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, Purva 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.
Parcel Layout Overview
Building Property Clearances
Site Overview and Floor Plan
Rough Carpenter

1. Structural Lumber: Grade marked Douglas Fir-Larch structural lumber complying with Standard Grading Rules No. 17 of the Western Lumber Inspection Bureau. Provide air-dry lumber with 19 percent maximum moisture content.

2. Classifications and Grades:

<table>
<thead>
<tr>
<th>Member</th>
<th>Size Classification</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rafters and Joists Larger Than 2x4</td>
<td>2&quot; to 4&quot; thick, 2&quot; and wider</td>
<td>No.2</td>
</tr>
<tr>
<td>2x4 Joists and Rafters</td>
<td>2&quot; to 4&quot; thick, 2&quot; and wider</td>
<td>No.2</td>
</tr>
<tr>
<td>4x Beams, Headers, and Strengtheners</td>
<td>4&quot; thick, 2&quot; and wider</td>
<td>No.1</td>
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<tr>
<td>Beams, Headers and Strengtheners Larger Than 4xBeams and Stringers</td>
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<tr>
<td>4x Posts</td>
<td>4&quot; thick, 4&quot; and wider</td>
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</tr>
<tr>
<td>Posts Larger Than 4x</td>
<td>Posts and Timbers</td>
<td>No.1</td>
</tr>
</tbody>
</table>


4. Pressure Treat Structural Lumber and pressure treated Concrete or Masonry: See specifications. Provide treated galvanized or stainless steel fasteners and hardware connectors at pressure treated structural lumber.

5. Nails: Common nails with dimensional properties complying with IBC 230.6. Install nails in compliance with CBC Chapter 23, including Table 2304.10.1.

6. Bolts: ASTM A307 bolts with standard cut washer under bolt head and nut. Provide holes for bolts 1/2 to 1/16 inch larger than nominal bolt diameter. Red-linest bolts prior to application of sheathing or finishing.

7. Lag Screws: ANSI/ASME Standard B18.2.1 for lag screw dimensions. Pre-drill all holes. Hole at shank portion to match diameter of shank. Holes at threaded portion to be 60 to 75 percent of shank diameter and equal to length of threaded portion. Use soap and lubricants to facilitate installation. Driving with hammer is not permitted.

8. Plate Washers: Provide under heads or nuts of bolts (including anchor bolts at sill plates) and lag screws of the following sizes: 1/2" diameter 1/8"x2" sq, 5/8" diameter 1/8"x2-1/2" sq, 3/4" diameter 1/4"x3" sq, 7/8" diameter 1/4"x3" sq, 1" diameter 5/8"x3-1/2" sq.


10. Nailing or Cutting Structural Lumber: Not permitted unless specifically detailed or indicated.

11. Lateral Support for Beams, Rafters and Joists: IBC Section 2308.7.

12. Wood Studs: A. Top Plate: construct with 2 pieces same width as studs. Splice as indicated.
   B. Stud Wall Bracing in Stud Walls not Plywood Sheathed: Compliance with IBC Section 2306.6.
   C. Fire Blocks: IBC Section 710A.
   D. Nailing or Boring Holes in Wood Stubs: IBC Section 2306.9.5.

13. Partition Support at Floor Framing: Double joists under partitions which are parallel to joists and provide solid fill depth blocking under partitions which are perpendicular to joists.

Nailing Schedule (Portion of IBC Table 2304.10.1)

- All nails are common nails unless written acceptance by Architect (Structural Engineer) is obtained.
- Joist to sill or girder, toenail 3-5d
- Bridging to joist, toe nail each end 2-6d
- 1"stud or joist less than each joist, face nail 2-6d
- Wider than 1"stud or joist each joist, face nail 3-6d
- 2" stud bolt, or girder, blind and face nail 2-6d
- Plate to plate of joist or plumbing, typical face nail 16d @ 16" o/c
- Plate sole to plate or blocking, at braced wall panels 3-15d per 16" stud or joist
- Stud to sole plate 4-5d, toe nail or 2-15d, end nail 2-6d
- Double studs, face nail 16d @ 24" o/c
- Double top plates, typical face nail 16d @ 16" o/c
- Double top plates, lap splice 8-16d
- Double top plates, bracing between joints or rafters to top plate, toe nail 3-5d
- Rim joist to top plate, toe nail 8d @ 6" o/c
- Top plates, laps and intersections, face nail 3-15d
- Continuous header, two pieces 16d @ 16" o/c along each edge
- Ceiling joist to plate, toe nail 3-5d
- Continuous header to stud, toe nail 3-5d
- Ceiling joists, laps over partitions, face nail 3-15d
- Ceiling joists to rafters, face nail 3-6d
- Rafter to plate, toe nail 3-5d
- 2" brace to each stud and plate, face nail 2-6d
- 3" 1/8" sheathing to each bearing, face nail 2-6d
- Wider than 1"stud sheathing to each bearing, face nail 3-6d
- 20" planks 2-15d at each bearing
- Built-up corner studs 16d @16" o/c
- Built-up girder and beams 20d @ 32" o/c at top and bottom and staggered 2-20d at ends and at each splice
PLAN NOTES:

1. SHEARWALLS TO BE 1/2" STRUCTURAL 1 PLYWOOD W/ 10D NAILS @ 6" WHERE INDICATED U.N.O.
2. EACH SHEARWALL TO HAVE HDU2 - SDS2.5 HOLDDOWNS ON DEL. STUD ON EACH END.
PLAN NOTES:
1. SHEARWALLS TO BE 3/4" STRUCTURAL 1 PLYWOOD W/ 10d NAILS @ 6" WHERE INDICATED U.N.O.
2. FLOOR DIAPHRAGM TO BE BLOCKED 3/4" STRUCTURAL 1 PLYWOOD W/ 10d NAILS @ 6" EVERYWHERE
3. EACH SHEARWALL TO HAVE HDU2 - SDS2.5 HOLDDOWNS ON DBL. STUD ON EACH END
1. TRUSSES TO BE DESIGNED BY MANUFACTURER. DL = 14 PSF LL = 48 PSF. SEE PLAN FOR LATERAL LOADS.
2. SHEARWALLS TO BE BLOCKED 3/4" STRUCTURAL 1 PLYWOOD W/ 10d NAILS @ 6" EVERYWHERE U.N.O.
3. ROOF DIAPHRAGM TO BE BLOCKED 3/4" STRUCTURAL 1 PLYWOOD W/ 10d NAILS @ 6" EVERYWHERE.
CALCULATION PACKAGE

STUDIO GREEN.

PROJECT ENGINEER: SPENCER SHOBE

DATE: 11/17/17
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
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<tbody>
<tr>
<td>BUILDING CRITERIA</td>
<td>BC-1</td>
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<tr>
<td>LOAD TAKEOFF</td>
<td>LT-1</td>
</tr>
<tr>
<td>VERTICAL DESIGN</td>
<td>V-1/1</td>
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<tr>
<td>LATERAL DESIGN</td>
<td>L-1/1</td>
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<tr>
<td>FOUNDATION DESIGN</td>
<td>F-1/4</td>
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<tr>
<td>CONNECTIONS</td>
<td>C-1/5</td>
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<td><strong>TOTAL</strong></td>
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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
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<thead>
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<tr>
<td>MEP</td>
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<tr>
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<td>FLOOR JOIST SELF WEIGHT</td>
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<tr>
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<tr>
<td>INSULATION</td>
<td>3.0</td>
</tr>
<tr>
<td>2x6 STUDS</td>
<td>2.5</td>
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<tr>
<td>GYPSUM WALL BOARD</td>
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<tr>
<td><strong>TOTAL</strong></td>
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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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</table>
SNOW LOAD

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

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

\[ C_s = 0.8 \quad \text{(ASCE FIG. 7.2)} \]

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

\[ p_r = 48 \text{ psf} \]
[RH-1] GARAGE HEADER

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

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

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

\[ W = 124 \text{ PLF} \]

\[ D = 28 \text{ PLF} \]

\[ S = 96 \text{ PLF} \]

\[ 992 \# \]

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

\[ 992 " \]

**BENDING**

\[ F_B' = F_B^* \cdot \frac{C_B}{C_T} \cdot \frac{C_E}{C_T'} \cdot \frac{C_L}{C_T'} \cdot \frac{C_T}{C_T'} \]

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

\[ P_B^2 = \frac{d e}{12} \quad \text{ASSUME}_G \times 12 \]

\[ c d = \frac{1613/12}{16} > 1 \]

\[ P_B^2 = 1.43 \times 5 \]

\[ = 1.13 \times 12 + 3 \times 12 \]

\[ = 348.96 \text{ in} \]

\[ \frac{348.96 \text{ in}}{55^2} = \frac{348.96}{55^2} = \frac{348.96}{3025} = 0.114 \]

\[ \text{FBE} = 1.2 E_{min} \times (1.2)(620,000) = 5635 \text{ psi} \]

\[ P_B^2 = 132 \]

\[ C_L = 1 + \left( \frac{F_B^*}{F_B'} \right) = \frac{1.9}{1.9} \]

\[ = \sqrt{\left( \frac{F_B^*}{F_B'} \right)^2 - 1} \]

\[ C_L = 1 + \left( \frac{1.9}{1.9} \right) \left( \frac{F_B^*}{F_B'} \right)^2 = 0.99 \]

\[ F_B' = 1265 \text{ psi} \]
\[ S_{xy} > \frac{M}{F'_{A}} \]

\[ S_{xy} \geq \frac{47,400 \text{ lb} \cdot \text{in}}{1260 \text{ psi}} \]  
\[ S_{xy} \geq 37.4 \text{ in}^3 \]

**USE 6 x 12 DF #1**  
**Syy = 121.2 in^3 \geq 37.4 \text{ in}^3 \checkmark**

**SHEAR**

\[ F'V = \frac{FV}{6} \cdot \frac{6}{2} \cdot \frac{6}{2} = 207 \text{ psi} \]

\[ F'V = \frac{V}{A} = \frac{924}{63.25 \text{ in}^2} = 14.6 \text{ psi} < 207 \text{ psi} \checkmark \]

**DEFLECTION**

\[ \frac{L}{360} - \frac{L}{240} = 2 \cdot \frac{\Delta_u}{L} = \frac{D_u}{L} = 0.53, 0.8 \]

\[ \Delta_L = \frac{5wL^4}{384E_1} = \frac{5 \cdot (9.1 \cdot 12)}{(384)(1700,000)(697.1)} = 0.12'' < 0.53'' \checkmark \]

\[ \Delta_{Dtl} = \frac{5NL^4}{384E_1} = \frac{5 \cdot (14.1 \cdot 12)}{(384)(1700,000)(697.1)} = 0.15'' < 0.8'' \checkmark \]

**USE 6 x 12 DF #1**
[RH-2] - TYP. HEADER (WORST CASE)

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

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

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

**BENDING**

\[ F_w' = F_a \cdot C_a \cdot C_e \cdot C_{sl} \cdot C_{yl} \cdot C_{fl} \cdot C_{fu} \cdot C_r \]

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

\[ S_x = \frac{M}{F_L} = \frac{12600 \text{ ft lb}}{1725} = 7.30 \text{ in}^2 \]

USE 6 x 6 CF @ 1" \[ S_x > 27.73 > 7.30 \checkmark \]

**SHEAR**

\[ F_v = 180 \text{ psi} \cdot C_r \]

\[ F_{v'} = 207 \text{ psi} \]

\[ F_{v'} = \frac{V}{A} = \frac{1400 \text{ ft lb}}{30.25 \text{ in}^2} = 46.3 \text{ psi} < 207 \psi \checkmark \]
DEFLECTION

\[
\frac{1}{3}L_0 \cdot \frac{L_0}{2} = 0.123, \quad 0.2
\]

\[
\Delta L = \frac{5}{3} \cdot \frac{L^4}{8 \cdot 46} = \frac{(5)(720/12)(3.12)^4}{(384)(170000)(76.24)} = 8.010'' < 0.133'' \quad \checkmark
\]

\[
\Delta L + D = \frac{(5)(930/12)(3.12)^4}{(384)(170000)(76.24)} = 0.013'' < 0.1'' \quad \checkmark
\]

[USE 6 x 6 DF # 1]
(FJ - 1) TYP. FLOOR JOIST

\[ W = D + L = 71 \text{ PLF} \]

\[ D = \left( \frac{6900 \text{ lb}}{2000 \text{ sq}} \right) \div \left( 10 \text{ psi} \right) \left( 1.33 \right) = 17 \text{ PLF} \]

\[ L = \left( 450 \text{ psi} \right) \left( 120 \right) = 54 \text{ PLF} \]

**BENDING**

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

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

\[ s_{xx} \geq \frac{M}{F'_{B}} = \frac{20 \text{ lb-in} \cdot \text{in}^{2}}{1035 \text{ psi}} = 20.17 \text{ in}^{3} \]

**USE** 2 x 10 @ 16" O.C.  \[ s_{xx} = 21.39 \text{ in}^{3} > 20.17 \text{ in}^{3} \] \[ \checkmark \]

**SHEAR**

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

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

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

\[ \frac{L^4}{3E_I} \cdot \frac{W}{L} = 0.47'' < 0.7'' \]

\[ D_{DL} = \frac{5W_L^4}{384EI} = \frac{(5)(7/2)(14/12)^{14/12}}{384E(I)(1,000,000)(98.93)} = 0.39'' < 0.7'' \checkmark \]

\[ D_L = \frac{5(5^{1/2})(14/12)^{14/12}}{384(1,000,000)(98.93)} = 0.29'' < 0.47'' \checkmark \]

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

$W = D + L = 756 \text{ PLF}$

$D = \left( \frac{6000 \text{ kips}}{2000 \text{ psf}} \right) \left( \frac{10 \text{ psf}}{14'} \right) = 196$

$L = \left( \frac{40 \text{ PSF}}{14'} \right) = 560 \text{ PLF}$

**BENDING**

$F'_{b} = \frac{1000}{1100} = 1000$ kips

$S_{xx} \geq \frac{M}{F'_{b}} = \frac{72000 \text{ ft} \cdot \text{in}}{1100 \text{ kips}} = 65.45 \text{ in}^3$

**SHEAR**

$F'_{V} = F'_{V} = 180$ kips

$F'_{V} = \frac{180}{12} = 15 \text{ kips}$

$F'_{V} = \frac{3000 \text{ kips}}{39.58 \text{ in}^3} = 76.18 \text{ psi} < 180 \text{ psi}$
DEFLECTION

\[
\frac{7/360}{1/240} = 0.27\text{in}, 0.4\text{in}
\]

\[
\Delta = \frac{5(1.56/2)^2}{(1.700,000)(115.3)} = 0.10\text{in} < 0.40\text{in} \quad \checkmark
\]

\[
\Delta = \frac{5(1.56/2)^2}{(1.700,000)(115.3)} = 0.07\text{in} < 0.27\text{in} \quad \checkmark
\]

USE 4 x 12 DEF #1
-studio green.

Project: Weed Housing Development  Page: V-10
By: Spencer Shobe
Title: [P-1] - Garage Post  Date: 11/17/2017

\[ F'c = F_c' \cdot \frac{2}{3} \cdot \frac{2}{3} \cdot \frac{2}{3} \cdot \frac{2}{3} \cdot \frac{2}{3} \cdot \frac{2}{3} \]

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

\[ A = \frac{P}{F'c} = \frac{992}{2587.5} \] in

\[ \text{will not govern} \]

\[ F'cl = F'c \cdot \frac{2}{3} \cdot \frac{2}{3} \cdot \frac{2}{3} = 107 \]

\[ C_b = \frac{d}{12} = \frac{0.375}{12} = \frac{5.5 + 0.375}{12} = 0.5 \]

\[ F'cl = 6688 \text{ psi} \]

\[ F'cl \geq P \]

\[ A^2 = \frac{P}{F'c} = \frac{992^{\text{psi}}}{669^{\text{psi}}} = 1.49 \text{ in}^2 \]

\[ (5.5'' \cdot 5.5'') = 30.25 \text{ in}^2 > 1.49 \text{ in}^2 \checkmark \]

Use 6x6 BE - 1
\[ F_c' = F_c \cdot C_p \cdot C_m \cdot C_t \cdot C_i \cdot C_s \]

\[ C_p = 1 + \frac{F_{ce}/F_{cu}}{2c} \sqrt{\left(1 + \frac{F_{ce}/F_{cu}}{2c}\right)^2 - \frac{F_{ce}/F_{cu}}{2c}} \]

\[ F_{ce} = F_c - 0.6 \cdot C_g \cdot C_s \cdot C_f \cdot C_e \]

\[ F_{ce} = 1500 \text{ psi} \]

\[ F_{ce} = \frac{0.822 \cdot 6000}{(8/15)^2} = 11,896 \text{ psi} \]

\[ C_p = \frac{1 + \frac{11,896}{1500}}{2(8)} = \frac{11,896}{1500} \cdot \frac{8}{13} \]

\[ C_p = 0.97 \]

\[ F_{c{'}} = F_c \cdot 0.97 \cdot C_m \cdot C_t \cdot C_i \cdot C_s \]

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

\[ A > \frac{P}{F_{c{'}}} = \frac{6000}{1459} \text{ psi} \]

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

\[ \text{USE 4 x 4 PT DF#1} \]

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

<table>
<thead>
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<th>DIAPHRAGM</th>
<th>LOAD (PSF)</th>
<th>AREA (SF)</th>
<th>TOTAL (LBS)</th>
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<td>ROOF</td>
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**TOTAL** 28700

### WALLS

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<th>LOAD (PSF)</th>
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<td>INTERIOR</td>
<td>8.5</td>
<td>8.0</td>
<td>114</td>
<td>7752</td>
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</tbody>
</table>

**TOTAL** 29172

**BUILDING WEIGHT** 43286
Knowns:

\[ W = 43,286 \text{ lb} \]
\[ R = 0.15 \text{ (wood shear walls) (ASCE Table 12.2-1)} \]
\[ I_2 = 1.0 \text{ (ASCE Table 1.5-2)} \]
\[ S_D = 0.595 \text{ (USGS values)} \]

Soil: Site Class D (Default)
Risk Category: III (ASCE Table 1.5-1)

\[ V = C_s W \]
\[ C_s = \frac{S_D}{(R^2 + (I_2/6)^2)^{1/2}} = 0.092 \]
\[ V = (0.092)(43,286 \text{ lb}) \]
\[ V = 3,984 \text{ lb} \]
\[ F_R = 3,984 \text{ lb} \]
Design Maps Summary Report

User-Specified Input

Building Code Reference Document: ASCE 7-10 Standard
(which utilizes USGS hazard data available in 2008)

Site Coordinates: 41.42891°N, 122.37939°W

Site Soil Classification: Site Class D – “Stiff Soil”

Risk Category: I/II/III

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, T, C_{RS}, and C_{R1} 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.

KNOWNS:

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

EXPOSURE CATEGORY: C (WEED MUNICIPAL CODE)

TOPOGRAPHIC FACTOR (Kz) = 1 (ASCE 26.8.2)

CNET = 0.78 (IEC Tab. 1609.6.2)

PNET = 0.00254 V^2 Kz CNET KzT

PNET = (0.00254)(110)^2(1)(0.78)(1)

PNET = 22.6 PSF

N-S

V=(P)(A)

V = (22.6 PSF)(941.4 sf)

V = 22.18 k

E-W

V=(P)(A)

V = (22.6 PSF)(1100.8 sf)

V = 24.88 k

WIND GOVERNS
**PROJECT:** WEED HOUSING DEVELOPMENT  **PAGE:** L-5

**BY:** SPENCER SHOBE  **DATE:** 11/17/2017

**TITLE:** SHEAR DISTRIBUTION

**Diagram Notes:***

- **N-S Line A:** (222 PLF)(10') = 2220#
- **E-W Line 1:** (225 PLF)(10') = 2250#
- **N-S Line B:** (222 PLF)(25') = 5550#
- **Line 2:** (225 PLF)(22.5') = 5063#
- **N-S Line C:** (222 PLF)(15') = 3330#
- **Line 3:** (225 PLF)(12.5') = 2813#
- **Line A:** (0.6)(222.0#/b) = 444 PLF
- **Line B:** (0.6)(5550#/b) = 339 PLF
- **Line C:** (0.6)(3330#/b) = 200 PLF
- **Line 1:** (0.6)(2250#/b) = 48 PLF
- **Line 2:** (0.6)(5063#/b) = 152 PLF
- **Line 3:** (0.6)(2813#/b) = 141 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" X 6" EVERYWHERE (SDPWS) (TL. 4.2A)

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

Use 1/4" Structural I Plywood w/ Grade Nails @ 6"

Everwhere, blocked

**Capacity:** 250 PLF > 152 PLF

- Aspect Ratio Check

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

**Shearwall 2**

WSW 15' x 9' Simpson Strong Wall

**Capacity:** 1720 # > (444 #/LF)(1.5') = 666 # ✓
\[ W = (\text{wind pressure})(\text{stud spacing}) = (22.6 \text{ psf})(1.33') = 30.1 \text{ psf} \]

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

**Bending**

\[ F'_{b} = F'_{b} \cdot C_{b} \cdot C_{x} \cdot C_{f} \cdot C_{f_{u}} \cdot C_{i} \cdot C_{r} \]

\[ F'_{b} = 2153 \text{ psi} \]

\[ S_{x} = \frac{M}{F'_{b}} = 3.694 \text{ # in} = 1.70 \text{ in}^2 < 7.56 \text{ in}^2 \checkmark \]

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

\[ F'_{c} = F_{c} \cdot G_{d} \cdot G_{f} \cdot G_{F} \cdot G_{C} \cdot G_{F} \cdot G_{d} \cdot G_{f} \cdot G_{F} \cdot G_{C} \cdot G_{F} \]

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

\[ F'_{c} > \frac{P}{A} = \frac{12.37}{8.25} \text{ in}^2 = 150 \text{ psi} < 2808 \text{ psi} \quad \checkmark \]

COMBINED

\[ F_{c1} = (0.822) (580,000) \left( \frac{n_{1.2}}{60} \right)^{2} \]

\[ F_{c2} = (0.822) (580,000) \left( \frac{n_{1.2}}{60} \right)^{2} \]

\[ F_{b1} = (1.2) (580,000) \left( \frac{n_{1.2}}{60} \right)^{2} \]

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

\[ f_{b1} = 0 \]

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

\[ \left( \frac{f_{c}}{F_{c1}} \right)^{2} + \frac{f_{b1}}{F_{c1}} \left( 1 - \frac{f_{b1}}{F_{c1}} \right) + \frac{f_{b2}}{F_{c2}} \left( 1 - \frac{f_{b2}}{F_{c2}} \right) = 0.31 < 1 \quad \checkmark \]

\[ 2 \times 10 \text{ DE #2 IS ADEQUATE} \]
Worst Case - 4'-0" SW @ Line 3

\[ \varepsilon M_c = (1141 \text{ plf})(4')(9') - (P)(4') = 0 \]

1141 plf \[ P = 1269 \text{#} \]

Hold down - USE HDU2/SDS2.5
-capacity = 3075# > 1269# ✓

Top Plate Stiffness - $V_{max}$
-(chord force) Domain:

N-S (11.4')(6) = 118 plf
415'

E-W (12.4')(6) = 149 plf $\leftarrow$ MAX
50'

USE LSTRA Capacity = 140 plf > 149 plf ✓

Anchor bolts

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

Demand = (4')(141 plf) = 564# < 650# ✓
STUD NAIL CONNECTION

USE 10d COMMON NAIL @ 6" O.C. STAGGERED  CAPACITY = 115#
(NDS Tab 12L)

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

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

* TOP PLATE STRAP & STUD NAILING CONNECTION ARE *
FOR PANEL TO PANEL FORCE TRANSFER
\[ W_{\text{MAX}} = (14 \text{ psf} + 48 \text{ psf})(15') + (10 \text{ psf} + 90 \text{ psf})(15') + (12 \text{ psf})(9') + (78 \text{ psf})(9'/12')(2.5') \]

\[ W_{\text{MAX}} = 1898 \text{ psf} \]

\[ b_c = \frac{1898 \text{ psf}}{1500 \text{ psf}} = 1.25' \]

**REBAR**

\[ As = \sqrt{b_c l} \]

\[ As = 0.0018 (12'')(1.5') \]

\[ As = 0.3456 \text{ in}^2 \]

\[ \text{USE (1) +6} \]

\[ A = 0.44 \text{ in}^2 > 0.346 \checkmark \]
Footings Under Floor Girders

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

\[ C > \frac{P}{A} \]

\[ A > \frac{6000 \text{#}}{1500 \text{psf}} \]

\[ A > 4 \text{ ft}^2 \]

Use 2' x 2' Pad Footing.

REBAR

\[ A_S = \frac{P}{f_y} \]

\[ A_S = 0.0018 \ (24") \ (12") \]

\[ A_S = 0.518 \text{ in}^2 \]

Use (2) 5". \( A_S = 0.62 \text{ in}^2 > 0.518 \text{ in}^2 \checkmark \)

Simpson Strong Wall Pad Footings

Per Simpson (see attached) W = 180
## 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 1</th>
<th>2,500 psi Concrete</th>
<th>Wind 1</th>
<th>Seismic 2</th>
<th>3,000 psi Concrete</th>
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<td>22,710</td>
<td>5,515</td>
<td>0.32</td>
<td>22,710</td>
</tr>
</tbody>
</table>

---

### Footnotes

1. Allowable ASD Shear Load, V (lb)
2. Drift at Allowable Shear, A (m)²
3. Anchor Tension at Allowable Shear, T (lb)
4. Anchor Tension at Allowable Shear, A (m)³
5. Drift at Allowable Shear, A (m)²
6. Anchor Tension at Allowable Shear, T (lb)
7. Anchor Tension at Allowable Shear, A (m)³

---

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.

5" min. for WSW-AB6, 6" min. for WSW-AB1.

Curb or Stemwall Section View

Perspective View
(Slab not shown for clarity)

Footing Plan

Slab-on-Grade Installation

Shear reinforcement per page 25 when required.

5" min. for WSW-AB6, 6" min. for WSW-AB1.

Slab-on-Grade Section View

Perspective View

Footing Plan

Brick Ledge Installation

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

5" min. for WSW-AB6, 6" min. for WSW-AB1.

Brick Ledge Section View

Perspective View

Footing Plan

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 \[ CAPACITY = 1200# \geq 992# \checkmark \]

USE FF-62 COLUMN CAP

(P-2) CAPS & BASES

DEMAND = 6000# DOWNWARD

USE ABU 442 POST BASE \[ CAPACITY = 6005# \geq 6000# \checkmark \]

USE FCHZ COLUMN CAP

(R1-1) DRAG STRAP

DEMAND = (44.4 PLF)(8') = 3552#

USE MSTC 40 STRAP \[ CAPACITY = 4745# \geq 3552# \checkmark \]

DRAG TIEUP STRAP

DEMAND = (152 PLF)(30') = 4560#

USE MSTC 40 STRAP \[ CAPACITY = 4745# \geq 4560# \checkmark \]
Holdowns & Tension Ties

**HDU/DTD 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 tennon 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 29 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:** See General Notes on page 45.
- 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 9/64 hex head driver.

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

---

**Table:**

<table>
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<tr>
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<td>SPF/HF</td>
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</table>

1. See page 45 for Holdown and Tension Tie General Notes.
2. Noted HDU14 allowable loads are based on a 5½" 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.

---

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.
### HRS/ST/PS/HST/LSTA/LSTI/MST/MSTA/MSTC/MSTI Strap Ties

**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.

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<td>(160)</td>
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1. Loads include a 60% load duration increase on the fasteners for wind or earthquake loading.
2. 10x1x1/2" 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 3 1/8" long) or 10d commons may be substituted where 16d commons are specified at 80% 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 3 1/8" long, 16d Sinker = 0.148" dia. x 3 1/8" long, 10d = 0.148" dia. x 3" long, 10x1x1/2" = 0.148" dia. x 1 1/2" long. See page 22-23 for other nail sizes and information.

**Typical LSTA Installation**

(Banger not shown)
Bend strap one time only, max 12/12 joist pitch.

**Material Thickness Gauge**

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<td>L</td>
<td>Oty Dia</td>
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<td>L</td>
<td>Oty Dia</td>
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</table>

1. PS strap design loads must be determined by the Designer for each installation. Bolts are installed both perpendicular and parallel-to-grain. Hole diameter in the part may be oversized to accommodate the HDG. Designer must determine if the oversize creates an unacceptable installation.
2. For allowable tension loads, see page 230.

**Typical PS720 Installation**
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 Masonry 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, ABU101D2 – 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.

<table>
<thead>
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<td>3%</td>
<td>5%</td>
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</table>

1. Uplift loads have been increased for wind or earthquake with no further increase allowed; reduce where other loads govern.
2. Downloads may not be increased for short-term loading.
3. Specifier to design concrete for uplift capacity.
4. ABU products may be installed with either bolts or nails (not both) to achieve table loads. ABU88Z, ABU88R, ABU101D2, and ABU101D2R may be installed with 8-1/2" Strong-Drive® SDS Heavy-Duty Connector screws (sold separately) for the same table load.
5. For AB bases, higher down loads can be achieved by solidly packing groud under 1" standoff plate before installation. Base load on column, grout, or concrete 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 SCI columns, the fasteners for these products should always be installed in the wide face.
8. Downloads shall be reduced where limited by the capacity of the post. See pages 245-246 for common post allowable loads.
9. NAILS: 16d = 0.188" dia. x 3/4" long, 10d = 0.148" dia. x 3/4" 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® #8x1 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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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 x 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® SD9x1 1/2 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 = 0.131” dia. x 1 1/2” long.

---

| Shim by Designer |
| Shim by Designer |

**PCZ Post Cap Installed on Double 2x Members**  
**EPCZ Post Cap Installed on Double 2x Members**