ALLIANCE ENGINEERING
Specialists in Post Frame Engineering

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POST FRAME BUILDING STRUCTURAL CALCULATION

(This structure has been analyzed and designed for structural adequacy only.)

City of Puyallup Building
REVIEWED FOR COMPLIANCE
BSnowden
05/01/2026
11:06:45 AM
CITY OF PUYALLUP STATE OF WASHINGTON

PROJECT No.
1200926

These calculations must be on site and made available by the Permittee for all inspections.

BUILDING OWNER / LOCATION:
Puyallup Seventh Day Adventist Church
902 Shaw Rd E
Puyallup, WA 98372

CLIENT:
Abel Construction
26020 Lawson St
Black Diamond, WA 98010

ENGINEER: 4/15/26

JAMES C LOUGHREY
STATE OF WASHINGTON
22009139
REGISTERED PROFESSIONAL ENGINEER

POST FRAME BUILDING

REFERENCES:

1. 2021 Edition of the International Building Code

2. ASCE 7-16 - Minimum Design Loads and Associated Criteria for Buildings and Other Structures, American Society of Civil Engineers, 2017

3. 2018 Edition, National Design Specification (NDS) For Wood Construction with 2018 Edition NDS Supplement, American Wood Council, 2018

4. 2021 Edition, Special Design Provisions for Wind and Seismic (SDPWS) American Wood Council, 2020

5. ASABE EP486.3 - Shallow Post and Pier Foundation Design American Society of Agricultural and Biological Engineers, 2017

DESIGN INPUT VALUES:

Building Dimensions

$W_{bldg} := 70 \cdot ft$ Width of Building

$L_{bldg} := 65 \cdot ft$ Length of Building

$H_{bldg} := 12 \cdot ft$ Eave Height of Building

$R_{pitch} := 4$ /12 Roof pitch

$O_{verhang} := 12 \cdot in$ Length of Eave Overhang

$GO_{verhang} := 12 \cdot in$ Length of Gable Overhang

$B_{ay} := 11 \cdot ft$ Greatest tributary spacing between eave wall posts

$A_{pron} := 0 \cdot ft$ Height of Wall Apron Below Roof Line

Design Loads for Building:

Risk_Category := "II"

Wind Design Values:

Wind Speed: Wind Exposure:

$V_{wind} = 110$ mph $E_{xposure} :=$ "C"

Seismic Design Values:

Site_class := "D"

$S_s := 1.254$ Mapped spectral acceleration for short period

$S_1 := 0.432$ Mapped spectral acceleration for 1 second period

$R_a := 1.5$ Response modification factor

Roof Load Design Values:

$p_g := 30 \cdot psf$ Ground snow load

$p_d = 5$ psf Roof dead load Roof_type_is = "metal sheathing"

$p_{Lr} = 20$ psf Roof live load

$p_{d2} = 1$ psf Additional truss bottom chord dead load (if applicable)

$p_{La} = 0$ psf Ceiling live load at storage areas (if applicable, where 24" wide x 42" tall object will fit between (2) or more truss members. The width of the storage_area_is = 0 ft)

DESIGN INPUT VALUES (Continued):

Structural Members for Building:

Eave Post Properties: *(Solid-sawn post unless otherwise specified)*

S_{post} := 8x12   Post Species := Hem-Fir   Post Grade := 1

$Post_{is}$:= Roug-Sawn

Purlin Properties:

Spurlin := Sx26

$Purlin_{species}$:= Doug-Fir

$Purlin_{grade}$:= 2 $Purlin_{spacing} := 24 \cdot in$

Post Hole and Footing Design Values:

$q_{soil} := 1500 \cdot psf$ Assumed soil vertical bearing capacity

$S_{soil} = 100\ psf$ / ft   Assumed soil lateral bearing capacity

$d_{ia\_footing} := 2.50 \cdot ft$ Main eave post footing diameter

$t_{CPfooting} = 6\ in$ Thickness of post concrete footing

Backfill_type := Concrete   Main eave post hole backfill

(GO TO LAST PAGE FOR SUMMARY OF RESULTS)

SNOW LOAD ANALYSIS:

For roof slopes greater than 5 degrees, and less than 70 degrees.

$p_g = 30\,psf$ Ground Snow Load (from above)

$R_{angle} = 18.43\,deg$ Angle of roof

$C_e = 1.00$ Exposure factor

$C_t = 1.20$ Thermal Factor

$C_s = 1.00$ Roof slope factor

$I_s = 1.00$ Importance factor

1. Determine Roof Snow Loads:

$p_f := 0.7 \cdot C_e \cdot C_t \cdot I_s \cdot p_g$ Equation 1

$p_f = 25.2\,psf$ Flat roof snow load; $Roof\_slope \le 5deg$

$p_s := C_s \cdot p_f$ Equation 2

$p_s = 25.2\,psf$ Sloped roof (balanced) snow load

2. Determine final snow load, p_{su}

$p_{su} = 26\,psf$ **Final roof snow load**

WIND ANALYSIS:

$V_{wind} = 110\ \text{mph}$	Wind Speed
$k_d = 0.85$	Wind Directionality Factor
$k_{zt} = 1.0$	Topographic Factor
$k_z = 0.849$	Wind Exposure Factor (windward)
$k_{z\_cc} = 0.849$	Wind Exposure Factor (components & cladding)
$I_w = 1.00$	Importance factor

$q_z := 0.00256 \cdot k_z \cdot k_{zt} \cdot k_d \cdot V_{wind}^{2}$

$q_z = 22.35\ \text{psf}$ Velocity Pressure

$q_{z\_cc} := 0.00256 \cdot k_{z\_cc} \cdot k_{zt} \cdot k_d \cdot V_{wind}^{2}$

$q_{z\_cc} = 22.35\ \text{psf}$ Velocity Pressure (Components & Cladding)

Calculated Wind Pressures:

Roof Wind:

$q_{roof} := q_z \cdot G \cdot C_{Nrw}$

$q_{roof} = 22.80\ \text{psf}$

Roof Uplift:

$q_{uplift} := q_z \cdot G \cdot C_{Nuplift}$

$q_{uplift} = -31.27\ \text{psf}$

Windward Eave Wall:

$q_{wwe} := q_z \cdot G \cdot C_{pwwe}$

$q_{wwe} = 15.20\ \text{psf}$

Leeward Eave Wall:

$q_{lwe} := q_z \cdot G \cdot C_{plwe}$

$q_{lwe} = -9.21\ \text{psf}$

Windward Gable Wall:

$q_{wwg} := q_z \cdot G \cdot C_{pwwg}$

$q_{wwg} = 15.20\ \text{psf}$

Leeward Gable Wall:

$q_{lwg} := q_z \cdot G \cdot C_{plwg}$

$q_{lwg} = -9.50\ \text{psf}$

Wall Elements:

$q_{we} := q_{z\_cc} \cdot GC_{pwall}$

$q_{we} = -17.88\ \text{psf}$

Roof Elements:

$q_r := q_{z\_cc} \cdot G \cdot C_{Nre}$

$q_r = -30.12\ \text{psf}$

Internal Wind Pressure (+/-):

$q_i := q_{z\_cc} \cdot GC_{pi}$

$q_i = 4.02\ \text{psf}$

SEISMIC CALCULATIONS:

$S_s = 1.25$ Mapped spectral acceleration for short periods (from above)

$S_1 = 0.43$ Mapped spectral acceleration for 1-second period (from above)

$I_e = 1.0$ Importance factor

$R_a = 1.5$ Response modification factor (from above)

1. Determine the Seismic Design Category

a. Calculate S_{DS} and S_{D1}

For S_{DS}:

For $S_s = 1.25$

$F_a = 1.20$

$S_{MS} := S_s \cdot F_a$

$S_{MS} = 1.50$

$S_{DS} := \left(\frac{2}{3}\right) \cdot S_{MS}$

$S_{DS} = 1.00$

For S_{D1}:

For $S_1 = 0.43$

$F_v = 1.57$

$S_{M1} := S_1 \cdot F_v$

$S_{M1} = 0.677$

$S_{D1} := \left(\frac{2}{3}\right) \cdot S_{M1}$

$S_{D1} = 0.45$

Seismic_Design_Category = "D"

2. Determine the building parameters

Building dead load weight, Wt:

$p_{f\_s} := \text{if}(p_f > 30 \cdot \text{psf}, p_f, 0)$ $p_{f\_s} = 0 \text{ psf}$

$H_{roof} = 11.67 \text{ ft}$ Height of roof

$T_{russ\_heel} = 2.83 \text{ ft}$ Height of gable end truss heel

Wall Load Design Values:

$p_{Dw} = 3 \text{ psf}$ Wall dead load (mean)

$A_{pron} = 0.00$ Height of Wall Apron Below Roof Line (if applicable)

$$W_t := \left[W_{bldg} + \left(2 \cdot O_{verhang}\right)\right] \cdot \left[L_{bldg} + \left(2 \cdot GO_{verhang}\right)\right] \cdot \left[\left(p_{f\_s} \cdot 0.20\right) + p_d + p_{d2}\right] \dots$$
$$+ \left[W_{attic} \cdot L_{bldg} \cdot \left(0.25 \cdot p_{La}\right)\right] + \left[\left(W_{bldg} - W_{attic}\right) \cdot L_{bldg} \cdot \left(0.25 \cdot p_{La2}\right)\right] \dots$$
$$+ \left[\left(2 \cdot W_{bldg} \cdot \max\left(A_{pron}, T_{russ\_heel}\right)\right) + \left(2 \cdot L_{bldg} \cdot A_{pron}\right) + \left(W_{bldg} \cdot H_{roof}\right)\right] \cdot p_{Dw}$$

$W_t = 32584 \text{ lb}$

Building area, A_b:

$A_b := L_{bldg} \cdot W_{bldg}$

$A_b = 4550 \text{ ft}^2$

3. Determine the shear force to be applied

a. Determine the fundamental period, T

$C_u = 1.4$ sec Coefficient for Upper Limit on Calculated Period

$$T_a := 0.02 \cdot \left(\frac{H_{bldg} + \frac{H_{roof}}{2}}{ft} \right)^{0.75} \qquad T_a = 0.174 \text{ sec}$$

$$T := \text{if}\left(T_a > C_u, C_u, T_a\right) \qquad T = 0.174 \text{ sec}$$ Fundamental period

b. Determine the Seismic Response Coefficient, C_s:

$T_L = 6$ Long-period transition period

C_s is calculated as: but C_s need not exceed:

$$C_{s1} := \frac{S_{DS}}{\frac{R_a}{I_e}} \qquad C_{s1} = 0.669$$

$$C_{s2} := \text{if}\left[T \le T_L, \frac{S_{D1}}{T \cdot \left(\frac{R_a}{I_e}\right)}, \frac{S_{D1} \cdot T_L}{T^2 \cdot \left(\frac{R_a}{I_e}\right)}\right] \qquad C_{s2} = 1.735$$

and C_s shall not be less than:

$$C_{s3} := \max\left[\max\left(0.044 \cdot S_{DS} \cdot I_e, 0.01\right), \text{if}\left[S_1 \ge 0.6, \frac{0.55 \cdot S_1}{\left(\frac{R_a}{I_e}\right)}, 0\right]\right] \qquad C_{s3} = 0.044$$

$$C_s := \text{if}\left(C_{s1} > C_{s2}, C_{s2}, \text{if}\left(C_{s1} < C_{s3}, C_{s3}, C_{s1}\right)\right)$$

$C_s = 0.669$ Seismic Response Coefficient to used in determination of seismic base shear

c. Determine the Seismic Base Shear:

$$V_{base\_shear} := C_s \cdot W_t \qquad V_{base\_shear} = 21792 \text{ lb}$$

4. Determine the seismic load on the building:

Since Seismic_Design_Category = "D" , $\rho = 1.30$ $\Omega_0 := 1.5$ Overstrength Factor

$E := \max\left(\rho, \Omega_0\right) \cdot V_{base\_shear}$ $E = 32688 \text{ lb}$ Seismic load on building

$P_{ost\_number} = 14$ Number of posts resisting seismic loads

$$f_{bseismic\_eave} := \frac{E \cdot L_{xpost\_bndg}}{\left(P_{ost\_number} \cdot S_{xpost}\right)} \qquad f_{bseismic\_eave} = 1338 \text{ psi}$$ This is the seismic load on one post

$$f_{bseismic\_gable} := \frac{E \cdot L_{ypost\_bndg}}{\left(P_{ost\_number} \cdot S_{ypost}\right)} \qquad f_{bseismic\_gable} = 2526 \text{ psi}$$ This is the seismic load on one post

BUILDING MODEL:

$a := B_{ay}$ $a = 132\,in$ Bay spacing in inches $H_{roof} = 11.667\,ft$ Roof height

$\Theta = 18.43\,deg$ Roof angle from horizontal

CALCULATE WIND LOADS:

Apply wind loads to the roof to determine moments and fiber stresses in the posts

Eave Wind Calculations:

Calculate the eave wind load on the roof in each bay.

$q_{roof} = 22.8\,psf$ Roof wind pressure

$P_{eave\_wind} := H_{roof} \cdot B_{ay} \cdot q_{roof}$ $P_{eave\_wind} = 2926\,lb$

Calculate the eave wind load on the eave wall aprons

$q_e = 24.4\,psf$ Eave wall wind pressure

$P_{eave\_apron} := A_{pron} \cdot B_{ay} \cdot q_e$ $P_{eave\_apron} = 0\,lb$

$M_{eave\_wind} := \left(P_{eave\_wind} + P_{eave\_apron}\right) \cdot \left(H_{bldg}\right)$ $M_{eave\_wind} = 421303\,in \cdot lb$

$f_{beave\_wind} := \dfrac{M_{eave\_wind}}{2 \cdot S_{xpost}}$ $f_{beave\_wind} = 1097\,psi$

Gable Wind Calculations:

Calculate the total gable roof/wall load

$q_g = 24.7\,psf$ Gable wall wind pressure

$P_{gable\_wind} := \left[\left(H_{roof} \cdot \dfrac{W_{bldg}}{2}\right) + W_{bldg} \cdot A_{pron}\right] \cdot q_g$ $P_{gable\_wind} = 10085\,lb$

$M_{gable\_wind} := P_{gable\_wind} \cdot H_{bldg}$ $M_{gable\_wind} = 1452220\,in \cdot lb$

$P_{ost\_number} = 14$

$f_{bgable\_wind} := \dfrac{M_{gable\_wind}}{\left(P_{ost\_number} \cdot S_{ypost}\right)}$ $f_{bgable\_wind} = 810\,psi$

MAIN POST DESIGN FOR EAVE WIND:

Calculate allowable unit compression stress, F_{cc}.

$F_{c1} = 750\ \text{psi}$ $F_c := F_{c1} \cdot C_{Mcpost} \cdot C_{tpost} \cdot C_{Fcpost} \cdot C_{ipost} \cdot C_{dASCE}$

$F_c = 900\ \text{psi}$ Allowable compression stress including load factors

$L_{xpost\_bndg} = 110\ \text{in}$ Bending length of post

$d_{post} = 8\ \text{in}$ Minimum unbraced dimension of post

$K_e := 1.2$ $c := 0.8$ $E_{min\_wood} = 470000\ \text{psi}$ $E'_{min} := E_{min\_wood} \cdot C_{MEpost} \cdot C_{tpostE} \cdot C_{ipostE}$

$l_e := K_e \cdot L_{xpost\_bndg}$ $l_e = 132.00\ \text{in}$ $E'_{min} = 470000\ \text{psi}$

$$F_{cE} := \frac{0.822 \cdot E'_{min}}{\left(\frac{l_e}{d_{post}}\right)^2} \qquad F_{cE} = 1419\ \text{psi}$$

Load duration factors (C_D):

$C_{Dconst} = 1.25$ $C_{Dwind} = 1.60$

$C_{Dsnow} = 1.15$ $C_{Dseismic} = 1.60$

$C_{Dlive} = 1.00$

Calculate Column Stability Factor, C_p:

$$C_p := \left(\frac{1 + \frac{F_{cE}}{F_c \cdot C_D}}{2 \cdot c}\right) - \sqrt{\left(\frac{1 + \frac{F_{cE}}{F_c \cdot C_D}}{2 \cdot c}\right)^2 - \frac{\frac{F_{cE}}{F_c \cdot C_D}}{c}}$$

$C_{p\_Lr} = 0.76$ $C_{p\_L} = 0.82$

$C_{p\_S} = 0.79$ $C_{p\_WorE} = 0.69$

$F_{cc\_L} := F_c \cdot C_{p\_L}$ $F_{cc\_L} = 739\ \text{psi}$ Allowable compression stress on the post; load case 1

$F_{cc\_Lr} := F_c \cdot C_{p\_Lr}$ $F_{cc\_Lr} = 688\ \text{psi}$ Allowable compression stress on the post; load case 2

$F_{cc\_S} := F_c \cdot C_{p\_S}$ $F_{cc\_S} = 709\ \text{psi}$ Allowable compression stress on the post; load case 3b & 4b

$F_{cc\_WorE} := F_c \cdot C_{p\_WorE}$ $F_{cc\_WorE} = 617\ \text{psi}$ Allowable compression stress on the post; all load cases except as note above

$P_{deadpost} = 2365\ \text{lb}$ Axial loading per post due to roof dead load

$P_{livepost} = 0\ \text{lb}$ Axial loading per post due to live load

$P_{Lroofpost} = 7920\ \text{lb}$ Axial loading per post due to live roof load

$P_{snowpost} = 10564\ \text{lb}$ Axial loading per post due to roof snow load (load case 3b & 4b)

$P_{snowpost\_fs} = 9979\ \text{lb}$ Axial loading per post due to roof snow load (load cases except as noted above)

$F_{b1} = 1050\ \text{psi}$ $F_b := F_{b1} \cdot C_{Dwind} \cdot C_{Mbpost} \cdot C_{tpost} \cdot C_{Lxpost} \cdot C_{Fbpost} \cdot C_{fupost} \cdot C_{ipost} \cdot C_{dASCE}$

$F_b = 2004\ \text{psi}$ Allowable bending stress per post including load factors

Check Eave Load Cases:

Load Case 1: Dead Load

$$f_c := \frac{P_{deadpost}}{A_{post}}$$ $f_c = 25\,psi$ **Actual compression stress per post**

$$CCFALI1 := \left(\frac{f_c}{F_{cc\_L}}\right)$$ $CCFALI1 = 0.03$

Load Case 2: Dead Load + Live Load

$$f_c := \frac{P_{deadpost} + P_{livepost}}{A_{post}}$$ $f_c = 25\,psi$ **Actual compression stress per post**

$$CCFALI2 := \left(\frac{f_c}{F_{cc\_L}}\right)$$ $CCFALI2 = 0.03$

Load Case 3a: Dead Load + Live Roof Load

$$f_c := \frac{P_{deadpost} + P_{Lroofpost}}{A_{post}}$$ $f_c = 107\,psi$ **Actual compression stress per post**

$$CCFALI3a := \left(\frac{f_c}{F_{cc\_Lr}}\right)$$ $CCFALI3a = 0.16$

Load Case 3b: Dead Load + Snow Load

$$f_c := \frac{P_{deadpost} + P_{snowpost}}{A_{post}}$$ $f_c = 135\,psi$ **Actual compression stress per post**

$$CCFALI3b := \left(\frac{f_c}{F_{cc\_S}}\right)$$ $CCFALI3b = 0.19$

Load Case 4a: Dead Load + 0.75 * Live load + 0.75 * Live Roof Load

$$f_c := \frac{P_{deadpost} + 0.75 \cdot P_{livepost} + 0.75 \cdot P_{Lroofpost}}{A_{post}}$$ $f_c = 87\,psi$ **Actual compression stress per post**

$$CCFALI4a := \left(\frac{f_c}{F_{cc\_Lr}}\right)$$ $CCFALI4a = 0.13$

Load Case 4b: Dead Load + 0.75 * Live load + 0.75 * Snow Load

$$f_c := \frac{P_{deadpost} + 0.75 \cdot P_{livepost} + 0.75 \cdot P_{snowpost}}{A_{post}}$$ $f_c = 107\,psi$ **Actual compression stress per post**

$$CCFALI4b := \left(\frac{f_c}{F_{cc\_S}}\right)$$ $CCFALI4b = 0.15$

Check Eave Load Cases - cont'd:

Load Case 5: Dead Load + 0.6 * Wind Load

$f_{b1} := 0.6 \cdot f_{beave\_wind}$ $f_{b1} = 658\ psi$ Actual bending stress on post

$f_c := \frac{P_{deadpost}}{A_{post}}$ $f_c = 25\ psi$ Actual compression stress per post

$$CCFALI5 := \left[\left(\frac{f_c}{F_{cc\_WorE}}\right)^2 + \frac{f_{b1}}{F_b \cdot \left(1 - \frac{f_c}{F_{cE}}\right)}\right]$$

$CCFALI5 = 0.34$

Load Case 6a: Dead Load + 0.75 * Live Load + 0.75 * (0.6 * Wind Load) + 0.75 * Live Roof Load

$f_{b1} := 0.75 \cdot (0.6 \cdot f_{beave\_wind})$ $f_{b1} = 494\ psi$ Actual bending stress on post

$f_c := \frac{P_{deadpost} + 0.75 \cdot P_{livepost} + 0.75 \cdot P_{Lroofpost}}{A_{post}}$ $f_c = 87\ psi$ Actual compression stress per post

$$CCFALI6a := \left[\left(\frac{f_c}{F_{cc\_WorE}}\right)^2 + \frac{f_{b1}}{F_b \cdot \left(1 - \frac{f_c}{F_{cE}}\right)}\right]$$

$CCFALI6a = 0.28$

Load Case 6a: Dead Load + 0.75 * Live Load + 0.75 * (0.6 * Wind Load) + 0.75 * Snow Load

$f_{b1} := 0.75 \cdot (0.6 \cdot f_{beave\_wind})$ $f_{b1} = 494\ psi$ Actual bending stress on post

$f_c := \frac{P_{deadpost} + 0.75 \cdot P_{livepost} + 0.75 \cdot P_{snowpost\_fs}}{A_{post}}$ $f_c = 103\ psi$ Actual compression stress per post

$$CCFALI6b := \left[\left(\frac{f_c}{F_{cc\_WorE}}\right)^2 + \frac{f_{b1}}{F_b \cdot \left(1 - \frac{f_c}{F_{cE}}\right)}\right]$$

$CCFALI6b = 0.29$

Load Case 7: 0.6 * Dead Load + 0.6 * Wind Load

$f_{b1} := 0.6 \cdot f_{beave\_wind}$ $f_{b1} = 658\ psi$ Actual bending stress on post

$f_c := \frac{0.6 \cdot P_{deadpost}}{A_{post}}$ $f_c = 15\ psi$ Actual compression stress per post

$$CCFALI7 := \left[\left(\frac{f_c}{F_{cc\_WorE}}\right)^2 + \frac{f_{b1}}{F_b \cdot \left(1 - \frac{f_c}{F_{cE}}\right)}\right]$$

$CCFALI7 = 0.33$

Check Eave Load Cases - cont'd:

$E_{vpost} := 0.2 \cdot S_{DS} \cdot P_{deadpost}$ $E_{vpost} = 475\,lb$ Vertical seismic load

Load Case 8: Dead Load + 0.7 * Vertical Seismic Load + 0.7 * Horizontal Seismic Load

$f_{b1} := 0.7 \cdot f_{bseismic\_eave}$ $f_{b1} = 936\,psi$ Actual bending stress on post

$$f_c := \frac{P_{deadpost} + 0.7 \cdot E_{vpost}}{A_{post}}$$

$f_c = 28\,psi$ Actual compression stress per post

$$CCFALI8 := \left[\left(\frac{f_c}{F_{cc\_WorE}} \right)^2 + \frac{f_{b1}}{F'_b \cdot \left(1 - \frac{f_c}{F_{cE}} \right)} \right]$$

$CCFALI8 = 0.48$

Load Case 9: Dead Load + 0.525 * Vertical Seismic Load + 0.525 * Horizontal Seismic Load + 0.75 * Live Load + 0.75 * Snow Load

$f_{b1} := 0.525 \cdot f_{bseismic\_eave}$ $f_{b1} = 702\,psi$ Actual bending stress on post

$$f_c := \frac{P_{deadpost} + 0.525 \cdot E_{vpost} + 0.75 \cdot P_{livepost} + 0.75 \cdot P_{snowpost\_fs}}{A_{post}}$$

$f_c = 105\,psi$ Actual compression stress per post

$$CCFALI9 := \left[\left(\frac{f_c}{F_{cc\_WorE}} \right)^2 + \frac{f_{b1}}{F'_b \cdot \left(1 - \frac{f_c}{F_{cE}} \right)} \right]$$

$CCFALI9 = 0.41$

Load Case 10: Dead Load - 0.7 * Vertical Seismic Load + 0.7 * Horizontal Seismic Load

$f_{b1} := 0.7 \cdot f_{bseismic\_eave}$ $f_{b1} = 936\,psi$ Actual bending stress on post

$$f_c := \frac{P_{deadpost} - 0.7 \cdot E_{vpost}}{A_{post}}$$

$f_c = 21\,psi$ Actual compression stress per post

$$CCFALI10 := \left[\left(\frac{f_c}{F_{cc\_WorE}} \right)^2 + \frac{f_{b1}}{F'_b \cdot \left(1 - \frac{f_c}{F_{cE}} \right)} \right]$$

$CCFALI10 = 0.48$

$CCFALI_{eave} = 0.48$ Less than or equal to 1.00 thus OK

MAIN POST DESIGN FOR GABLE WIND:

Calculate allowable unit compression stress, F_{cc}.

$F_{c1} = 850\,psi$ $\quad F_c := F_{c1} \cdot C_{Mcpost} \cdot C_{tpost} \cdot C_{Fcpost} \cdot C_{ipost} \cdot C_{dASCE}$

$F_c = 1020\,psi$ Allowable compression stress including load factors

$L_{ypost\_bndg} = 138.5\,in$ Bending length of post

$d_{post} = 8\,in$ Minimum unbraced dimension of post

$K_e := 1.2$ $\quad c := 0.8$ $\quad E_{min\_wood} = 470000\,psi$ $\quad E'_{min} := E_{min\_wood} \cdot C_{MEpost} \cdot C_{tpostE} \cdot C_{ipostE}$

$l_e := K_e \cdot L_{ypost\_bndg}$ $\quad l_e = 166.2\,in$ $\quad E'_{min} = 470000\,psi$

$$F_{cE} := \frac{0.822 \cdot E'_{min}}{\left(\dfrac{l_e}{d_{post}}\right)^2} \qquad F_{cE} = 895\,psi$$

Load duration factors (C_D):

$C_{Dconst} = 1.25$ $\quad C_{Dwind} = 1.60$

$C_{Dsnow} = 1.15$ $\quad C_{Dseismic} = 1.60$

$C_{Dlive} = 1.00$

Calculate Column Stability Factor, C_p:

$$C_p := \left(\frac{1 + \dfrac{F_{cE}}{F_c \cdot C_D}}{2 \cdot c}\right) - \sqrt{\left(\frac{1 + \dfrac{F_{cE}}{F_c \cdot C_D}}{2 \cdot c}\right)^2 - \frac{\dfrac{F_{cE}}{F_c \cdot C_D}}{c}}$$

$C_{p\_Lr} = 0.56$ $\quad C_{p\_L} = 0.64$

$C_{p\_S} = 0.59$ $\quad C_{p\_WorE} = 0.47$

$F_{cc\_L} := F_c \cdot C_{p\_L}$ $\quad F_{cc\_L} = 657\,psi$ Allowable compression stress on the post; load case 1

$F_{cc\_Lr} := F_c \cdot C_{p\_Lr}$ $\quad F_{cc\_Lr} = 571\,psi$ Allowable compression stress on the post; load case 2

$F_{cc\_S} := F_c \cdot C_{p\_S}$ $\quad F_{cc\_S} = 603\,psi$ Allowable compression stress on the post; load case 3b & 4b

$F_{cc\_WorE} := F_c \cdot C_{p\_WorE}$ $\quad F_{cc\_WorE} = 476\,psi$ Allowable compression stress on the post; all load cases except as note above

$P_{deadpost} = 2365\,lb$ Axial loading per post due to roof dead load

$P_{livepost} = 0\,lb$ Axial loading per post due to live load

$P_{Lroofpost} = 7920\,lb$ Axial loading per post due to live roof load

$P_{snowpost} = 10564\,lb$ Axial loading per post due to roof snow load (load case 3b & 4b)

$P_{snowpost\_fs} = 9979\,lb$ Axial loading per post due to roof snow load (load cases except as noted above)

$F_{b1} = 975\,psi$ $\quad F_b := F_{b1} \cdot C_{Dwind} \cdot C_{Mbpost} \cdot C_{tpost} \cdot C_{Lypost} \cdot C_{Fbpost} \cdot C_{fupost} \cdot C_{ipost} \cdot C_{dASCE}$

$F_b = 1872\,psi$ Allowable bending stress per post including load factors

Check Gable Load Cases:

Load Case 1: Dead Load

$$f_c := \frac{P_{deadpost}}{A_{post}}$$ $f_c = 25\,\text{psi}$ Actual compression stress per post

$$CCFALI1 := \left(\frac{f_c}{F_{cc\_L}}\right)$$ $CCFALI1 = 0.04$

Load Case 2: Dead Load + Live Load

$$f_c := \frac{P_{deadpost} + P_{livepost}}{A_{post}}$$ $f_c = 25\,\text{psi}$ Actual compression stress per post

$$CCFALI2 := \left(\frac{f_c}{F_{cc\_L}}\right)$$ $CCFALI2 = 0.04$

Load Case 3a: Dead Load + Live Roof Load

$$f_c := \frac{P_{deadpost} + P_{Lroofpost}}{A_{post}}$$ $f_c = 107\,\text{psi}$ Actual compression stress per post

$$CCFALI3a := \left(\frac{f_c}{F_{cc\_Lr}}\right)$$ $CCFALI3a = 0.19$

Load Case 3b: Dead Load + Snow Load

$$f_c := \frac{P_{deadpost} + P_{snowpost}}{A_{post}}$$ $f_c = 135\,\text{psi}$ Actual compression stress per post

$$CCFALI3b := \left(\frac{f_c}{F_{cc\_S}}\right)$$ $CCFALI3b = 0.22$

Load Case 4a: Dead Load + 0.75 * Live load + 0.75 * Live Roof Load

$$f_c := \frac{P_{deadpost} + 0.75 \cdot P_{livepost} + 0.75 \cdot P_{Lroofpost}}{A_{post}}$$ $f_c = 87\,\text{psi}$ Actual compression stress per post

$$CCFALI4a := \left(\frac{f_c}{F_{cc\_Lr}}\right)$$ $CCFALI4a = 0.15$

Load Case 4b: Dead Load + 0.75 * Live load + 0.75 * Snow Load

$$f_c := \frac{P_{deadpost} + 0.75 \cdot P_{livepost} + 0.75 \cdot P_{snowpost}}{A_{post}}$$ $f_c = 107\,\text{psi}$ Actual compression stress per post

$$CCFALI4b := \left(\frac{f_c}{F_{cc\_S}}\right)$$ $CCFALI4b = 0.18$

Check Gable Load Cases - cont'd:

Load Case 5: Dead Load + 0.6 * Wind Load

$f_{b1} := 0.6 \cdot f_{bgable\_wind}$ $f_{b1} = 486\,psi$ Actual bending stress on post

$f_c := \frac{P_{deadpost}}{A_{post}}$ $f_c = 25\,psi$ Actual compression stress per post

$$CCFALI5 := \left[\left(\frac{f_c}{F_{cc\_WorE}}\right)^2 + \frac{f_{b1}}{F_b \cdot \left(1 - \frac{f_c}{F_{cE}}\right)}\right]$$

$CCFALI5 = 0.27$

Load Case 6a: Dead Load + 0.75 * Live Load + 0.75 * (0.6 * Wind Load) + 0.75 * Live Roof Load

$f_{b1} := 0.75 \cdot (0.6 \cdot f_{bgable\_wind})$ $f_{b1} = 365\,psi$ Actual bending stress on post

$f_c := \frac{P_{deadpost} + 0.75 \cdot P_{livepost} + 0.75 \cdot P_{Lroofpost}}{A_{post}}$ $f_c = 87\,psi$ Actual compression stress per post

$$CCFALI6a := \left[\left(\frac{f_c}{F_{cc\_WorE}}\right)^2 + \frac{f_{b1}}{F_b \cdot \left(1 - \frac{f_c}{F_{cE}}\right)}\right]$$

$CCFALI6a = 0.25$

Load Case 6a: Dead Load + 0.75 * Live Load + 0.75 * (0.6 * Wind Load) + 0.75 * Snow Load

$f_{b1} := 0.75 \cdot (0.6 \cdot f_{bgable\_wind})$ $f_{b1} = 365\,psi$ Actual bending stress on post

$f_c := \frac{P_{deadpost} + 0.75 \cdot P_{livepost} + 0.75 \cdot P_{snowpost\_fs}}{A_{post}}$ $f_c = 103\,psi$ Actual compression stress per post

$$CCFALI6b := \left[\left(\frac{f_c}{F_{cc\_WorE}}\right)^2 + \frac{f_{b1}}{F_b \cdot \left(1 - \frac{f_c}{F_{cE}}\right)}\right]$$

$CCFALI6b = 0.27$

Load Case 7: 0.6 * Dead Load + 0.6 * Wind Load

$f_{b1} := 0.6 \cdot f_{bgable\_wind}$ $f_{b1} = 486\,psi$ Actual bending stress on post

$f_c := \frac{0.6 \cdot P_{deadpost}}{A_{post}}$ $f_c = 15\,psi$ Actual compression stress per post

$$CCFALI7 := \left[\left(\frac{f_c}{F_{cc\_WorE}}\right)^2 + \frac{f_{b1}}{F_b \cdot \left(1 - \frac{f_c}{F_{cE}}\right)}\right]$$

$CCFALI7 = 0.27$

Check Gable Load Cases - cont'd:

$E_{vpost} := 0.2 \cdot S_{DS} \cdot P_{deadpost}$ $E_{vpost} = 475\,lb$ **Vertical seismic load**

Load Case 8: Dead Load + 0.7 * Vertical Seismic Load + 0.7 * Horizontal Seismic Load

$f_{b1} := 0.7 \cdot f_{bseismic\_gable}$ $f_{b1} = 1768\,psi$ Actual bending stress on post

$$f_c := \frac{P_{deadpost} + 0.7 \cdot E_{vpost}}{A_{post}}$$ $f_c = 28\,psi$ Actual compression stress per post

$$CCFALI8 := \left[\left(\frac{f_c}{F_{cc\_WorE}}\right)^2 + \frac{f_{b1}}{F_b \cdot \left(1 - \frac{f_c}{F_{cE}}\right)}\right]$$ $CCFALI8 = 0.98$

Load Case 9: Dead Load + 0.525 * Vertical Seismic Load + 0.525 * Horizontal Seismic Load + 0.75 * Live Load + 0.75 * Snow Load

$f_{b1} := 0.525 \cdot f_{bseismic\_gable}$ $f_{b1} = 1326\,psi$ Actual bending stress on post

$$f_c := \frac{P_{deadpost} + 0.525 \cdot E_{vpost} + 0.75 \cdot P_{livepost} + 0.75 \cdot P_{snowpost\_fs}}{A_{post}}$$

$f_c = 105\,psi$ Actual compression stress per post

$$CCFALI9 := \left[\left(\frac{f_c}{F_{cc\_WorE}}\right)^2 + \frac{f_{b1}}{F_b \cdot \left(1 - \frac{f_c}{F_{cE}}\right)}\right]$$ $CCFALI9 = 0.85$

Load Case 10: Dead Load - 0.7 * Vertical Seismic Load + 0.7 * Horizontal Seismic Load

$f_{b1} := 0.7 \cdot f_{bseismic\_gable}$ $f_{b1} = 1768\,psi$ Actual bending stress on post

$$f_c := \frac{P_{deadpost} - 0.7 \cdot E_{vpost}}{A_{post}}$$

$f_c = 21\,psi$ Actual compression stress per post

$$CCFALI10 := \left[\left(\frac{f_c}{F_{cc\_WorE}}\right)^2 + \frac{f_{b1}}{F_b \cdot \left(1 - \frac{f_c}{F_{cE}}\right)}\right]$$ $CCFALI10 = 0.97$

$CCFALI_{gable} = 0.98$ Less than or equal to 1.00 thus OK

EMBEDMENT FOR MAIN EAVE POST:

Calculate the minimum required post embedment depth for lateral loading for the main posts.

Post_is = "not constrained by a concrete slab" Backfill_type = "Concrete"

$V_a = 1634\,\text{lb}$ Lateral shear load at the ground line

$M_a = 18864\,\text{lb}\cdot\text{ft}$ Moment at the ground line

$d_{ia\_footing} = 2.5\,\text{ft}$ Main post footing diameter, used with concrete backfill

$b_{post} = 14.4\,\text{in}$ Diagonal dimension of main post, used with granular backfill

$S_{soil} = 100\,\text{psf}$ Lateral capacity of soil

Trial depth = 1.5 ft.- The starting depth of the post hole depth. The final post hole depth is determined by iterating to a final depth.

$d_{epth\_post} = 4.1\,\text{ft}$ This is the minimum required post embedment depth for lateral loading

FOOTING DESIGN FOR MAIN EAVE POST:

Determine the footing size and depth for vertical bearing for the main posts.

$q_{soil} = 1500\,\text{psf}$ Soil bearing capacity for footing

$d_{ia\_footing} = 2.5\,\text{ft}$ Footing diameter

$A_{footing} := \pi\cdot\left(\frac{d_{ia\_footing}^{2}}{4}\right)$ $A_{footing} = 4.91\,\text{ft}^2$ Footing area

$P_{ost\_depth} = 5.0\,\text{ft}$ Minimum required post embedment depth

$P_{ftg\_allow} := A_{footing}\cdot q_{soil}\cdot d_{factor} + P_{skin}$

$P_{ftg\_allow} = 13548\,\text{lb}$ Allowable end bearing capacity of footing

$p_{ftg\_applied} = 12929\,\text{lb}$ Total applied footing load

Note that the end bearing capacity (P_{ftg_allow}) is greater than the combined footing load ($p_{ftg\_applied}$). This is OK.

Next, check main eave post uplift:

$q_{uplift} = -31.27 \text{ psf}$ Wind uplift pressure

$$P_{ul} := 0.6 \cdot \left[\left(\frac{W_{bldg}}{2} + O_{verhang} \right) \cdot B_{ay} \cdot \left(\left| q_{uplift} \right| \right) \right]$$

$P_{ul} = 7429 \text{ lb}$ This is the uplift on one eave post

Assume a total weight of roof area to be 0.6*Dead Load (p_d). The area of the roof that will tend to keep the truss post in the ground will be as follows:

$$E_{post\_hole} := 150 \cdot pcf \cdot P_{ost\_depth} \cdot \left(\pi \cdot \frac{d_{ia\_footing}^{2}}{4} - A_{post} \right)$$

$E_{post\_hole} = 3182 \text{ lb}$ Weight of concrete in post hole

$$W_{ulr} := \left[0.6 \cdot \left[\left(\frac{W_{bldg}}{2} + O_{verhang} \right) \cdot B_{ay} \cdot p_d \right] \right] + E_{post\_hole} + P_{skinU}$$

$W_{ulr} = 7806 \text{ lb}$ Total uplift resistance

Note that the total uplift resistance (W_{ulr}) is greater than the uplift load (P_{ul}). This is OK.

PURLIN DESIGN: (Worst case shown)

The purlins simply span between pairs of trusses or rafters. Determine the adequacy of the purlins.

Purlins = "2x6 #2 Doug-Fir" $Purlin_{spacing} = 24\,in$ o.c.

$L_{purlin\_span} = 126.5\,in$ Bending length of purlin

$w_{purlin} = 4.9\,pli$ Maximum combined distributed roof load along top edge of purlin

$M_{purlin} := \frac{w_{purlin} \cdot L_{purlin\_span}^2}{8}$ $M_{purlin} = 9804\,in \cdot lb$ Bending moment in the purlin

$f_{bpurlin} := \frac{M_{purlin}}{S_{purlin}}$ $f_{bpurlin} = 1296\,psi$ Bending stress applied to the purlin

Determine the allowable member stress including load factors

$F_{bPurlin} = 900\,psi$ $C_{Dsnow} = 1.15$ $C_{Mbpurlin} = 1.00$ $C_{tpurlin} = 1.00$ $C_{Lpurlin} = 1.00$

$C_{Fpurlin} = 1.30$ $C_{fupurlin} = 1.00$ $C_{rpurlin} = 1.15$

$F_{bpurlin} := F_{bPurlin} \cdot C_{Dsnow} \cdot C_{Mbpurlin} \cdot C_{tpurlin} \cdot C_{Lpurlin} \cdot C_{Fpurlin} \cdot C_{fupurlin} \cdot C_{rpurlin}$

$F_{bpurlin} = 1547\,psi > f_{bpurlin}$ This is OK

MAIN POST CORBEL BLOCK DESIGN: (Worst case shown)

Determine the required number and size of bolts required in the main post corbel block.

Allowable fastener shear capacities

$z_{Tbolt\_58} = 1590\,lb$ Shear capacity for 5/8" dia. bolts

$z_{Tbolt\_34} = 2190\,lb$ Shear capacity for 3/4" dia. bolts

$z_{Tbolt\_10} = 3600\,lb$ Shear capacity for 1" dia. bolts

$z_{Tnail\_16d} = 122\,lb$ Shear capacity for 16d nails

$z_{Tnail\_20d} = 147\,lb$ Shear capacity for 20d nails

$p_{Tcorbel} = 12929\,lb$ Combined dead, live roof or snow, and live (if applicable) loads on corbels

If 5/8 dia. bolts are used:

$N_{bolts58} = 7.1$ Number of 5/8" dia. bolts required in the corbel block, if used.

If 3/4 dia. bolts are used:

$N_{bolts34} = 5.1$ Number of 3/4" dia. bolts required in the corbel block, if used.

If 1 dia. bolts are used:

$N_{bolts10} = 3.1$ Number of 1" dia. bolts required in the corbel block, if used.

If 20d nails are to be used:

$N_{ails20d} = 38.2$ Number of 20d nails required in each corbel block, if used.

If 16d nails are to be used:

$N_{ails16d} = 46.1$ Number of 16d nails required in each corbel block, if used.

SUMMARY OF RESULTS:

Building Dimensions

$W_{bldg} = 70\,ft$ Width of Building

$L_{bldg} = 65\,ft$ Length of Building

$H_{bldg} = 12\,ft$ Eave Height of Building

$O_{verhang} = 12\,in$ Length of Eave Overhang

$R_{pitch} = 4$ /12 Roof pitch

Building Design Loads

Roof_dead_load = 5 psf

Live_roof_load = 20 psf

Ground_snow_load = 30 psf

Roof_snow_load = 26 psf

Wind_speed = 110 mph

Wind_exposure = "C"

Seismic_Design_Category = "D"

Post Details

Post_size = "8x12"

Post_grade = "#1 Hem-Fir"

Post_usage = 98 % Combined stress usage of post

Footing Details:

$d_{ia\_footing} = 2.5\,ft$ Design Footing Diameter

Postdepth = 5.0 ft Design Post Depth

Footingusage = 95 % Stress usage of footing

Backfill_type = "Concrete"

Purlin Details:

Purlin1_usage = 84 % Stress usage of roof purlin

Corbel Block Bolts:

$N_{bolts58} = 7.1$ Number of 5/8" dia. bolts required in the corbel block, if used.

$N_{bolts34} = 5.1$ Number of 3/4" dia. bolts required in the corbel block, if used.

$N_{bolts10} = 3.1$ Number of 1" dia. bolts required in the corbel block, if used.

$N_{ails20d} = 38.2$ Number of 20d nails required in each corbel block, if used.

$N_{ails16d} = 46.1$ Number of 16d nails required in each corbel block, if used.

SPECIAL NOTE:
The drawings attendant to this calculation shall not be modified by the builder unless authorized in writing by the engineer. No special inspections are required. No structural observation by the design engineer is required.