} / 2 = 250 \text{ lb} \]

\( P \) \text{ LOAD COMBO #2 CONTROLS} \[ R_{\text{MIN}} = 450 \text{ lb} \]

\[ P = 3 \text{ BMS} \times 450 = \frac{135}{3} \text{ lb} \]

HSS 2'\( \frac{3}{4} \) x 2'\( \frac{3}{4} \) x \( \frac{1}{8} \)

COMBINED AXIAL & BENDING (AISC310 \( C \& H \))

\[ \frac{P}{P_{C}} = \frac{1.35}{15} = \frac{1.35}{15} \approx (AISC310 \ T4-1) = 0.09 < 0.2 \]

\[ \begin{align*}
\ell_c &= \frac{P_{1.35}}{1.35} \\
\ell_c &= 1.35 \text{ ft} \\
\end{align*} \]

\[ M_{\text{MAX}} = \frac{W_{\text{L}} \ell_{c}^2}{8} = \frac{100.14 \times (10) \ell_{c}^2}{8} = 125 \text{ k} \]

\[ V_{\text{MAX}} = 5 \text{ k} \]

\[ A_{\text{MAX}} = 1.35 \text{ k} \]
SAMPLE BM CALC COUP

\[ \frac{P_r}{P_c} \leq 0.2 \quad (\text{USE AISC EON H1-1b}) \]

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

\[
\begin{align*}
1.35k + 15k'' \\
15.1k'' + \left( 3.55k'' \times 12'' \times 10 \right) & \leq \text{AISC T3-13} \\
= 0.44 \leq 1.0 & \checkmark
\end{align*}
\]
LATERAL WIND LOADS

PARTIALLY ENCLOS. BLDG., LOW RISE BLDG W/100'

ASCE 7-110 CH 28

1. RISK CATEGORY: II (ASCE 7-110 T.5-1)

2. BASIC WIND SPEED V = 95 MPH (ASCE 7-110 FIG 26.5-1B)

3. EXPOSURE CATEGORY: C (ASCE 26.11)

TOPOGRAPHIC FACTOR K24 = 1.0 (FLAT) (ASCE 7-110 26.8.1)

ENCLOSURE: PARTIALLY ENCLOS. → HIGH INTERNAL PRESSURE (ASCE 26.13.1)

WIND DIRECTIONALITY KD = 0.85 (ASCE 7-110 T. 26.6-1)

GROUND ELEVATION FACTOR KE = 1 (ASCE 7-110 26.9)

INTERNAL PRESSURE COEFFICIENT GCp = ±.55 (ASCE 7-110 T26.13-1)

4. VELOCITY PRESSURE EXPOSURE COEFFICIENT KDP/KD = 0.85 (ASCE 7-110 T26.10-1)

5. VELOCITY PRESSURE $q_p/30$ (ASCE 7-110 ECON 26.10-1)

$$q_p = 0.02556 K_2 K_2 e K_4 K_6 V^2 \text{ (lb/ft}^2)$$

$$= 0.02556(0.85)(1)(0.85)(1.0)(.95)$$

$$= 110.69 \text{ #/ft}^2$$
D. EXTERNAL PRESSURE COEFFICIENT (GC)  (ASCE 7-10 FIG 28.3-1)

\[ \theta = 0 \]

<table>
<thead>
<tr>
<th>LOAD</th>
<th>CASE A</th>
<th>BLDG. SURFACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td>1.4 - .019 - .37 - .21 - .01 - .047 - .053 - .045</td>
</tr>
</tbody>
</table>

**LOAD CASE B**

<table>
<thead>
<tr>
<th>LOAD</th>
<th>CASE A</th>
<th>BLDG. SURFACE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>.45 - .64 - .39 - .45 - .40 - .21 - .48 - .109 - .35 - .38 - .60 - .78 - .45</td>
</tr>
</tbody>
</table>

7. WIND PRESSURE P  (ASCE 7-10 28.3-1)

\[ P = g_n \left( GC_{pf} + GC_{pc} \right) \approx 1 \text{ ft}^2 \]

\[ P_A = 10.69 \left( .4 + .55 \right) = 15.85 \text{ psf} \]

\[ P_B = 10.69 \left( -.49 - .55 \right) = -20.69 \text{ psf} \]

\[ P_C = 10.69 \left( .37 - .55 \right) = -15.35 \text{ psf} \]

\[ P_D = 10.69 \left( -.29 - .55 \right) = -14.02 \text{ psf} \]

\[ P_E = 10.69 \left( -.45 - .55 \right) = -10.69 \text{ psf} \]

\[ P_F = 10.69 \left( -.69 - .55 \right) = -26.69 \text{ psf} \]

\[ P_G = 10.69 \left( .37 - .55 \right) = -15.35 \text{ psf} \]

\[ P_H = 10.69 \left( -.45 - .55 \right) = -10.69 \text{ psf} \]

\[ P_I = 10.69 \left( .4 + .55 \right) = 15.85 \text{ psf} \]

\[ P_J = 10.69 \left( -.29 - .55 \right) = -14.02 \text{ psf} \]

*P NOT TO BE LESS THAN 10 psf on walls & 8 psf on roof

(ASCE 7-10 28.3-4)
SAMPLE BRACE CALCULATION

\[ W = 10 \times 0.9216 \text{ (8' TRUS WIDTH) (10' HT)} = 1001.4 \text{#} \]

\[ F_{\text{max}} = \frac{W}{0.1} = \frac{F_{B}}{11.86} \]

\[ F_{B} = 1.95 \text{ k} \] (T & C for W both directions)

\[ P_{D} = 500 \text{#} \] (from BM calc)

\[ W_{L} = 60 \text{#} \] (from BM calc)

LOAD COMPOS (ASCE 7-10 2.3.1)

\[ A. 1.2 D + 1.0 W + 1.0 L = 1.2(\frac{5}{2}) + 1.95k + .06(3.5) = 2.43k \text{ ON BRACE C} \]

\[ 1.2(\frac{5}{2}) - 1.95k + .06(3.5) = -1.47k \text{ ON BRACE T} \]

\[ F_{D} = 2.43k \text{ CONTROLS (C)} \]

\[ \Phi_{D} = 10.9k \text{ (CONSERVATIVE @12") (ASCE 31600 T.4.4)} \]

\[ \text{C} = \frac{2.43}{10.9} = 0.22 < 1.0 \text{V} \]
BEAM ON TOP OF COLUMN  DETAIL

HSS 2.5X2.5X1/8

0' - 1"
0' - 2"
0' - 1"

1/2" BOLT TYP

1/8" PL TYP

HSS 2.5X2.5X1/8

3/16"
BEAM ON TOP OF COLUMN

Ryn from 15M → See wind calcs
R_b = 450 kips
\[ P_u = 450 \times 0.9 = 405 \text{ kips} \]

Bearing:

\[
\sigma_{\text{b}} = \frac{P_u}{A} = \frac{405}{1.9+1.1} = 166 \text{ ksi}
\]

\[
f_{\text{b}} \text{tess} = 50 \text{ ksi} > \sigma_{\text{b}} \text{tess} \checkmark
\]

BOLTS FOR SHEAR:

Wind ~ 17 psf, from wind calcs
C8M (10 1/2" x 6") (17 psf) = 510#
Use 1/2" A325 bolt

Rupture on fss
\[
\phi P_n = \phi f_{\text{u}} A_n
\]

\[
75 \times (6.25 \times 2.5) \times (25-6) \times 0.116
\]

\[
\phi P_n = 0.12 \text{ ksi} = 0.12 \text{ ksi} = 0.8 \leq 1.0
\]

Yield on fss

\[
\phi P_n = 0.65 f_{\text{u}} A_n
\]

\[
1.0 (6.25) (2.5) (25-6) \times 0.116
\]

\[
\phi P_n = 8.7 \text{ ksi} = 8.7 \text{ ksi} \leq 1.0
\]
BEAM ON COL COVID

STEEL:

YIELD ON STEEL TAB:

\[ \phi_{ry} = 0.6F_{y}\sqrt{A} \]
\[ = 0.6(60,000)(2.5^2)(1.25^2) \]
\[ = 0.62k \quad d/c = 0.51/0.75 = 0.8 < 1.0 \]

YIELD ON STEEL TAB:

\[ \phi_{ry} = 0.6F_{y}\sqrt{A} \]
\[ = 0.6(60,000)(2.5^2)(1.25^2) \]
\[ = 0.62k \quad d/c = 0.51/0.75 = 0.8 < 1.0 \]

1/2" Anchor Bolt in STEEL

\[ \phi_{kn} = \frac{F_{n}}{A_{n}} \] (TJ3:2)
\[ = \frac{675 \times 2.725 \times \pi}{(12)^2} \]
\[ = 3.98k \quad d/c = 0.51/3.98 = 0.13 < 1.0 \]

1/2" Anchor Bolt in 2.5x2.5x1/4 HSS w/ 1/8" FL OKAY

BOLT SUFFICIENT USE TWO TO CREATE A MORE RIGID CONNECTION
BEAM TO COL CONNECTION:

RAN FROM BURGL SEE BM CALS (WORST CASE)

\( R_b = 150 \) #

RUPTURE ON HSS:

\[ \phi R_n = \frac{\phi_n Fu_{Anu}}{A_{eqm} \text{ EQN J4-9)}} \]

\( 0.75(0.6)(62)(2.5 - \left(\frac{1}{2} + \frac{1}{8}\right) \times 1.16) \)

\( \phi R_n = 6.07 \text{ K} \geq 1.5k \)

\[ d/V = \frac{0.15}{6.07} = 0.024 < 1.0 \]

YIELD ON HSS:

\[ \phi R_n = \phi_n Fu_{Ag} \]

\( 1.0(0.6)(56)(2.5)(116) \)

\( \phi R_n = 8.7 \text{ K} \)

\[ d/V = \frac{0.15}{8.7} = 0.02 < 1.0 \]

RUPTURE ON FLANGE:

\[ \phi R_n = \phi_{bflm} \]

\( 0.75(0.6)(58)(51)(2.5 - \left(\frac{1}{2} + \frac{1}{8}\right))(1.12) \)

\( \phi R_n = 6.12 \text{ K} \)

\( d/V = \frac{0.15}{6.12} = 0.025 < 1.0 \)

YIELD ON FLANGE:

\[ \phi R_n = \phi_{fflm} \]

\( 1.0(0.6)(58)(51)(2.5)(1.12) \)

\( \phi R_n = 6.75 \text{ K} \)

\[ d/V = \frac{0.15}{6.75} = 0.022 < 1.0 \]
BEAM TO COL CONN

BEARING:

DIMENSIONAL LIMITATIONS PER AISC CH 10

\[ L_{el} \geq 2d_1 = 2(\frac{1}{2}) = 1\text{ in} \]

\[ L_{el} = 1\text{ in} \]

\[ L_{p} = \frac{d_{bh}}{2} + \frac{1}{16} = \frac{1}{2} + \frac{1}{16} = 0.3125 \]

\[ 0.125 < 0.3125 \checkmark \]

BEARING OF BOLT ON SHEAR TAB:

AISC EQ J3-6A

\[ \phi_{Rn} = \phi_{2} A_d t F_c \]

Shear Tab Smaller Than H31 Conn.

\[ = 0.75(24)(\frac{1}{2})(16)(60\text{ksi}) \]

\[ \phi_{Rn} = 65.25 \text{ k} \quad d/c = 0.15/65.25 \quad \cos \theta < 1.0 \]

WELD (FLUENT STRENGTH)

\[ \phi_{Rn} = \phi_{flu} A_w t_e (AISC J2.4) \]

\[ = 0.75(0.707)(\frac{1}{16})(1.0)(1.0)(70\text{ksi}) \]

\[ \phi_{Rn} = 1.392 \text{ k} / \text{in} / \text{mil} \text{ of Flu} \]

USE MIN 3/16" WELD \[ \phi_{Rn} = 1.392(3)(2.5\text{ in}) = 10.44 \text{ k} \]

3/16" WELD 2.5" LONG
BEAM TO COLLAR

WELD COLLAR
IN DIRECTION OF LOADING →

YIELD:

\[ \Phi_{ny} = 0.75 \frac{F_y}{A_{fm}} \]
\[ = 1.0 \times 0.75 \times 30 \text{ksi} \times \left( \frac{1}{8}'' \right) \times \left( 25'' \right) \]
\[ \Phi_{ny} = 0.75 \times 0.15 \times 0.75 = 0.2 \leq 1.0 \]

RUPTURE:

\[ \Phi_{ru} = 0.75 \frac{F_y}{A_{fm}} \]
\[ = 0.75 \times 30 \text{ksi} \times \left( \frac{1}{8}'' \right) \times \left( 25'' \right) \]
\[ \Phi_{ru} = 8.13 \times 0.15 \times 0.75 = 0.2 \leq 1.0 \]

GRAVITY ON WELD ↓ SHEAR
ASO 1/8" Fl. SHEAR TAB

YIELD:

\[ \Phi_{ny} = 0.75 \frac{F_y}{A_{fm}} \]
\[ = 0.75 \times 30 \text{ksi} \times \left( 2.5'' \right) \times \left( 1.25'' \right) \]
\[ \Phi_{ny} = 0.75 \times 0.75 \times 0.75 = 0.2 \leq 1.0 \]

RUPTURE:

\[ \Phi_{ru} = 0.75 \times 30 \text{ksi} \times \left( 2.5'' \right) \times \left( 1.25'' \right) \]
\[ \Phi_{ru} = 8.13 \times 0.75 \times 0.75 = 0.2 \leq 1.0 \]
BEAM TO COL COND

1/2" BOLT IN SHEAR (A325)

$\phi P_n = \phi P \cdot A_b$

$.75(274k)(\pi)(\frac{1\frac{1}{2}}{2})^2$

$\phi P_n = 398k \quad d/c = .15\frac{db}{c} = .64 < 1.0$

1/2" A325 BOLT IN 2'12" 2'12" 1/8" HSS W/ 1/8" OKAY

1 BOLT SUFFICIENT USE 2 TO CREATE A MORE RIGID CONNECTION
**BEAM CONNECTION**

From Beam Calc:
\[ F_0 = 1.95k \quad \theta = \tan^{-1}(19\%) = 51^0 \]

\[ F_x = 1.95 \cos 59^\circ = 1.094k \]

\[ F_y = 1.95 \sin 59^\circ = 1.67k \]

**STEER:**

Rupture on HSS (AISC Sec J4.4)
\[ f_{rn} = 0.6 F_{uA}n \]
\[ 75(0.6)(62ksi)(2.5 - (2.5/16)) / 0.116'' \]
\[ f_{rn} = 10.11k \quad d/c = 1.95 / 10.11 = 0.2 < 1.0 \]

Yield on HSS
\[ f_{rn} = 0.6 F_{yA} \]
\[ 110(0.6)(50ksi)(2.5'')(0.116) \]
\[ f_{rn} = 8.7k \quad d/c = 1.95 / 8.7 = 0.22 < 1.0 \]

Rupture on Steer Tab:
\[ f_{rn} = 0.6 F_{uA}n \]
\[ 75(0.6)(58ksi)(2.5 - (2.5/16)) / 0.125 \]
\[ f_{rn} = 6.1 \quad d/c = 1.95 / 6.1 = 0.32 < 1.0 \]

Yield on Steer Tab:
\[ f_{rn} = 0.6 F_{yA} \]
\[ 10(0.6)(30ksi)(2.5'')(0.125) \]
\[ f_{rn} = 6.75k \quad d/c = 1.95 / 6.75 = 0.3 < 1.0 \]
WELD:

FILLER WELD STRENGTH

\[ \Phi n = \Phi_{fw} A_{me} \quad (AISC \ J2.1) \]

\[ \Rightarrow \Phi n = 10.44k \quad \text{FOR 3/16" FILLER WELD 2S" LOADS} \]

(S SEE BM TO COL FOR FULL CALL)

IN DIRECTION OF LOADING →

YIELD

\[ \Phi F_n = \Phi_{Fv} B_m A_{bm} \]

\[ (1.0 \times 10 \times 30 \times 5)(\frac{1}{8}) (2S) \]

\[ \Phi F_n = 10.75k > 1k \quad \frac{d}{c} = \frac{1}{0.75} = 1.33 < 1.0 \]

RUPTURE

\[ \Phi R_n = \Phi_{Rv} B_m A_{bm} \]

\[ (7S \times 6)(38 \times 5)(\frac{1}{8}) (2S) \]

\[ \Phi R_n = 8.76k > 1k \]

\[ \frac{d}{c} = \frac{1}{8.76} = 0.12 < 1.0 \]
BRACE CONNECTION CONTO

GRAVITY ON WELD, S12AR

FLANGE PLATE
A36 1/8" P

YIELD
\[ \phi_r n = 0.105A_{pl} \]
\[ = 0.105(0.1)(2.5)(0.125) \]
\[ \phi_r n = 0.75 k > 1.07 k \]
\[ a = \frac{1.07}{0.75} = \frac{1.25}{1.0} \leq 1.0 \]

RUPTURE
\[ \phi_r n = 0.75(1.6)(0.8)(2.5)(0.125) \]
\[ \phi_r n = 8.156 k > 1.07 k \]
\[ a = \frac{1.07}{8.156} = \frac{1.2}{8.156} \leq 1.0 \]
FORM TO BEAM DETAIL

HSS 2.5X2.5X1/8

0' - 1"

1/8" PL TYP

1" SQ TUBE

1/2" BOLT TYP
FORM TO BEAM CONNECTION

RIN OF FORM: \( \frac{500\text{ lb}}{2} = 250\text{ lb} \)  
(Worst Case)

BU RIN: \( \frac{250\text{ lb}}{2} = 125\text{ lb} \)

SHEAR:

Rupture on TUBE:
\[ \phi_{RN} = 0.6F_{u} \]
\[ 0.75(1.6) (0.25) (1 - (0.12 + 0.1))(0.0216) \]
\[ \phi_{RN} = 257\text{ K} \quad d_K = \frac{125}{257} = 0.49 < 1.0 \]

YIELD ON TUBE:
\[ \phi_{RN} = 0.6F_{yA} \]
\[ 1.0(1.0) (0.05) (1)(0.0216) \]
\[ \phi_{RN} = 738\text{ K} \quad d_K = \frac{125}{738} = 0.17 < 1.0 \]

Rupture on SHEAR TAB:
\[ \phi_{RN} = 0.6F_{u} \]
\[ 0.75(1.6) (0.25) (1 - (0.12 + 0.1))(0.125) \]
\[ \phi_{RN} = 891\text{ K} \quad d_K = \frac{125}{891} = 0.15 < 1.0 \]

YIELD ON SHEAR TAB:
\[ \phi_{RN} = 0.6F_{yA} \]
\[ 1.0(1.0) (0.05) (1)(0.125) \]
\[ \phi_{RN} = 272\text{ K} \quad d_K = \frac{125}{272} = 0.46 < 1.0 \]
FOAM TO BEAM CONNECTION CIVET

1/2" BOLT IN SHEAR

\[ \phi_{\text{fn}} = \phi_{\text{fn Av}} \]

\[ = 0.75(54 \text{ksi}) \times \pi \times \left(\frac{1}{2}\right)^2 \]

\[ = 7.95 \text{ ksi} \]

\[ d/c = 0.125 / 3.05 = 0.041 < 1.0 \]

BEARING:

DIMENSIONAL LIMITATIONS PER AISC CH 10

\[ L_{\text{bf}} \geq 2d = 2(1/2) = 1" \]

\[ t_{\phi} = \frac{d_{\text{bolt}}}{2} + \frac{1}{16}" \]

1/2 + 1/16 = 3/16" = 0.1875"

1/8" < 0.1875" ✔

1/8" P.O.K.

BEARING OF BOLT ON SHEAR TAB:

(AISC EQ 73-6A)

\[ \phi_{\text{fn}} = \phi_{2A} d \times f_u \]

\[ = 0.75(2A)(1/8)(1/8)(58 \text{ksi}) \]

\[ = 6.525 \text{ ksi} \]

\[ d/c = 0.125 / 6.525 = 0.02 < 1.0 \]
FOOTING DESIGN

WORST GRAVITY CASE:

2.3k ↓ FROM SAP ANALYSIS (SEE APPENDIX)

USE SOIL BEARING PRESSURE Fb = 1000 psf (WORST CASE)

\[ C = \frac{P}{A} \quad 1000 \text{ psf} = \frac{2300}{A} \]

\[ A = 2.3 \text{ ft}^2 \]

USE 1.6' x 1.3' FTC PRESSURE TREATED TIMBER

LNB 10' W/ 6" SOIL BEARING Fc

1.6' x 1.3' = 2.08 ft\(^2\) < 2.3 \text{ ft}^2 \quad \text{BUT BEARING FROM EARTH ANCHORS WILL COVER .22 EXTRA SF.}

CHECK Fc\(_t\) ON TIMBER

\[ \text{FCt} = \frac{\text{EFN}}{\text{ABE}} \]

\[ \frac{2300}{600} = 63.33 \text{ psi} \]

C1 GRADE 2 DFL = 625 psi (NDS 2015 4A)

FCt Allow 625 psi > FCt Actual 63.89 psi
FOOTING CONTOUR

WORST UPLIFT CASE:

1. ACT FROM SAP ANALYSIS
2. UNKNOWN SOIL CLASSIFICATIONS
   ASSUME SILTY CLAYY SAND
3. USE AMERICAN EARTH ANCHORS, SEE APPENDIX FOR CAPACITIES
   36" PEP60
   PONSEN CAPACITY ~ 2000# PER THIS SOIL CONDITION
4. USE TWO TO OVERESTIMATE FOR UNKNOWN SOIL
   CAPACITY ~ 4200#

\[ \frac{C}{L} = 1.4/4.2 = \frac{1.33}{1.0} < 1.0 \]

CHECK SLIDING:

F\text{wind} < 0.30 \quad \text{COEFFICIENT OF FRICTION}

VERT KIN FROM SAP .2k \text{ Gravity}

\begin{align*}
X_{\text{kin}} &= 0.000786 k \\
Y_{\text{kin}} &= 0.000520 k
\end{align*}

\begin{align*}
13(2) &= 0.06k > 0.000786 k \checkmark \\
0.06k &> 0.000520 k \checkmark
\end{align*}
UPLIFT SEE SAP RESULTS
SAP RUN = 1.4k WORST CASE

COH DIM = 25"
FIT CASE DIM = 3 - 2(3/16) = 26 25/32"
2.625" > 2.5" → SAFE FIT

CHECK BOLTS (1/2") TEAROUT:

SPACING EDGE DISTANCE
MIN EDGE DIST = 3/4" (AISC J3.4)
1/2" BOLT IN DOUBLE SHEAR (HS) THREMS EXCLUDED

\[ \sigma_n = \sigma_{n, A} \quad (AISC J3-1) \]
\[ \sigma_{n, A} = 7500 (27 ksi) \left( \frac{1}{2} \right)^{1/2} \approx (27 ksi FROM J3.2) \]
\[ \sigma_n = 3.78 k \quad \alpha_k = 1.4/69.8 = 0.05 < 1.0 \]

MIN SPACING

\[ 2\sqrt{d} = 2\sqrt{3/16} = 1.38" \]

USE 2" SPACING & 3 BOLTS TO CREATE A MORE RELIABLE CONNECTION
FOOTING CONT'D

COL ON 7" FTG

COL ON 6' x 6' BASE & BEARING

\[ t_{\text{min}} = \frac{L(2R_d)}{P_{h,w,b}} \quad (AISC M-76) \]

\[ 1.25 \sqrt{\frac{2(2.3k)}{0.9(36ksi)(6)6}} \]

\[ t_{\text{min}} = 0.678 \text{ in} \quad \Rightarrow \text{USE } \frac{1}{8} \text{" R BEARING} \]

CHECK BOLT THROUGH BEARING & WOOD:

1.9 k IN TENSION

\[ \frac{1}{2} \text{" A307 BOLT } F_{\text{ct}} = 45 \text{ksi} \quad (AISC TJ3.2) \]

\[ \phi R_n = \phi F_n A_0 \quad (J3-1) \]

\[ = 0.62(45ksi)(\frac{1}{2})^2 \]

\[ = 6.62 k \quad \phi L = 1.4/0.62 = 2.3 < 4.0 \]

USE TWO BOLTS FOR EVEN DISTRIBUTION
# TABLE: Joint Reactions

<table>
<thead>
<tr>
<th>Joint</th>
<th>OutputCase</th>
<th>CaseType</th>
<th>F1</th>
<th>F2</th>
<th>F3</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
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</thead>
<tbody>
<tr>
<td>58</td>
<td>COMB3asdx Combination</td>
<td>-0.557</td>
<td>0.008486</td>
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<td>COMB1asd Combination</td>
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</tbody>
</table>
Penetrator Load Capacity Chart - US lbs

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
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 \( \theta = 0 \) 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 \( 0 \leq 10^\circ \).

\( \theta \) 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, \((GC_{a})\), 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