

Wood Bearing Connection - 3 1/2 x 11 7/8 LVL to 5 1/4 x 11 7/8 LVL:

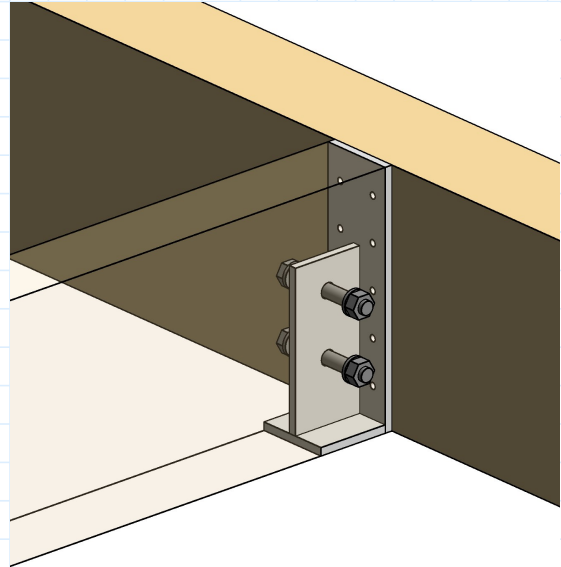
$$Dead := 0.511 \text{ kip}$$

$$Snow := 1.125 \text{ kip}$$

$$Wind := -0.675 \text{ kip}$$

$$P_{asd} := \begin{bmatrix} Dead \\ Dead + Snow \\ Dead + 0.75 \cdot Wind + 0.75 \cdot Snow \\ 0.6 \cdot Dead + 0.6 \cdot Wind \end{bmatrix} = \begin{bmatrix} 511 \\ 1636 \\ 848.5 \\ -98.4 \end{bmatrix} \text{ lbf}$$

$$P_u := \begin{bmatrix} 1.4 \cdot Dead \\ 1.2 \cdot Dead + 1.6 \cdot Snow \\ 1.2 \cdot Dead + 1.0 \cdot Wind + 0.5 \cdot Snow \\ 1.2 \cdot Dead + 0.5 \cdot Wind + 1.6 \cdot Snow \\ 0.9 \cdot Dead + 1.0 \cdot Wind \end{bmatrix} = \begin{bmatrix} 715.4 \\ 2413.2 \\ 500.7 \\ 2075.7 \\ -215.1 \end{bmatrix} \text{ lbf}$$



$$\text{Bearing Length Measured Parallel To Grain: } l_b := 4 \text{ in}$$

$$\text{Thickness of Knife Plate: } t_{plate} := \frac{3}{8} \cdot \text{in}$$

$$\text{Bearing Width: } Width := 3.5 \text{ in} - t_{plate} = 3.125 \text{ in}$$

$$C_m := 1 \quad C_i := 1 \quad C_t := 1 \quad K_f := 1.67 \quad \phi := 0.90$$

$$F_{cp} := 750 \text{ psi}$$

$$C_b := \begin{cases} \text{if } l_b \leq 6 \text{ in} \\ \quad \text{return } \frac{l_b + 0.375 \text{ in}}{l_b} \\ \text{else} \\ \quad \text{return } 1.0 \end{cases} = 1.094 \quad \text{NDS 3.10-2}$$

$$F'_{cp_ASD} := F_{cp} \cdot C_m \cdot C_t \cdot C_i \cdot C_b = 820.313 \text{ psi}$$

$$F'_{cp_LRFD} := \phi \cdot K_f \cdot F_{cp} \cdot C_m \cdot C_t \cdot C_i \cdot C_b = 1232.93 \text{ psi}$$

$$Capacity_{ASD} := F'_{cp_ASD} \cdot Width \cdot l_b = 10.254 \text{ kip}$$

$$Capacity_{LRFD} := F'_{cp_LRFD} \cdot Width \cdot l_b = 15.412 \text{ kip}$$

Calculations for Wood Bearing Connection:

Bearing Width = 3.125 in
 Bearing Length = 4.000 in
 Angle to Grain = 90 deg
 Fpc = 750.000 ksi, Fc = 2510.000 ksi
 Cm = 1.00, Ci = 1.00
 Ct = 1.00, Cb = 1.09
 Connection Code Check = 0.16
 P = 1.64 kips vs 10.25 kips
 For Dead + Snow

Calculations for Wood Bearing Connection:

Bearing Width = 3.125 in
 Bearing Length = 4.000 in
 Angle to Grain = 90 deg
 Fpc = 750.000 ksi, Fc = 2510.000 ksi
 Cm = 1.00, Ci = 1.00
 Ct = 1.00, Cb = 1.09
 Connection Code Check = 0.16
 P = 2.41 kips vs 15.41 kips
 For 1.2 Dead + 1.6 Snow

Bolt Design for Uplift Connection:

Fastener Diameter: $D := 0.5 \text{ in}$

Main Member
Bearing Length: $l_m := t_{plate} = 0.375 \text{ in}$

Side Member
Bearing Length: $l_s := \frac{3.5 \text{ in} - t_{plate}}{2} = 1.563 \text{ in}$

Load angles: $\theta := 90 \text{ deg}$

G Values for wood members: $G := 0.5$

Dowel Bearing Strength: $F_{yb} := 45000 \text{ psi}$

$$F_{em} := 87000 \text{ psi}$$

$$K_{\theta} := 1 + 0.25 \cdot \left(\frac{\theta}{90 \text{ deg}} \right) = 1.25$$

$$F_{es} := \left\| \begin{array}{l} F_{e_par} \leftarrow 11200 \text{ psi} \cdot G \\ F_{e_perp} \leftarrow \frac{6100 \text{ psi} \cdot G^{1.45}}{\sqrt{\frac{D}{\text{in}}}} \\ F_e \leftarrow \frac{F_{e_par} \cdot F_{e_perp}}{F_{e_par} \cdot \sin(\theta)^2 + F_{e_perp} \cdot \cos(\theta)^2} \end{array} \right\| = 3157.558 \text{ psi}$$

$$I_m := \left\| \begin{array}{l} R_d \leftarrow 4 \cdot K_{\theta} \\ \text{return } \frac{D \cdot l_m \cdot F_{em}}{R_d} \end{array} \right\| = 3262.5 \text{ lbf}$$

$$I_s := \left\| \begin{array}{l} R_d \leftarrow 4 \cdot K_{\theta} \\ \text{return } \frac{2 \cdot D \cdot l_s \cdot F_{es}}{R_d} \end{array} \right\| = 986.737 \text{ lbf}$$

$$III_s := \left\| \begin{array}{l} R_d \leftarrow 3.2 \cdot K_{\theta} \\ R_e \leftarrow \frac{F_{em}}{F_{es}} \\ k_3 \leftarrow -1 + \sqrt{\frac{2 \cdot (1 + R_e)}{R_e} + \frac{2 \cdot F_{yb} \cdot (2 + R_e) \cdot D^2}{3 \cdot F_{em} \cdot l_s^2}} \\ \text{return } \frac{2 \cdot k_3 \cdot D \cdot l_s \cdot F_{em}}{(2 + R_e) \cdot R_d} \end{array} \right\| = 880 \text{ lbf}$$

$$IV := \left\| \begin{array}{l} R_d \leftarrow 3.2 \cdot K_{\theta} \\ R_e \leftarrow \frac{F_{em}}{F_{es}} \\ \text{return } \frac{2 \cdot D^2}{R_d} \cdot \sqrt{\frac{2 \cdot F_{em} \cdot F_{yb}}{3 \cdot (1 + R_e)}} \end{array} \right\| = 1195.102 \text{ lbf}$$

$$I_m = 3262.5 \text{ lbf} \quad I_s = 986.737 \text{ lbf} \quad III_s = 880 \text{ lbf} \quad IV = 1195.102 \text{ lbf}$$

$$Z := \min(I_m, I_s, III_s, IV) = 880 \text{ lbf}$$

Number of Bolts: $N_{bolts} := 2$ Bolt Spacing: $s := 3 \text{ in}$ $End_Distance := 3 \text{ in}$

$E_m := 29000 \text{ ksi}$

$E_s := 2000 \text{ ksi}$

$A_m := l_m \cdot s = 1.125 \text{ in}^2$

$A_s := l_s \cdot s = 4.688 \text{ in}^2$

Calculate the group factor per NDS 10.3-1

$$C_g := \left\{ \begin{array}{l} \gamma \leftarrow 0 \frac{\text{lbf}}{\text{in}} \\ \gamma \leftarrow 270000 \frac{\text{lbf}}{\text{in}} \cdot \left(\frac{D}{\text{in}} \right)^{1.5} \\ u \leftarrow 1 + \frac{\gamma}{\frac{\text{lbf}}{\text{in}}} \cdot \frac{s}{2 \cdot \text{in}} \cdot \left(\frac{1}{\frac{E_m}{\text{psi}} \cdot \frac{A_m}{\text{in}^2}} + \frac{1}{\frac{E_s}{\text{psi}} \cdot \frac{A_s}{\text{in}^2}} \right) \\ m \leftarrow u - \sqrt{u^2 - 1} \\ R_{EA} \leftarrow \min \left(\frac{E_s \cdot A_s}{E_m \cdot A_m}, \frac{E_m \cdot A_m}{E_s \cdot A_s} \right) \\ \text{return } \frac{m \cdot (1 - m^{2 \cdot N_{bolts}})}{N_{bolts} \cdot \left((1 + R_{EA} \cdot m^{N_{bolts}}) \cdot (1 + m) - 1 + m^{2 \cdot N_{bolts}} \right)} \cdot \left(\frac{1 + R_{EA}}{1 - m} \right) \end{array} \right. = 0.9894$$

Calculate the Geometry Factor per NDS 11.5.1

$$C_{\Delta} := \left\{ \begin{array}{l} C_{end_distance} \leftarrow 1.0 \\ C_{fastener_spacing} \leftarrow 1.0 \\ \text{if } 2 \cdot D \leq End_Distance \leq 4 \cdot D \\ \quad \left\{ \begin{array}{l} C_{end_distance} \leftarrow \frac{End_Distance}{4 \cdot D} \end{array} \right. \\ \text{else if } End_Distance < 2 \cdot D \\ \quad \left\{ \begin{array}{l} C_{end_distance} \leftarrow 0.0 \end{array} \right. \\ \text{else} \\ \quad \left\{ \begin{array}{l} C_{end_distance} \leftarrow 1.0 \end{array} \right. \\ \text{if } 3 \cdot D \leq s \leq 4 \cdot D \\ \quad \left\{ \begin{array}{l} C_{fastener_spacing} \leftarrow \frac{s}{4 \cdot D} \end{array} \right. \\ \text{else if } s < 3 \cdot D \\ \quad \left\{ \begin{array}{l} C_{fastener_spacing} \leftarrow 0.0 \end{array} \right. \\ \text{else} \\ \quad \left\{ \begin{array}{l} C_{fastener_spacing} \leftarrow 1.0 \end{array} \right. \\ \text{return } \min(C_{end_distance}, C_{fastener_spacing}) \end{array} \right. = 1$$

Calculate the connection ASD Capacity:

$$C_D := \begin{bmatrix} 0.9 \\ 1.15 \\ 1.15 \\ 1.6 \end{bmatrix} \quad C_m = 1 \quad C_g = 0.9894 \quad C_\Delta = 1$$

$$P_{uplift_ASD} := |P_{asd_3}| = 98.4 \text{ lbf}$$

$$Z' := Z \cdot C_{D_3} \cdot C_m \cdot C_t \cdot C_g \cdot C_\Delta = 1393.129 \text{ lbf} \quad \text{NDS Table 10.3.1}$$

$$P_{allowable} := N_{bolts} \cdot Z \cdot C_{D_3} \cdot C_m \cdot C_t \cdot C_g \cdot C_\Delta = 2.786 \text{ kip}$$

$$\frac{P_{uplift_ASD}}{P_{allowable}} = 0.035$$

Calculations for NDS Fastener Connection:

Fastener Type = Bolt
 Total Number of Fasteners = 2
 Fastener Diameter = 0.500 in
 Cm = 1.00, Ct = 1.00
 Cg = 0.99, Ceg = 1.00
 Cdelta_main = 1.00, Cdelta_side = 1.00
 Single Fastener Z' = 1393 lbs
 Connection Code Check = 0.04
 P = -0.10 kips vs 2.79 kips
 For 0.6 Dead + 0.6 Wind

Calculate the connection LRFD Capacity:

$$K_f := 3.32 \quad \phi := 0.65 \quad \lambda := \begin{bmatrix} 0.6 \\ 0.8 \\ 0.8 \\ 1.0 \end{bmatrix}$$

$$P_{uplift_LRFD} := |P_{u_4}| = 215.1 \text{ lbf}$$

$$Z' := Z \cdot C_m \cdot C_t \cdot C_g \cdot C_\Delta \cdot K_f \cdot \phi \cdot \lambda_4 = 1878.982 \text{ lbf} \quad \text{NDS Table 10.3.1}$$

$$P_{LRFD} := N_{bolts} \cdot Z \cdot C_m \cdot C_t \cdot C_g \cdot C_\Delta \cdot K_f \cdot \phi \cdot \lambda_4 = 3.758 \text{ kip}$$

$$\frac{P_{uplift_LRFD}}{P_{LRFD}} = 0.057$$

Calculations for NDS Fastener Connection:

Fastener Type = Bolt
 Total Number of Fasteners = 2
 Fastener Diameter = 0.500 in
 Cm = 1.00, Ct = 1.00
 Cg = 0.99, Ceg = 1.00
 Cdelta_main = 1.00, Cdelta_side = 1.00
 Single Fastener Z' = 1879 lbs
 Connection Code Check = 0.06
 P = -0.22 kips vs 3.76 kips
 For 0.9 Dead + 1.0 Wind

AISC Fillet Weld Design for weld between bottom plate and knife plate:

Weld Material: $F_{EXX} := 70 \text{ ksi}$

Weld Length: $L_{weld} := l_b = 4 \text{ in}$

Weld Thickness: $T_{weld} := \frac{3}{16} \cdot \text{in}$

Angle between load and axial direction of weld: $\theta := 90 \text{ deg}$

Fillet Welds: $\phi := 0.75$ $\Omega := 2.0$

Number of welds: $N_{welds} := 2$

Shear - Weld: $V_{n_weld} := 0.6 \cdot F_{EXX} \cdot \frac{\sqrt{2}}{2} \cdot T_{weld} \cdot \left(1 + \frac{\sin(\theta)^{1.5}}{2} \right) = 8.353 \frac{\text{kip}}{\text{in}}$

Weld Capacity - ASD:

$$V_{asd_weld} := \frac{V_{n_weld}}{\Omega} = 4.176 \frac{\text{kip}}{\text{in}} \quad V_{asd} := V_{asd_weld} \cdot L_{weld} \cdot N_{welds} = 33.411 \text{ kip}$$

Calculations for AISC Line Weld Connection:

Number of Welds = 2

F_{exx} = 70 ksi

L = 4.000 in

Thickness of Weld = 0.188 in

Connection Code Check = 0.05

P = 1.64 kips vs 33.41 kips

For Dead + Snow

Weld Capacity - LRFD:

$$\phi V_{n_weld} := \phi \cdot V_{n_weld} = 6.265 \frac{\text{kip}}{\text{in}} \quad \phi V_n := \phi V_{n_weld} \cdot L_{weld} \cdot N_{welds} = 50.116 \text{ kip}$$

Calculations for AISC Line Weld Connection:

Number of Welds = 2

F_{exx} = 70 ksi

L = 4.000 in

Thickness of Weld = 0.188 in

Connection Code Check = 0.05

P = 2.41 kips vs 50.12 kips

For 1.2 Dead + 1.6 Snow

AISC Bolt Design - A307:

Bolt Nominal Tension Strength: $F_{nt} := 45 \text{ ksi}$

Bolt Nominal Shear Strength: $F_{nv} := 27 \text{ ksi}$

Number of Bolts: $n := 2$

Diameter: $d := \frac{1}{2} \cdot \text{in}$

Single (1) or Double (2) Loading: $l := 2$

Shear Strength Calculation:

Per J3-1: $\phi := 0.75$ $\Omega := 2.0$

$$A_b := \pi \cdot \left(\frac{d}{2}\right)^2 = 0.196 \text{ in}^2$$

$$R_n := F_{nv} \cdot A_b \cdot n \cdot l = 21.206 \text{ kip}$$

$$\phi R_{n_bolt_shear} := \phi \cdot R_n = 15.904 \text{ kip} \quad R_{bolt_shear} := \frac{R_n}{\Omega} = 10.603 \text{ kip}$$

Bearing Strength Calculation: $\phi := 0.75$ $\Omega := 2.0$

Number of Plates: $N_{plates} := 1$

Material thickness: $t_{plate} = 0.375 \text{ in}$

Steel Fracture Strength: $F_u := 58 \text{ ksi}$

If deformation at service loads **IS** important: $R_n := 2.4 \cdot d \cdot t_{plate} \cdot F_u = 26.1 \text{ kip}$ AISC J3-6a

$$\phi R_{n_bearing} := \phi \cdot R_n = 19.575 \text{ kip} \quad R_{bolt_bearing} := \frac{R_n}{\Omega} = 13.05 \text{ kip}$$

Tear-out Strength Calculation: $\phi := 0.75$ $\Omega := 2.0$

Material thickness: $t_{plate} = 0.375 \text{ in}$

Edge Distance: $l_c := 1.5 \text{ in}$

Steel Fracture Strength: $F_u = 58 \text{ ksi}$

If deformation at service loads **IS** important: $R_n := 1.2 \cdot l_c \cdot t_{plate} \cdot F_u = 39.15 \text{ kip}$ AISC J3-6c

$$\phi R_{n_bolt_tearout} := \phi \cdot R_n = 29.363 \text{ kip} \quad R_{bolt_tearout} := \frac{R_n}{\Omega} = 19.575 \text{ kip}$$

Bolt Design Summary - ASD:

$$R_{bolt_shear} = 10.603 \text{ kip}$$

$$R_{bolt_bearing} = 13.05 \text{ kip}$$

$$R_{bolt_tearout} = 19.575 \text{ kip}$$

$$R_{bolt} := \min \left(\begin{bmatrix} R_{bolt_shear} \\ R_{bolt_bearing} \\ R_{bolt_tearout} \end{bmatrix} \right) = 10.603 \text{ kip}$$

Calculations for AISC Shear Bolt Connection:

Number of Bolts = 2

Fnv = 27 ksi

Bolt Diameter = 0.500 in²

Connection Code Check = 0.01

P = -0.10 kips vs 10.60 kips

For 0.6 Dead + 0.6 Wind

Bolt Design Summary - LRFD:

$$\phi R_{n_bolt_shear} = 15.904 \text{ kip}$$

$$\phi R_{n_bearing} = 19.575 \text{ kip}$$

$$\phi R_{n_bolt_tearout} = 29.363 \text{ kip}$$

$$\phi R_n := \min \left(\begin{bmatrix} \phi R_{n_bolt_shear} \\ \phi R_{n_bearing} \\ \phi R_{n_bolt_tearout} \end{bmatrix} \right) = 15.904 \text{ kip}$$

Calculations for AISC Shear Bolt Connection:

Number of Bolts = 2

Fnv = 27 ksi

Bolt Diameter = 0.500 in²

Connection Code Check = 0.01

P = -0.22 kips vs 15.90 kips

For 0.9 Dead + 1.0 Wind

Check for SDS Screws from plate to Beam:

$$SDS := 420 \text{ lbf}$$

Number of Screws:

$$N_{Screws} := 10$$

$$V_{capacity} := SDS \cdot N_{Screws} = 4200 \text{ lbf}$$

Calculations for Generic Connection:

Positive Capacity (down) = 4.20 kips

Negative Capacity (uplift) = 4.20 kips

Connection Code Check = 0.39

P = 1.64 kips vs 4.20 kips

For Dead + Snow

$$\frac{|\min(P_{asd})|}{V_{capacity}} = 0.023$$

$$\frac{|\max(P_{asd})|}{V_{capacity}} = 0.39$$