Residential Housing Project – Weed, CA
California Polytechnic State University San Luis Obispo
Fall 2017

Project by
Spencer Shobe

In Association with
Dewi Bleher, Munenari Hirata, Purvaa Goel and Ryan O’Neill
About the Project:

In September of 2014, the Boles Fire swept through the small city of Weed in northern California. Over 150 structures were destroyed in the fire and many families were displaced. One of the buildings destroyed included a commercial building that once sat on what is now divided into seven lots in the eastern part Weed. Great Northern Services (GNS), a non-profit organization committed to the growth and redevelopment of the city, bought the empty seven lots to develop residential housing for work-force families who were displaced by the fire. Within the seven lots, GNS plans to develop five single family residences and two duplexes.

California Polytechnic University’s Contribution:

GNS had several goals for the project including; resiliency, passive energy design, prefabrication, constructability and low budget. In order to keep budget low and recruit creative and innovative minds, GNS turned to California Polytechnic University and the College of the Siskiyous to help with the architectural design, structural design and construction. In addition, GNS wanted these buildings to be able to be built at California Polytechnic University and transported to Weed, CA. By approaching the project with an Integrated Project Delivery (IPD) approach, California Polytechnic University combined groups of Architecture, Architectural Engineering and Construction Management students into eight teams of four to six students to take on the project. The idea of IPD is that each group is tasked with designing the architectural, structural and construction design with an integrated approach.

The Design Process and My Involvement:

Being the only Architectural Engineer of the group and the architectural design being the first step in the process, I was challenged to apply my specific knowledge of structural engineering to help inform my team what I thought the best approach was. My main goals when deciding what direction to take were keeping cost low and creating a project that could be easily prefabricated and transported. In order to achieve these goals, I created two objectives for design. First, I thought it would be best to build in four foot panels because that is the most common size plywood is manufactured in. Second, I tried to direct the design to stay fairly regular in shape so that structural member sizes wouldn’t have to vary throughout the project and roof trusses could be utilized throughout the entire length of the roof in order to reduce the need for extra roof beams, posts and foundations. This would make the project more transportable and potentially more affordable. In the end the first objective was somewhat a failure because as a team we learned that designing the house with such tight restrictions made the design feel unnatural and made the floor plan unreasonable. The second objective however, did work out. In the end the entire roof was constructed of roof trusses and there were less than six unique structural members throughout the entire structure. The next step, the structural design, included the structural calculation and planning of the building. Because I was the only member of my group with the necessary knowledge to complete this task, this part of the project was done solely by me.
Site Overview and Floor Plan
Penalization Details
Masonry

1. Special Compressive Strength of Masonry (f′): 1500 psi.

2. Concrete Block: ASTM C90, medium weight, Grade N1 attaining a minimum compressive strength as required to meet specified compressive strength of masonry (fn). Where applicable, use masonry cement or plastic cement.

3. Mortar: ASTM C270, Type S conforming with IBC Section 2103.1 and attaining a minimum compressive strength at 28 days of 1800 psi. Do not use masonry cement or plastic cement.

4. Grout: ASTM C476 or IBC Table 2103.10 attaining a minimum compressive strength as required to meet specified compressive strength of masonry (fn). However, in no case shall grout compressive strength be less than 2000 psi at 28 days.


6. Reinforcing Steel: Reinforcing steel section of general notes unless indicated otherwise.

7. Reinforcing Steel Splices: Lap reinforcement at splices to a minimum of 72 bar diameters, unless noted otherwise. Where clear distance between bars at adjacent splices is 3 inches or less, increase lap length 30 percent unless splices are staggered at least 24 bar diameters.


a. Horizontal Construction Joints: Hold grout 1/2 inch below top of masonry unit if work is stopped one hour or longer.

b. Grout Cover Around Reinforcing Steel: Anchor Bolts and Inserts Penetrating Masonry Shell: 1 inch minimum.

Earthwork and Foundations

1. Design Assumption: In lieu of more detailed soils information, existing subgrade is assumed to be class "S" in compliance with CBC Table 1805.2 with allowable bearing pressure of 1,500 psi.

2. Excavations, Backfill and Completion of Basalt: Comply with requirements of IBC Section 1804. Contractor is responsible for all excavation, backfilling, lagging, or underpinning and related procedures.

3. Minimum Footing Depths: 12 inches below adjacent grade (excluding landscaping soil) or finish floor, whichever is lower.

4. Water Exposure at Building Perimeter Footings: At areas where sidewalks or paving do not immediately adjoin structure, provide positive drainage away from structure at building perimeter. Landscape irrigation is not permitted within five feet of building perimeter footings except when enclosed in protected planters with direct drainage away from structure or which complies with applicable code. Discharge from downslope, roof drainage, and scupper outlets is not permitted onto unpaved soild within five feet of building perimeter. Refer to geotechnical report for complete requirements.

Reinforcing Steel

1. All bars unless indicated otherwise: ASTM A615, Grade 60

2. Smooth welded wire fabric: ASTM A185

3. Deformed wire stirrups (D4 and larger only): ASTM A416

4. Lap Lengths: As shown on drawings. If lap lengths cannot be determined, verify with Structural Engineer. Lap wire fabric 1-1/2 to 2 spaces (1 foot minimum)

5. Minimum Cast-In-Place Concrete Cover:

   Slabs on Grade
   Min. cover in center of slab
   (a) Concrete Exposed to Earth or Weather (Unformed)
   3

   (b) Chairs or Rebars: Plastic or plastic coated when resting on exposed surfaces.

   (c) Belt: Bend cold unless otherwise accepted by Architect (Structural Engineer). Do not field-bend reinforcing steel bars embedded in concrete unless otherwise shown on contract documents or pre-approved by Structural Engineer.
Plan Notes:

1. Shearwalls to be 1/4" structural 1 plywood w/ 10d nails @ 6" where indicated U.N.O.
2. Each shearwall to have HDU2-SDG2.5 holddowns on del. stud on each end.
PLAN NOTES:

1. SHEARWALLS TO BE 3/8" STRUCTURAL 1 PLYWOOD W/ 10d NAILS @ 6" WHERE INDICATED U.N.O.

2. FLOOR DIAPHRAGM TO BE BLOCKED 3/8" STRUCTURAL 1 PLYWOOD W/ 10d NAILS @ 6" EVERYWHERE

3. EACH SHEARWALL TO HAVE HDU2 - SDS2.5 HOLDDOWNS ON DBL. STUD ON EACH END
PLAN NOTES:

1. TRUSSES TO BE DESIGNED BY MANUFACTURER. DL = 14 PSF LL = 48 PSF. SEE PLAN FOR LATERAL LOADS
2. SHEARWALLS TO BE BLOCKED 1/2 STRUCTURAL 1 PLYWOOD W/ 10d NAILS @ 6" EVERYWHERE U.N.O.
3. ROOF DIAPHRAGM TO BE BLOCKED 1/2 STRUCTURAL 1 PLYWOOD W/ 10d NAILS @ 6" EVERYWHERE
Residential Housing Project - Weed, CA
Great Northern Services

Class Information:
ARCH 451-02 Lab
Architectural Design 4.1
Fall 2017
California Polytechnic State University
San Luis Obispo

Team members:
Dewi Bleher
Purvaa Goel
Munenari Hirata
Ryan O’Neill
Spencer Shobe

Date: 11/17/17

Details

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CALCULATION PACKAGE

STUDIO GREEN.

PROJECT ENGINEER: SPENCER SHOBE

DATE: 11/17/17
BUILDING CRITERIA

LOAD TAKEOFF

VERTICAL DESIGN

LATERAL DESIGN

FOUNDATION DESIGN

CONNECTIONS

TOTAL
LOCATION: 780 S. DAVIS STREET WEED, CA PARCEL 1

ARCHITECT: STUDIO GREEN

OWNER: GREAT NORTHERN SERVICES

JURISDICTION: CITY OF WEED

BUILDING CODE:
GENERAL: 2015 IBC
ASCE 7-10

TIMBER DESIGN: NDS 2015

STRUCTURAL SYSTEMS:

VERTICAL: WOOD ROOF, WOOD FLOOR, WOOD WALLS
CONCRETE FOOTINGS, MASONRY STEM WALL

LATERAL: WOOD SHEAR PANELS
### Roof

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<td>Metal Roof</td>
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<td>Truss Self Weight</td>
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<td>MEP</td>
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<tr>
<td>Misc.</td>
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<tr>
<td><strong>Roof Live (Snow)</strong></td>
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### Floor

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<tr>
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### Exterior Walls

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<tr>
<td>Plywood Sheathing</td>
<td>1.5</td>
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<tr>
<td>Insulation</td>
<td>3.0</td>
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<tr>
<td>2x6 Studs</td>
<td>2.5</td>
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<tr>
<td>Gypsum Wall Board</td>
<td>3.0</td>
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<tr>
<td><strong>Total</strong></td>
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### Interior Walls

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<td>2x4 Studs</td>
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<tr>
<td>1/2&quot; Gypsum Wall Board (Both Sides)</td>
<td>6.0</td>
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<tr>
<td><strong>Total</strong></td>
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SNOW LOAD

\[ p_c = 60 \text{ psf} \quad \text{(NEED BUILDING CODE)} \]

\[ p_s = c_s p_c \quad \text{(ASCE 7.4-1)} \]

\[ c_s = 0.8 \quad \text{(ASCE FIG. 7-2)} \]

\[ p_f = (60 \text{ psf})(0.8) \]

\[ p_f = 48 \text{ psf} \]
**Studio Green**

**Project:** WEED HOUSING DEVELOPMENT  
**Page:** V-2  
**By:** SPENCER SHOBE  
**Title:** (RH-1) - GARAGE HEADER  
**Date:** 11/17/2017

**(RH-1) GARAGE HEADER**

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\[ W = D + S = 124 \text{ PLF} \]

\[ D = (14 \text{ PSF})(2') = 28 \text{ PLF} \]

\[ S = (48 \text{ PSF})(2') = 96 \text{ PLF} \]

\[ \text{W} = 16' \]

\[ 3.97 \text{ k-ft} \]

\[ 992\# \]

**BENDING**

\[ F_B^* = F_B' \cdot C_B' \cdot C_B' \cdot C_B' \cdot C_B' \cdot C_B' \cdot C_B' \]

\[ F_B^* = 1265 \text{ psi} \]

\[ S_B^2 = \frac{de}{w^2} \]

\[ A \times 12 = \frac{1000}{1.15} = 120.12' = 16 > 7 \]

\[ \frac{h}{w} = 1.63 \text{ k-ft} \times 3.12 \]

\[ = 1.13 (16 \times 12) + 3 \times 12 \]

\[ = 348.96 \text{ in} \]

\[ E_B^2 = \frac{(348.96 \text{ in})(11.5)}{(3.5^2)} = 132 \]

\[ F_B E = 1.2 F_{min} = (1.2)(620,000) = 5635 \text{ psi} \]

\[ P_B^2 = 132 \]

\[ C_L = 1 + \left( \frac{F_{ex}/F_E}{S_B^2} \right) \cdot \frac{1 + (5.45/12.5)}{1.9} \]

\[ = 0.999 \]

\[ F_B' = F_B \cdot C_B' \cdot C_B' \cdot C_B' \cdot C_B' \cdot C_B' \cdot C_B' \]

\[ F_B' = 1265 \text{ psi} \]
\[ S_{xx} \geq \frac{M}{F_A} \]
\[ S_{xx} = \frac{47,440 \text{ ft}}{126 \text{ ft}} = 374.4 \text{ in}^2 \]
\[ S_{xx} \geq 374.4 \text{ in}^2 \]

**USE** 6x12 DF #1

\[ S_{xx} = 121.2 \text{ in}^2 \geq 374.4 \text{ in}^2 \checkmark \]

**SHEAR**

\[ F'V = \frac{F_V}{n} \cdot \phi_6 \cdot \phi_6 \cdot \phi_6 \cdot \phi_6 \]
\[ F'V = \frac{207 \text{ psi}}{6} = 34.5 \text{ psi} < 207 \text{ psi} \checkmark \]

**DEFORMATION**

\[ L_{360} \cdot \frac{1}{240} = \frac{12}{360} \cdot \frac{1}{240} = 0.33 \text{ in} \]

\[ \Delta_L = \frac{5}{384} \cdot \frac{L^4}{E_1 I_1} = \frac{5}{(384)(1,700,000)(697.1)} \]
\[ \Delta_L = 0.12'' \approx 0.53'' \checkmark \]

\[ \Delta_N = \frac{5}{384} \cdot \frac{L^4}{E_1 I_1} = \frac{5}{(384)(1,700,000)(697.1)} \]
\[ \Delta_N = 0.15'' \approx 0.8'' \checkmark \]

**USE** 6x12 DF #1
[RH-2] - TYP. HEADER (WORST CASE)

\[ W = D + S = 930 \text{ PLF} \]

\[ D = \left(14 \text{ psf}\right) \times \left(15'\right) = 210 \text{ PLF} \]

\[ S = \left(48 \text{ psf}\right) \times \left(15'\right) = 720 \text{ PLF} \]

**BENDING**

\[ F_{u}' = F_u \cdot C_A \cdot C_Z \cdot C_E \cdot C_L \cdot C_F \cdot C_G \cdot C_B \cdot C_R \]

\[ F_{b}' = 1725 \text{ psf} \]

\[ S_x > M \quad \frac{12600 \text{ ft}}{1725} = 7.30 \text{ in} \]

**USE**

\[ C_x = 6 \text{ of } \frac{\pi}{4} \quad S_x = 27.73 > 7.30 \checkmark \]

**SHEAR**

\[ F_v = F_u \cdot C_B \cdot C_E \cdot C_K \]

\[ F_v = 140 \text{ psf} \]

\[ F'_v = \frac{V}{A} = \frac{1400 \text{ ft}}{30.25 \text{ in}^2} = 46.3 \text{ psi} = 207 \text{ psi} \checkmark \]
DEFLECTION

\[ \frac{L}{3h_1} \] \[ \frac{L}{2h_2} = 0.183 \div 0.2 \]

\[ \Delta_L = \frac{5wL^4}{384EI} = \frac{(5)(720/12)(3.12)^4}{(384)(1700000)(16.24)} = 0.010'' < 0.133'' \checkmark \]

\[ \Delta_{L+D} = \frac{(5)(930/12)(3.12)^4}{(384)(1700000)(16.24)} = 0.013'' < 0.12'' \checkmark \]

USE 6 x 6 DF # 1
**Project:** WEED HOUSING DEVELOPMENT  
**By:** SPENCER SHOBE  
**Title:** {FJ-1} TYP. FLOOR JOIST  
**Date:** 11/17/2017

**[FJ-1] TYP. FLOOR JOIST**

\[ W = \frac{D + L}{2} = 7.1 \text{ PLF} \]

\[ D = \frac{8900 \text{ lbs}}{2000 \text{ sq ft}} + (10 \text{ psf})(1.3) = 17 \text{ PLF} \]

\[ L = \frac{490 \text{ psf}}{(152)} = 5.4 \text{ PLF} \]

**Bending**

\[ F'_{a} = F_{a} \cdot \frac{C_{a} \cdot C_{u} \cdot C_{b} \cdot C_{f}}{C_{a} \cdot C_{u} \cdot C_{b} \cdot C_{f}} = 1.15 \]

\[ F'_{b} = 1035 \text{ psi} \]

\[ S_{xx} \geq \frac{M}{F'_{b}} = \frac{20,940 \text{ in} \cdot \text{lb}}{1035 \text{ psi}} = 20,171 \text{ in}^2 \]

Use 2 x 10 @ 16" O.C.  
\[ S_{xx} = 21.39 \text{ in}^2 > 20.17 \text{ in}^2 \checkmark \]

**Shear**

\[ F'_{V} = F_{V} \cdot \frac{C_{a} \cdot C_{u} \cdot C_{b} \cdot C_{f}}{C_{a} \cdot C_{u} \cdot C_{b} \cdot C_{f}} \]

\[ F'_{V} = 180 \text{ psi} \]

\[ F'_{V} \geq \frac{V}{A} = \frac{497 \text{ #}}{13.98 \text{ in}^2} = 35.81 \text{ psi} \leq 180 \text{ psi} \checkmark \]
DEFLECTION

\[ \frac{L}{240} = \frac{L}{240} = 0.47'' \]

\[ \frac{L}{4} = \frac{(5)(7/2)(14/12)}{384.41 \times (88.4)(144000000)(98.93)} = 0.39'' < 0.7'' \checkmark \]

\[ \frac{D_L}{5} = \frac{(5^{4/3})(14/12)}{384.41 \times (88.4)(144000000)(98.93)} = 0.29'' < 0.47'' \checkmark \]

USE 2x10 DF #2 @ 16'' O.C.
[FG-1] - TYP. FLOOR WIDER

\[ W = D + L = 756 \text{ PLF} \]

\[ D = \left( \left( \frac{1000 \text{ kips}}{2000 \text{ kips}} \right) + 10 \text{ psi} \right) \left( \frac{114}{14} \right) = 196 \]

\[ L = (40 \text{ PSF}) \left( \frac{114}{14} \right) = 560 \text{ PLF} \]

**BENDING**

\[ F'_{B} = \frac{F_{B} \cdot C_{A} \cdot C_{R} \cdot C_{L} \cdot C_{T} \cdot C_{S}}{C_{F}} \]

\[ F'_{B} = 1100 \text{ psi} \]

\[ S_{xx} \geq \frac{M}{F'_{B}} = \frac{12000 \text{ #} \cdot \text{in}}{1100 \text{ psi}} = 10.91 \text{ in}^{3} \]

**USE** 4 x 12 \[ S_{xx} = 73.8 \text{ in}^{3} > 10.91 \text{ in}^{3} \]

**SHEAR**

\[ F'_{V} = \frac{F_{V} \cdot C_{R} \cdot C_{A} \cdot C_{L} \cdot C_{T} \cdot C_{S}}{C_{F}} \]

\[ F'_{V} = 180 \text{ psi} \]

\[ F'_{V} \geq \frac{V}{A} = \frac{3000 \text{ ft} \cdot \text{psf}}{39.58 \text{ in}^{2}} = 76.18 \text{ kpsi} > 180 \text{ psi} \]

\[ V = 180 \text{ psi} \]
DEFLECTION

\[ \frac{L^3}{360} \cdot \frac{K}{24} = 0.27'' , 0.4'' \]

\[ \Delta = \left( \frac{5}{(5.50/12)(12.8)} \right)^2 \left( \frac{58.4}{17.00000} \right)^{10.3} \]

\[ \Delta = 0.10'' < 0.40'' \checkmark \]

\[ \Delta = \left( \frac{5}{(5.50/12)(12.8)} \right)^2 \left( \frac{58.4}{17.00000} \right)^{10.3} \]

\[ 0.07'' < 0.27'' \checkmark \]

USE 4 X 12 DE #1
\[ F'c = \frac{F_c}{F'c} \cdot \frac{C'}{C} \cdot \frac{A'}{A} \cdot \frac{G}{G'} \cdot \frac{P}{P'} \cdot \frac{E}{E'} \]

\[ F'c = 2587.5 \text{ psi} \]

\[ A = \frac{P}{F'c} = \frac{992}{2587.5} = 0.38 \text{ in}^2 \]

This will not govern.

\[ F'c = \frac{F_c}{F'c} \cdot \frac{C'}{C} \cdot \frac{A'}{A} \cdot \frac{G}{G'} \cdot \frac{P}{P'} \cdot \frac{E}{E'} \]

\[ C_b = 0.375 \cdot \frac{5.5}{0.375} = 5.5 \cdot \frac{5.5}{0.375} = 5.5 \]

\[ F'c = 6068 \text{ psi} \]

\[ F'c \geq \frac{A}{P} \]

\[ A = \frac{P}{F'c} = \frac{992}{6068} = 1.64 \text{ in}^2 \]

\[ (5.5'' \times 5.5'') = 30.25 \text{ in}^2 > 1.64 \text{ in}^2 \]

Use 6x6 DF #11
\[ F'c = Fc \cdot C_p \cdot C_m \cdot C_t \cdot C_s \cdot C_\phi \]

\[ C_p = 1 + \frac{f_{ce}}{f_{ck}} \cdot \left( 1 + \frac{f_{ck}}{2c} \right)^{-1} \]

\[ f_{ce} = \frac{f_{ck}}{(1 + 0.55)} \]

\[ f_{ck} = 1500 \text{ psi} \]

\[ f_{ck} = \frac{0.822 \cdot f_{ck, min}}{(1 + 0.55)} = \frac{(0.822 \cdot 6200 \text{ psi})}{(1 + 0.55)} = \frac{5194 \text{ psi}}{1.55} \]

\[ C_p = 1 + \frac{1154}{1500} - \frac{1}{2(c, s)} \]

\[ C_p = 0.97 \]

\[ F'c = Fc \cdot C_p \cdot C_m \cdot C_t \cdot C_s \cdot C_\phi \]

\[ F'c = 1459 \text{ psi} \]

\[ A > \frac{p}{F'c} = \frac{6000\#}{1459 \text{ psi}} \]

\[ A > 4.11 \text{ in}^2 \]

**USE 4 x 4 FT DF#1**

\[ A = 12.25 \text{ in}^2 > 4.11 \text{ in}^2 \]
### Roof

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<th>Diaphragm</th>
<th>Load (PsF)</th>
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**Total** | 28700

### Walls

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<th>Type</th>
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<th>Load (PsF)</th>
<th>Length (FT)</th>
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<td>Interior</td>
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**Total** | 29172

**Building Weight** | 43286
KNOWN:

\[ W = 43,246 \text{ lb} \]
\[ R = 0.5 \text{ (Wood Shear Walls) (ASCE Tbl. 12.2-1)} \]
\[ I_x = 1.0 \text{ (ASCE Tbl. 11.5-2)} \]
\[ S_{ds} = 0.475 \text{ (USGS values)} \]
\[ SOIL: \text{ SITE CLASS D (DEFAULT)} \]
\[ RISK \text{ CATEGORY: II (ASCE Tbl. 11.5-1)} \]

\[ V = C_s \cdot W \]
\[ C_s = \frac{S_{ds}}{(\frac{R}{I_x})^{0.5}} = \frac{0.475}{(0.5)^{0.5}} = 0.92 \]

\[ V = (0.092)(43,246 \text{ lb}) \]
\[ V = 3,988 \text{ lb} \]

\[ F_r = 3,988 \text{ lb} \]
USGS—Provided Output

\[
\begin{align*}
S_s &= 0.736 \text{ g} & S_{MS} &= 0.891 \text{ g} & S_{DS} &= 0.594 \text{ g} \\
S_I &= 0.328 \text{ g} & S_{MI} &= 0.572 \text{ g} & S_{DI} &= 0.381 \text{ g}
\end{align*}
\]

For information on how the SS and S1 values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please return to the application and select the "2009 NEHRP" building code reference document.

For PGA, Tc, CSR, and CRI values, please view the detailed report.

Although this information is a product of the U.S. Geological Survey, we provide no warranty, expressed or implied, as to the accuracy of the data contained therein. This tool is not a substitute for technical subject-matter knowledge.
KNOWN S:

RISK CATEGORY: II
V = 110 MPH (ASCE Fig. 26.5-1A)

EXPOSURE CATEGORY: C (WEED MUNICIPAL CODE)

TOPOGRAPHIC FACTOR (Kzt): 1 (ASCE 26.8-2)

C_{net} = 0.73 (IEC Tab. 1609.6-2)

P_{net} = 0.00254 \cdot V^2 \cdot K_z \cdot C_{net} \cdot K_{zt}

P_{net} = (0.00254) (110)^2 (1) (0.73) (1)

P_{net} = 22.6 PSF

N-S

V = \left( \frac{P}{A} \right) (A)

V = (22.6 \text{ PSF}) (941.4 \text{ SF})

V = 22.14 k

E-W

V = \left( \frac{P}{A} \right) (A)

V = (22.6 \text{ PSF}) (1100.4 \text{ SF})

V = 24.88 k

WIND GOVERNS
STUDIO GREEN.

PROJECT: WEED HOUSING DEVELOPMENT

BY: SPENCER SHOBE

TITLE: SHEAR DISTRIBUTION

DATE: 11/17/2017

---

### N-S

- **LINE A:** \((222 \text{ PLF})(10') = 2220 \text{ #} \)
- **LINE B:** \((222 \text{ PLF})(25') = 5550 \text{ #} \)
- **LINE C:** \((222 \text{ PLF})(15') = 3330 \text{ #} \)

### E-W

- **LINE 1:** \((225 \text{ PLF})(10') = 2250 \text{ #} \)
- **LINE 2:** \((225 \text{ PLF})(22.5') = 5063 \text{ #} \)
- **LINE 3:** \((225 \text{ PLF})(12.5') = 2813 \text{ #} \)

---

- **LINE A:** \((0.6)(222.0 \text{ #} ) = 444 \text{ PLF} \)
- **LINE B:** \((0.6)(5550 \text{ #} ) = 139 \text{ PLF} \)
- **LINE C:** \((0.6)(3330 \text{ #} ) = 100 \text{ PLF} \)

- **LINE 1:** \((0.6)(2250 \text{ #} ) = 48 \text{ PLF} \)
- **LINE 2:** \((0.6)(5063 \text{ #} ) = 152 \text{ PLF} \)
- **LINE 3:** \((0.6)(2813 \text{ #} ) = 141 \text{ PLF} \)
- ASPECT RATIO CHECK

WORST CASE = 45:30 = 1.5:1
ALLOWABLE = 4:1 > 1.5:1 ✔

USE 1/2" STRUCTURAL I PLYWOOD BLOCKED W/ 6d NAILS @ 6" & 6" EVERYWHERE (SDPWS) (TL. H.2A)

CAPACITY = 260 PLF > 225 PLF ✔
**SHEARWALL 1**

*Use 3/4" Structural I Plywood w/ 6d Nails @ 6" everywhere, blocked.*

**Capacity:** 280 plf > 152 plf ✓

- **Aspect Ratio Check**

  **Worst Case:** 8.5': 4' = 2.125:1
  **Allowable:** 3.5:1 > 2.125:1 ✓

**SHEARWALL #**

WSW15x9 Simpson Strong Wall

**Capacity:** 1920 # > (444 plf)(1.5') = 666 # ✓
W = (WIND PRESSURE) (STUD SPACING) = (22.6 PSF) (1.33') = 30.1 PLF

\[ P = (14 \text{ PSF})(15') + (40 \text{ PSF})(15')(1.33') = 1237 \text{ lb} \]

**BENDING**

\[ F'B = F'B \cdot C_{E} \cdot C_{X} \cdot C_{G} \cdot C_{F} \cdot C_{F_U} \cdot C_{F_V} \cdot C_{R} \]

\[ F'B = 2153 \text{ psi} \]

\[ S_{X} \geq \frac{M}{F'B} = \frac{3654 \text{ ft} \cdot \text{in}}{2153 \text{ psi}} = 1.70 \text{ in}^2 > 7.54 \text{ in}^2 \checkmark \]

\[ f_{b} = \frac{M}{S_{X}} = 483 \text{ psi} \]
**COMPRESSION**

\[ F'c = f_c \cdot C_0 \cdot C_1 \cdot C_2 \cdot C_F \cdot C_i \cdot C_t \]

\[ F'c = 2808 \text{ psi} \]

\[ F'c > \frac{P}{A} = \frac{1237 \#}{8.25 \text{ in}^2} = 150 \text{ psi} < 2808 \text{ psi} \]

**COMBINED**

\[ F_{C1} = \frac{(0.822)(580,000)}{1236 \text{ psi}} = 1236 \text{ psi} \]

\[ F_{C2} = \frac{(0.422)(580,000)}{m_{12}^2} = 92 \text{ psi} \]

\[ F_{BE} = \frac{(1.2)(580,000)}{m_{12}^2} = 1905 \text{ psi} \]

\[ f_c = \frac{P}{A} = 150 \text{ psi} \]

\[ f_{b1} = 0 \]

\[ f_{b2} = 483 \text{ psi} \]

\[ \left( \frac{f_c}{F_{c1}} \right)^2 + \frac{f_{b1} + f_{b2}}{F_{c1} + F_{BE}} + \frac{f_{b2}}{F_{BE}(1 - \frac{f_{b1}}{F_{c1}})} = \frac{150}{2808} \times \frac{1153 \text{ psi}}{2153(1 - 150/236)} = 0.31 < 1 \]

**2 x 10 DF #2 IS ADEQUATE**
WORST CASE - 4' - 0" SW @ LINE 3

\[ EM_c = (141 \text{ PLF})(4')(9') - (P)(4') = 0 \]

\[ 141 \text{ PLF} \quad P = 1269 \text{#} \]

HOLDOWN - USE HDU2 - SDS2.5
CAPACITY = 3075# > 1269# ✓

TOP PLATE STEEP = VMAX
(NORTH FORCE)

N-S (11.4})(.6) = 141 PLF
\[ 415' \]

E-W (12.4})(.6) = 149 PLF \[ \text{MAX} \]
\[ 50' \]

USE LSTRM CAPACITY = 744 PLF > 149 PLF ✓

ANCHOR BOLTS

USE 1/2" DIAMETER ANCHOR BOLTS @ 4' O.C., CAPACITY = 650#
(DNS TO 12E)

DEMAND = (4')(141 PLF) = 564# < 650# ✓
STUD NAIL CONNECTION

USE 10d COMMON NAIL @ 6" O.C. STAGGERED CAPACITY = 115# (NDS Table 22)

DEMAND = (141 PLF)(9') = 1269#

CAPACITY = (16 NAILS)(115#/NAIL) = 1840 # > 1269# ✓

* TOP PLATE STRAP & STUD NAILING CONNECTION ADEQUATE FOR PANEL TO PANEL FORCE TRANSFER
$W_{max} = \left(14 \text{ psf} + 48 \text{ psf}\right)(15') + \left(10 \text{ psf} + 90 \text{ psf}\right)(15') + \left(12 \text{ psf}\right)(9')$
$\quad + \left(78 \text{ psf}\right)(\frac{9'}{12'})(2.5')$

$W_{max} = 1898 \text{ psf}$

$bf = \frac{1898 \text{ psf}}{1500 \text{ psf}} = 1.25'$

16" x 12" CONT. FGC.  
16" x 12" CONT. FGC.

Rebar

$A_s = \sqrt{bf}$

$A_s = 0.0018 (12")(14")$
$A_s = 0.3456 \text{ in}^2$

USE (1) = 6$ a = 0.44 \text{ in}^2 > 0.34 \text{ in}^2$  \checkmark
Footings under floor girders:

- $P_{max} = 6000 \text{#} (2) [FG.1]$

- $C > P$

- $A > \frac{6000 \text{#}}{1500 \text{psf}}$

- $A > 4 \text{ft}^2$

- Use $2' \times 2'$ pad footing.

Rebar:

- $A_s = \frac{P}{f_y}$
- $A_s = 0.0018 \times (2.4 \text{ in}) (12 \text{ in})$
- $A_s = 0.518 \text{ in}^2$

- Use $(2, 3, 5)$ $A_s = 0.62 \text{ in}^2 > 0.518 \text{ in}^2$ ✓

Simpson Strongwall pad footings

Per Simpson (see attached) $W = 18'$
### Standard and Balloon Framing on Concrete Foundations

#### Strong-Wall® Wood Shearwall Standard Application on Concrete Foundation

<table>
<thead>
<tr>
<th>Strong-Wall® Wood Shearwall Model*</th>
<th>Allowable Vertical Load, P (lb)*</th>
<th>Seismic</th>
<th>2,500 psi Concrete</th>
<th>Wind</th>
<th>Seismic</th>
<th>3,000 psi Concrete</th>
<th>Wind</th>
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<tbody>
<tr>
<td></td>
<td>Allowable ASD Shear Load, V (lb)</td>
<td>Drift at Allowable Shear, A (in m)</td>
<td>Anchor Tension at Allowable Shear, T (lb)</td>
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<td>Anchor Tension at Allowable Shear, T (lb)</td>
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</tbody>
</table>

See footnotes on page 13.
Anchorage Solutions

Curb or Stemwall Installation

Minimum curb/stemwall width per page 25.
Shear reinforcement per page 25 when required.

Perspective View
(Slab not shown for clarity)

Slab-on-Grade Installation

Shear reinforcement per page 25 when required.

Perspective View

Brick Ledge Installation

Minimum curb/stemwall width per page 25.
Shear reinforcement per page 25 when required.

Foundation design (size and reinforcement) by Designer.

Anchorage Solutions General Notes
1. The Designer may specify alternate embedment, footing size or bolt grade.
2. Footing dimensions and rebar requirements are for anchorage only.
(P-1) Caps & Bases

Demand = 992# Downward

Use ABU 662 Post Base  | Capacity = 1000# > 992# ✓
Use EP662 Column Cap

(P-2) Caps & Bases

Demand = 6000# Downward

Use ABU442 Post Base  | Capacity = 6650# > 6000# ✓
Use EC42 Column Cap

(RH-1) Drag Strap

Demand = (444 plf)(5') = 3552#

Use MSTC 40 Strap  | Capacity = 4745# > 3552# ✓
Drag Tie-Us Strap

Demand = (152 plf)(30') = 4560#

Use MSTC 40 Strap  | Capacity = 4745# > 4560# ✓
**HDU/DTT Holdowns**

This product is preferable to similar connectors because of:
- a) easier installation,
- b) higher loads,
- c) lower installed cost, or a combination of these features.

HDU holdowns are pre-deflected during the manufacturing process, virtually eliminating deflection under load due to material stretch. They use Simpson Strong-Tie® Strong-Drive® SDS Heavy-Duty Connector screws which install easily, reduce fastener slip, and provide a greater net section when compared to bolts. The HDU series of holdowns are designed to replace previous versions of the product such as PHDs as well as bolted holdowns. The HDU2, 4, and 5 are direct replacements for the PHD2, 5, and 6, respectively.

The DTT tension ties are designed for lighter-duty holdown applications on single or 2x posts. The new DTT1Z is installed with nails or Simpson Strong-Tie® Strong-Drive SD Connector screws and the DTT2Z installs easily with the Strong-Drive SDS Heavy-Duty Connector screws (included). The DTT1Z holdowns have been tested for use in designed shearwalls and prescriptive braced wall panels as well as prescriptive wood-deck applications (see page 209 for deck applications).

For more information on holdown options, contact Simpson Strong-Tie.

**HDU Special Features:**
- Holdown designs virtually eliminate deflection due to material stretch.
- Uses Strong-Drive SDS Heavy-Duty Connector screws which install easily, reduce fastener slip, and provide a greater net section area of the post compared to bolts.
- Strong-Drive SDS Heavy-Duty Connector screws are supplied with the holdowns to ensure proper fasteners are used.
- No stud bolts to countersink at openings.

**Material:** See table

**Finish:** HDU – Galvanized, DTT1Z and DTT2Z – ZMAX® coating; DTT2ZS – stainless steel

**Installation:**
- The HDU requires no additional washer, the DTT requires a standard cut washer (included with DTT2Z) be installed between the nut and the seat.
- Strong-Drive SDS Heavy-Duty Connector screws install best with a low speed high torque drill with a ½" hex head driver.

**Codes:** See page 12 for Code Reference Key Chart.

---

These products are available with additional corrosion protection. Additional products on this page may also be available with this option, check with Simpson Strong-Tie for details.

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<table>
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<td>1½</td>
<td>7½</td>
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<td>¾</td>
<td>½</td>
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<td>¾</td>
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<td>1½</td>
<td>½</td>
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<td>36-SDS #9x2½</td>
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</table>

1. See page 45 for Holdown and Tension Tie General Notes.
2. Noted HDU4 allowable loads are based on a 5¼" wide post (6x6 min.).
3. HDU14 requires heavy hex anchor nut to achieve tabulated loads (supplied with holdown).
4. Loads are applicable to installation on either narrow or wide face of post.

---

**Horizontal HDU Tie Offset Installation (Plan View)**

See Holdown and Tension Tie General Notes on page 45.

---

**Vertical HDU Installation**

---
### Codes

See page 12 for Code Reference Key Chart.

- These products are available with additional corrosion protection. Additional products on this page may also be available with this option; check with Simpson Strong-Tie for details.
- These products are approved for installation with the Strong-Drive® SD Connector screw. See page 27 for more information.

<table>
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<td>20</td>
<td>1½ 9</td>
<td></td>
<td>(160)</td>
<td>(160)</td>
<td>I4, L3, F2, F5</td>
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<td>36 24</td>
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</table>

1. Loads include a 60% load duration increase on the fasteners for wind or earthquake loading.
2. 100x1½ nails may be substituted where 16d sinkers or 10d are specified at 100% of the table loads except where straps are installed over sheathing.
3. 10d commons may be substituted where 16d sinkers are specified at 100% of table loads.
4. 16d sinkers (0.148" dia x 3½" long) or 10d commons may be substituted where 16d commons are specified at 0.84 of the table loads.
5. Use half of the nails in each member being connected to achieve the listed loads.
6. Tension loads apply for uplift when installed vertically.
7. NAILS: 16d = 0.162" dia x 3½" long, 16d Sinker = 0.148" dia x 3½" long, 10d = 0.148" dia x 3" long. 10d x 1½ = 0.148" dia x 1½" long. See page 22-23 for other nail sizes and information.
ABA/ABU/ABW Adjustable and Standoff Post Bases

Additional standoff bases are on page 232.

The AB series of retrofit adjustable post bases provide a 1" standoff for the post, are slotted for adjustability and can be installed with nails, Strong-Drive® SD Connector screws or bolts (ABU). Depending on the application needs, these adjustable standoff post bases are designed for versatility, cost-effectiveness and maximum uplift performance.

Features:
- The slot in the base enables flexible positioning around the anchor bolt, making precise post placement easier.
- The 1" standoff helps prevent rot at the end of the post and meets code requirements for structural posts installed in basements or exposed to weather or water splash.

MATERIAL: Varies (see table)
FINISH: All galvanized, most offered in ZMAX®; see Corrosion Information, pages 13-15.
INSTALLATION: Use all specified fasteners. See General Notes.
- See our Anchoring and Fastening Systems for Concrete and Masonary catalog, or visit www.strongtie.com for retrofit anchor options or reference technical bulletin T-ANCHORSPEC.
- Post bases do not provide adequate resistance to prevent members from rotating around the base and therefore are not recommended for non top-supported installations (such as fences or unbraced carports).
- Place the base, load transfer plate and nut on the anchor bolt. Loosely tighten the nut.

ABW—Place the standoff base and then the post in the ABW and fasten on three vertical sides, using nails or Strong-Drive SD Connector screws.
  - Make any necessary adjustments to post placement and tighten the nut securely on the anchor bolt.
  - Bend up the fourth side of the ABW and fasten using the correct fasteners.

ABU—Place the standoff base and then the post in the ABU.
  - Fasten using nails or Strong-Drive SD Connector screws or bolts (ABU88Z, ABU1010Z – SDS optional).

ABA—Place the post in the ABA.
  - Fasten using nails or Strong-Drive SD Connector screws.

CODES: See page 12 for Code Reference Key Chart.

These products are approved for installation with the Strong-Drive® SD Connector screw. See page 27 for more information.

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1. Uplift loads have been increased for wind or earthquake with no further increase allowed; reduce where other loads govern.
2. Download may be increased for short-term loading.
3. Specifiers to design concrete for uplift capacity.
4. AUU products may be installed with either bolts or nails (not both) to achieve table loads. ABU88Z, ABU1010Z, and ABU1010RZ may be installed with 8-1/2" Strong-Drive SDS Heavy-Duty Connector screws (sold separately) for the same table loads.
5. For AB bases, higher download can be achieved by solidly nailing or bolting under 1" standoff plate before installation. For anchor plate, concrete or ground according to the code.
6. HB dimension is the distance from the bottom of the post up to the first bolt hole.
7. Structural composite lumber columns have sides that show either the wide face or the edges of the lumber strands/veneers. For SCL columns, the fasteners for these products should always be installed in the wide face.
8. Download shall be reduced where limited by the capacity of the post. See pages 245-246 for common post allowable loads.
9. NAILS: 16d - 0.160" dia. x 3/4" long, 10d - 0.148" dia. x 3 1/2" long. See page 22-23 for other nail sizes and information.
The next-generation PCZ/EPCZ post caps are designed with their post and beam flanges in-line so that one PCZ/EPCZ model can accommodate several post sizes. The PCZ/EPCZ now uses easier-to-install 10d common nails. An alternate choice of fasteners is Strong-Drive® #9x1 1/2” SD Connector screws. ZMAX® finish is standard to meet exposure conditions in many environments. See additional corrosion information at www.strongtie.com/info.

**MATERIAL:** 16 gauge  
**FINISH:** ZMAX coating

**INSTALLATION:**  
- Use all specified fasteners; see General Notes.  
- Do not install bolts into pilot holes.

**OPTIONS:**  
- For end conditions, specify EPCZ post caps.  
- For heavy-duty applications, see CCQ and CC Series.  
- For retrofit applications, see AC and LC Series.

**CODES:** See page 12 for Code Reference Key Chart.

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These products are available with additional corrosion protection. Additional products on this page may also be available with this option, check with Simpson Strong-Tie for details.

These products are approved for installation with the Strong-Drive® SD Connector screw. See page 27 for more information.

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### Table: Allowable Loads (DF/SP)

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1. Allowable loads have increased for wind or earthquake with no further increase allowed; reduce where other loads govern.  
2. Uplift loads do not apply to spliced conditions. Spliced conditions must be detailed by the Designer to transfer tension loads between spliced members by means other than the post cap.  
3. Structural composite lumber columns have sides that show either the wide face or the edges of the lumber strands/veneers. Values in the tables reflect installation into the wide face and do not allow for installation into the narrow face.  
4. Post and beam may consist of multiple members provided they are connected independently of the post cap fasteners.  
5. 10d by 2½” (0.148” dia. x 2½” long) nails may be used with no load reduction for uplift and 0.85 of the table loads for lateral.  
6. Strong-Drive® SD9x1½ Connector screws may be substituted for table fasteners with no load reduction.  
7. Models available for rough size lumber, specify RZ suffix. Ex. PC4RZ.  
8. NAILS: 10d = 0.148” dia. x 3” long. See page 22-23 for other nail sizes and information.  
**SCREWS:** SD9112 = 0.161” dia. x 1 1/2” long.