Osoconn

Validation Record for

HB001AM10

Double Angle Horozontal Bracing Connection

(March 27, 2025)

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1 Introduction

Osoconn is a free and open source connection design application. The Osoconn project is a personal project developed by Roshn Noronha for educational purposes and licensed under the MIT Open Source license. For more information visit `https://osoconn.com`.

1.1 Purpose and scope

The purpose of this document is to validate the results of the connection code HB001AM10 for the Osoconn project.

1.2 Methodology

To validate the results of the program a set of sample calculations are prepared and the results are compared with the output from the program. If the results obtained are equal within a tolerance of one percent, the validation is deemed successful.

The connection code HB001AM10 refers to the double angle horozontal bracing connection, and the design of this connection type is checked against the requirements of AISC 360-2010 [1]. The detailed calculation and a summary of the comparison with the program output is provided in section 2. The full output of the program is provided in section 3.

To minimize the chance of errors the selected validation problems tries to cover as many different options and connections configurations available in the program as possible. However, while every attempt is made to ensure the accuracy of the program, it should be noted that, not every aspect of the program can be tested,and the user shall independently verify the output of the program before using it.

References

[1] AISC. *Specification for Structural Steel Buildings*. 360. American Institute of Steel Construction, Chicago, IL, 2010.

2 Validation Calculation

2.1 Executive summary

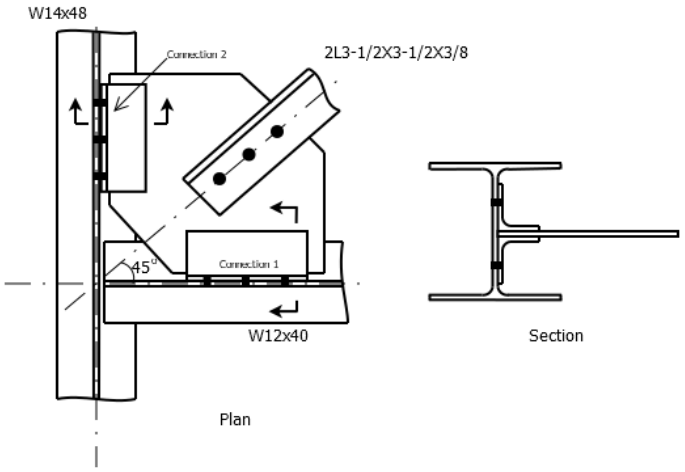
Table 1: Executive Summary

	Result
Validation problem 1	OK
Validation problem 2	OK
Validation problem 3	OK
Validation problem 4	OK
Validation problem 5	OK
Validation problem 6	OK

2.2 Validation Problem 1

Problem Statement

Design a horizontal brace connection for a double angle 2L3-1/2X3-1/2X3/8 brace, with their back to back leg horizontal, framing into the junction between a W12X40 and a W14X48 using the LRFD method. The brace has an angle of 45 degrees with the W12 beam. The brace has an axial force of 35kip. The beams, angles and plates are of grade ASTM A36. The bolts are ASTM 3125 A325 slip critical type.



Design Inputs

Material Properties

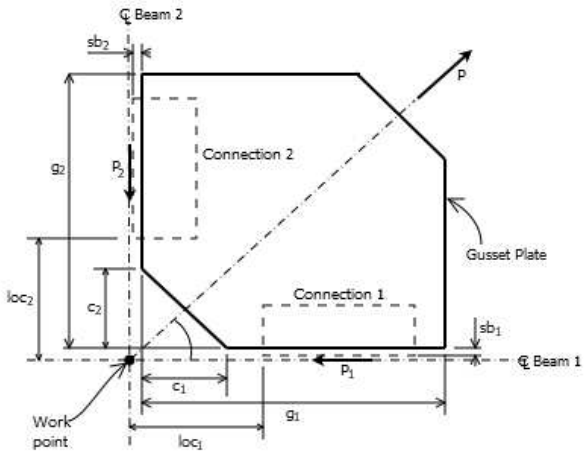
Material grade for plate	ASTM A36
Yield strength	$F_{yp} := 36\ ksi$
Tensile strength	$F_{up} := 58\ ksi$
Material grade of beam	ASTM A36
Yield strength	$F_{yb} := 36\ ksi$
Tensile strength	$F_{ub} := 58\ ksi$
Material grade of angles	ASTM A36
Yield strength	$F_{ya} := 36\ ksi$
Tensile strength	$F_{ua} := 58\ ksi$
Material grade for weld electrode	E70XX
Tensile strength	$F_{EXX} := 70\ ksi$
Material specification for bolts	ASTM 3125 A325
Tensile strength	$F_{nt} := 90\ ksi$
Shear strength	$F_{nv} := 54\ ksi$
Young's modulus for steel	$E := 29000\ ksi$

Design Forces

Axial force in brace	$P := 35\ kip$

Connection Geometry

Brace section	2L3-1/2X3-1/2X3/8
Thickness	$t_{br} := 0.375\ in$
Outstanding leg length	$l_{obr} := 3.5\ in$
Back-to-back leg length	$l_{ibr} := 3.5\ in$
Gross cross section area	$A_{br} := 5\ in^2$
Centroid of brace outstanding leg	$x'_{br} := 1\ in$
Brace angle with horizontal	$\theta_{br} := 45\ deg$
Beam section at connection 1	W12X40
Section depth	$d_{xb1} := 11.9\ in$
Flange width	$b_{fb1} := 8.01\ in$
Flange thickness	$t_{fb1} := 0.515\ in$
Web thickness	$t_{wb1} := 0.295\ in$
Distance from outer face to fillet edge	$k_{bdet1} := 1.375\ in$
Beam section at connection 2	W14X48
Section depth	$d_{xb2} := 13.8\ in$
Flange width	$b_{fb2} := 8.03\ in$
Flange thickness	$t_{fb2} := 0.595\ in$
Web thickness	$t_{wb2} := 0.34\ in$
Distance from outer face to fillet edge	$k_{bdet2} := 1.4375\ in$
Clip angle section	L3-1/2X3X3/8
Thickness	$t_a := 0.375\ in$
Outstanding leg length	$l_{oa} := 3.5\ in$
Welded leg length	$l_{ia} := 3\ in$



Gusset plate thickness	$t_g := 0.5\ in$
Gusset dimension along connection 1	$g_1 := 15\ in$
Gusset dimension along connection 2	$g_2 := 15\ in$
Gusset cutout at connection 1	$c_1 := 4\ in$
Gusset cutout at connection 2	$c_2 := 4\ in$

Bolt diameter $d_b := \frac{7}{8}\ in$

Bolt hole diameter $d_{bh} := \frac{15}{16}\ in$

Slip coefficient (class A surface) $\mu := 0.3$

Bolt pretension $T_{pre} := 39\ kip$

Number of bolts per row on brace $n_{br} := 3$

Number of bolts at clip at beam 1 $n_1 := 3$

Number of bolts at clip at beam 2 $n_2 := 3$

Bolt spacing $s := 2.5\ in$

Bolt gage on brace $g_{br} := 1.75\ in$

Bolt gage on clip $g := 1.75\ in$

Location of brace edge from the work point $loc_{br} := 16\ in$

Location of connection 1 from work point $loc_1 := 6\ in$

Location of connection 2 from work point $loc_2 := 6\ in$

Bolt edge distance on brace $ed_1 := 1.25\ in$

Bolt edge distance on gusset $ed_2 := 1.25\ in$

Bolt edge distance on clip $ed_3 := 1.125\ in$

Clip to gusset weld thickness $w := 0.25\ in$

Connection setback at connection 1 $sb_1 := 0.5\ in$

Connection setback at connection 2 $sb_2 := 0.5\ in$

Design Calculations

Connection forces

Shear per bolt at brace connection

$$P_b := \frac{P}{n_{br}} \qquad P_b = 11.667\ kip$$

Component of brace force along connection 1

$$P_1 := P \cdot \cos(\theta_{br}) \qquad P_1 = 24.749\ kip$$

Force per bolt along connection 1

$$P_{b1} := \frac{P_1}{2 \cdot n_1} \qquad P_{b1} = 4.125\ kip$$

Component of brace force along connection 2

$$P_2 := P \cdot \sin(\theta_{br}) \qquad P_2 = 24.749\ kip$$

Force per bolt along connection 2

$$P_{b2} := \frac{P_2}{2 \cdot n_2} \qquad P_{b2} = 4.125\ kip$$

Bolt shear at brace to gusset connection

Nominal slip resistance of bolt

$$R_n := \mu \cdot 1.13 \cdot T_{pre} \cdot 2 \qquad R_n = 26.442\ kip$$

Interaction ratio in bolt shear

$$I_0 := \frac{P_b}{R_n} \qquad I_0 = 0.441$$

Bolt bearing on brace check

Minimum clear distance for bearing check

$$l_{c1} := min\left(s - d_{bh}, ed_1 - 0.5 \cdot d_{bh}\right) \qquad l_{c1} = 0.02\ \textit{m}$$

Nominal strength in bearing

$$R_n := min\left(1.2 \cdot l_{c1} \cdot t_{br} \cdot F_{ua}, 2.4 \cdot d_b \cdot t_{br} \cdot F_{ua}\right) \qquad R_n = 20.391\ \textit{kip}$$

Interaction ratio in bolt bearing at brace

$$I_1 := \frac{0.5\ P_b}{0.75 \cdot R_n} \qquad I_1 = 0.381$$

Bolt bearing on gusset check

Minimum clear distance for bearing on gusset

$$l_{c2} := min\left(s - d_{bh}, ed_2 - 0.5 \cdot d_{bh}\right) \qquad l_{c1} = 0.02\ \textit{m}$$

Nominal strength in bearing

$$R_n := min\left(1.2 \cdot l_{c2} \cdot t_g \cdot F_{up}, 2.4 \cdot d_b \cdot t_g \cdot F_{up}\right) \qquad R_n = 27.188\ \textit{kip}$$

Interaction ratio in bolt bearing at gusset

$$I_2 := \frac{P_b}{0.75 \cdot R_n} \qquad I_2 = 0.572$$

Brace tension rupture check

Net cross section area of brace

$$A_{nbr} := A_{br} - 2 \cdot d_{bh} \cdot t_{br} \qquad A_{nbr} = 4.297\ \textit{in}^2$$

Length of connection

$$l_{br} := s \cdot \left(n_{br} - 1\right) \qquad l_{br} = 5\ \textit{in}$$

Shear lag factor

$$U := 1 - \frac{x'_{br}}{l_{br}} \qquad U = 0.8$$

Brace strength in tension rupture

$$P_n := F_{ua} \cdot U \cdot A_{nbr} \qquad P_n = 199.375\ \textit{kip}$$

Interaction ratio for brace tension rupture

$$I_3 := \frac{P}{0.75 \cdot P_n} \qquad I_3 = 0.234$$

Brace block shear check

Gross area in shear

$$A_{gv} := 2 \cdot \left(\left(n_{br} - 1\right) \cdot s + ed_1\right) \cdot t_{br} \qquad A_{gv} = 4.688\ \textit{in}^2$$

Net area in shear

$$A_{nv} := A_{gv} - 2 \cdot \left(n_{br} - 0.5\right) \cdot d_{bh} \cdot t_{br} \qquad A_{nv} = 2.93\ \textit{in}^2$$

Net area in tension

$$A_{nt} := 2 \cdot \left(l_{ibr} - g_{br} - 0.5 \cdot d_{bh}\right) \cdot t_{br} \qquad A_{nt} = 0.961\ in^2$$

Nominal strength block shear

$$R_{n1} := 0.6 \cdot F_{ua} \cdot A_{nv} + F_{ua} \cdot A_{nt}$$

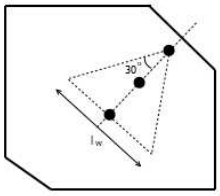
$$R_{n2} := 0.6 \cdot F_{ya} \cdot A_{gv} + F_{ua} \cdot A_{nt}$$

$$R_n := min\left(R_{n1}, R_{n2}\right) \qquad R_n = 156.984\ kip$$

Interaction ratio in block shear

$$I_4 := \frac{P}{0.75 \cdot R_n} \qquad I_4 = 0.297$$

Gusset tension yielding check



Length of Whitmore section

$$l_w := 2 \cdot l_{br} \cdot \tan\left(30\ deg\right) \qquad l_w = 5.774\ in$$

Nominal strength of gusset in yielding

$$P_n := F_{yp} \cdot l_w \cdot t_g \qquad P_n = 103.923\ kip$$

Interaction ratio in tension yielding

$$I_5 := \frac{P}{0.9 \cdot P_n} \qquad I_5 = 0.374$$

Gusset tension rupture check

Net area of gusset in tension

$$A_{ng} := \left(l_w - d_{bh}\right) \cdot t_g \qquad A_{ng} = 2.418\ in^2$$

Nominal strength of gusset in rupture

$$P_n := F_{up} \cdot A_{ng} \qquad P_n = 140.244\ kip$$

Interaction ratio in tension rupture

$$I_6 := \frac{P}{0.75 \cdot P_n} \qquad I_6 = 0.333$$

Bolt shear at connection 1

Nominal slip resistance of bolt

$$R_n := \mu \cdot 1.13 \cdot T_{pre} \qquad R_n = 13.221\ kip$$

Interaction ratio in bolt shear

$$I_7 := \frac{P_{b1}}{R_n} \qquad I_7 = 0.312$$

Bolt bearing at clip angle at connection 1

Clear distance between bolt holes/ hole and edge

$$l_c := min\left(s - d_{bh}, ed_3 - 0.5 \cdot d_{bh}\right) \qquad l_c = 0.656\ in$$

Nominal strength in bearing

$$R_n := min\left(1.2 \cdot l_c \cdot t_a \cdot F_{ua}, 2.4 \cdot d_b \cdot t_a \cdot F_{ua}\right) \qquad R_n = 17.128\ kip$$

Interaction ratio in bolt bearing

$$I_8 := \frac{P_{b1}}{0.75\ R_n} \qquad I_8 = 0.321$$

Bolt bearing at beam web at connection 1

Nominal strength in bearing

$$R_n := min\left(1.2 \cdot \left(s - d_{bh}\right) \cdot t_{wb1} \cdot F_{ub}, 2.4 \cdot d_b \cdot t_{wb1} \cdot F_{ub}\right) \qquad R_n = 32.081\ kip$$

Interaction ratio in bolt bearing

$$I_9 := \frac{P_{b1}}{0.75\ R_n} \qquad I_9 = 0.171$$

Gusset shear yielding at connection 1

Nominal shear strength of gusset in yielding

$$R_n := 0.6 \cdot F_{yp} \cdot \left(g_1 - c_1\right) \cdot t_g \qquad R_n = 118.8\ kip$$

Interaction ratio in gusset yieldling

$$I_{10} := \frac{P_1}{R_n} \qquad I_{10} = 0.208$$

Gusset plate block shear at connection 1

Length of gusset to column clip

$$L_1 := \left(n_1 - 1\right) \cdot s + 2\ ed_3 \qquad L_1 = 7.25\ in$$

Distance of gusset outer edge from work point

$$loc_{go} := g_1 + sb_2 + 0.5 \cdot t_{wb2} \qquad loc_{go} = 15.67\ in$$

Distance of gusset inner edge from work point

$$loc_{gi} := c_1 + sb_2 + 0.5 \cdot t_{wb2} - \mathbf{if}\left(c_2 = 0, 0, \left(l_{ia} - sb_1\right) \cdot \frac{c_1}{c_2}\right) \qquad loc_{gi} = 2.17\ in$$

Outer edge distance for clip on gusset

$$ed_{go} := loc_{go} - loc_1 - L_1 \qquad ed_{go} = 2.42\ in$$

Inner edge distance for clip on gusset

$$ed_{gi} := loc_1 - loc_{gi} \qquad ed_{gi} = 3.83\ in$$

Minimum edge distance for clip on gusset

$$ed_g := min\left(ed_{go}, ed_{gi}\right) \qquad ed_g = 2.42\ in$$

Gross area subjected to block shear

$$A_{gv} := \left(L_1 + ed_g\right) \cdot t_g \qquad A_{gv} = 4.835\ in^2$$

Net area subjected to tension

$$A_{nt} := \left(l_{ia} - sb_1\right) \cdot t_g \qquad A_{nt} = 1.25\ in^2$$

Nominal strength in block shear

$$R_n := 0.6 \cdot F_{ya} \cdot A_{gv} + F_{ua} \cdot A_{nt} \qquad R_n = 176.936\ kip$$

Interaction ratio in block shear

$$I_{11} := \frac{P_1}{0.75\ R_n} \qquad I_{11} = 0.186$$

Gusset flexure yielding at connection 1

Eccentricity of force at connection 1

$$ec_1 := c_2 + sb_1 + 0.5\ t_{wb1} \qquad ec_1 = 4.648\ in$$

Nominal moment strength of gusset

$$M_n := \frac{F_{yp} \cdot t_g \cdot g_1^{\ 2}}{4} \qquad M_n = 84.375\ kip \cdot ft$$

Interaction ratio in gusset flexure

$$I_{12} := \frac{P_1 \cdot ec_1}{0.9 \cdot M_n} \qquad I_{12} = 0.126$$

Clip angle shear yielding at connection 1

Gross area in shear

$$A_{gv} := 2 \cdot L_1 \cdot t_a \qquad A_{gv} = 5.438\ in^2$$

Nominal strength in shear yielding

$$R_n := 0.6 \cdot F_{ya} \cdot A_{gv} \qquad R_n = 117.45\ kip$$

Interaction ratio in shear yielding

$$I_{13} := \frac{P_1}{R_n} \qquad I_{13} = 0.211$$

Clip angle shear rupture at connection 1

Net area in shear

$$A_{nv} := A_{gv} - 2 \cdot n_1 \cdot d_{bh} \cdot t_a \qquad A_{nv} = 3.328\ in^2$$

Nominal strength in shear rupture

$$R_n := 0.6 \cdot F_{ua} \cdot A_{nv} \qquad R_n = 115.819\ kip$$

Interaction ratio in shear rupture

$$I_{14} := \frac{P_1}{0.75\ R_n} \qquad I_{14} = 0.285$$

Clip angle block shear at connection 1

Gross area subjected to block shear

$$A_{gv} := 2 \cdot \left(L_1 - ed_3\right) \cdot t_a \qquad A_{gv} = 4.594\ in^2$$

Net area subjected to block shear

$$A_{nv} := A_{gv} - 2 \cdot \left(n_1 - 0.5\right) \cdot d_{bh} \cdot t_a \qquad A_{nv} = 2.836\ in^2$$

Net area subjected to tension

$$A_{nt} := \left(2 \cdot l_{oa} + t_g - 2 \cdot g - d_{bh}\right) \cdot t_a \qquad A_{nt} = 1.148\ in^2$$

Nominal strength in block shear

$$R_{n1} := 0.6 \cdot F_{ua} \cdot A_{nv} + F_{ua} \cdot A_{nt}$$

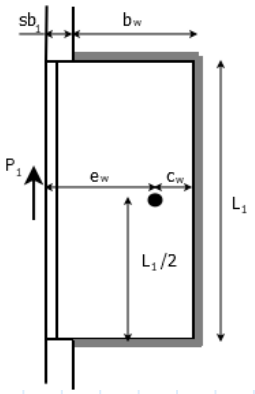
$$R_{n2} := 0.6 \cdot F_{ya} \cdot A_{gv} + F_{ua} \cdot A_{nt}$$

$$R_n := min\left(R_{n1}, R_{n2}\right) \qquad R_n = 165.3\ kip$$

Interaction ratio in block shear

$$I_{15} := \frac{P_1}{0.75\ R_n} \qquad I_{15} = 0.2$$

Weld check at connection 1



Length of horizontal run of weld

$$b_w := l_{ia} - sb_1 \qquad b_w = 2.5\ in$$

Centroid of weld group

$$c_w := \frac{{b_w}^2}{2 \cdot b_w + L_1} \qquad c_w = 0.51\ in$$

Eccentricity of shear force

$$e_w := l_{ia} - c_w \qquad e_w = 2.49\ in$$

Polar moment of inertia of weld group

$$I_w := \frac{\left(2 \cdot b_w + L_1\right)^3}{12} - \frac{{b_w}^2 \cdot \left(b_w + L_1\right)^2}{2 \cdot b_w + L_1} \qquad I_w = 104.688\ in^3$$

Component of weld stress along x

$$f_{wx} := \frac{P_1 \cdot e_w \cdot L_1}{4 \cdot I_w} \qquad f_{wx} = 1.067 \ \frac{kip}{in}$$

Component of weld stress along y

$$f_{wy} := \frac{P_1}{2 \cdot (2 \cdot b_w + L_1)} + \frac{P_1 \cdot e_w \cdot (b_w - c_w)}{2\ I_w} \qquad f_{wy} = 1.596 \ \frac{kip}{in}$$

Resultant weld stress

$$f_w := \sqrt{f_{wx}^{\ 2} + f_{wy}^{\ 2}} \qquad f_w = 1.92 \ \frac{kip}{in}$$

Nominal weld strength

$$R_n := 0.6 \cdot F_{EXX} \cdot \frac{\sqrt{2}}{2} \cdot w \qquad R_n = 7.425 \ \frac{kip}{in}$$

Interaction ratio for weld check

$$I_{16} := \frac{f_w}{0.75\ R_n} \qquad I_{16} = 0.345$$

Gusset rupture at weld at connection 1

Minimum web thickness to match weld strength

$$t_{g.min} := \frac{2 \cdot f_w}{0.75 \cdot 0.6 \cdot F_{up}} \qquad t_{g.min} = 0.147 \ in$$

Interaction ratio in web rupture

$$I_{17} := \frac{t_{g.min}}{t_g} \qquad I_{17} = 0.294$$

Bolt shear at connection 2

Nominal slip resistance of bolt

$$R_n := \mu \cdot 1.13 \cdot T_{pre} \qquad R_n = 13.221 \ kip$$

Interaction ratio in bolt shear

$$I_{18} := \frac{P_{b2}}{R_n} \qquad I_{18} = 0.312$$

Bolt bearing at clip angle at connection 2

Nominal strength in bearing

$$R_n := min\left(1.2 \cdot l_c \cdot t_a \cdot F_{ua}, 2.4 \cdot d_b \cdot t_a \cdot F_{ua}\right) \qquad R_n = 17.128 \ kip$$

Interaction ratio in bolt bearing

$$I_{19} := \frac{P_{b2}}{0.75\ R_n} \qquad I_{19} = 0.321$$

Bolt bearing at beam web at connection 2

Nominal strength in bearing

$$R_n := min\left(1.2 \cdot (s - d_{bh}) \cdot t_{wb2} \cdot F_{ub}, 2.4 \cdot d_b \cdot t_{wb2} \cdot F_{ub}\right) \qquad R_n = 36.975 \ kip$$

Interaction ratio in bolt bearing

$$I_{20} := \frac{P_{b2}}{0.75\ R_n} \qquad I_{20} = 0.149$$

Gusset shear yielding at connection 2

Nominal shear strength of gusset in yielding

$$R_n := 0.6 \cdot F_{yp} \cdot (g_2 - c_2) \cdot t_g \qquad R_n = 118.8\ \textit{kip}$$

Interaction ratio in gusset yieldling

$$I_{21} := \frac{P_2}{R_n} \qquad I_{21} = 0.208$$

Gusset plate block shear at connection 2

Distance of gusset outer edge from work point

$$loc_{go} := g_2 + sb_1 + 0.5 \cdot t_{wb1} \qquad loc_{go} = 15.648\ \textit{in}$$

Distance of gusset inner edge from work point

$$loc_{gi} := c_2 + sb_1 + 0.5 \cdot t_{wb1} - \text{if}\left(c_1 = 0, 0, (l_{ia} - sb_2) \cdot \frac{c_2}{c_1}\right) \qquad loc_{gi} = 2.148\ \textit{in}$$

Length of gusset to column clip

$$L_2 := (n_2 - 1) \cdot s + 2\ ed_3 \qquad L_2 = 7.25\ \textit{in}$$

Outer edge distance for clip on gusset

$$ed_{go} := loc_{go} - loc_2 - L_2 \qquad ed_{go} = 2.398\ \textit{in}$$

Inner edge distance for clip on gusset

$$ed_{gi} := loc_2 - loc_{gi} \qquad ed_{gi} = 3.853\ \textit{in}$$

Minimum edge distance for clip on gusset

$$ed_g := min(ed_{go}, ed_{gi}) \qquad ed_g = 2.398\ \textit{in}$$

Gross area subjected to block shear

$$A_{gv} := (L_2 + ed_g) \cdot t_g \qquad A_{gv} = 4.824\ \textit{in}^2$$

Net area subjected to tension

$$A_{nt} := (l_{ia} - sb_2) \cdot t_g \qquad A_{nt} = 1.25\ \textit{in}^2$$

Nominal strength in block shear

$$R_n := 0.6 \cdot F_{ya} \cdot A_{gv} + F_{ua} \cdot A_{nt} \qquad R_n = 176.693\ \textit{kip}$$

Interaction ratio in block shear

$$I_{22} := \frac{P_2}{0.75\ R_n} \qquad I_{22} = 0.187$$

Gusset flexure yielding at connection 2

Eccentricity of force at connection 2

$$ec_2 := c_1 + sb_2 + 0.5\ t_{wb2} \qquad ec_2 = 4.67\ \textit{in}$$

Nominal moment strenght of gusset

$$M_n := \frac{F_{yp} \cdot t_g \cdot g_2^{\,2}}{4} \qquad M_n = 84.375\ kip \cdot ft$$

Interaction ratio in gusset flexure

$$I_{23} := \frac{P_2 \cdot ec_2}{0.9 \cdot M_n} \qquad I_{23} = 0.127$$

Clip angle shear yielding at connection 2

Gross area in shear

$$A_{gv} := 2 \cdot L_2 \cdot t_a \qquad A_{gv} = 5.438\ in^2$$

Nominal strength in shear yielding

$$R_n := 0.6 \cdot F_{ya} \cdot A_{gv} \qquad R_n = 117.45\ kip$$

Interaction ratio in shear yielding

$$I_{24} := \frac{P_2}{R_n} \qquad I_{24} = 0.211$$

Clip angle shear rupture at connection 2

Net area in shear

$$A_{nv} := A_{gv} - 2 \cdot n_2 \cdot d_{bh} \cdot t_a \qquad A_{nv} = 3.328\ in^2$$

Nominal strength in shear rupture

$$R_n := 0.6 \cdot F_{ua} \cdot A_{nv} \qquad R_n = 115.819\ kip$$

Interaction ratio in shear rupture

$$I_{25} := \frac{P_2}{0.75\ R_n} \qquad I_{25} = 0.285$$

Clip angle block shear at connection 2

Gross area subjected to block shear

$$A_{gv} := 2 \cdot \left(L_2 - ed_3\right) \cdot t_a \qquad A_{gv} = 4.594\ in^2$$

Net area subjected to block shear

$$A_{nv} := A_{gv} - 2 \cdot \left(n_2 - 0.5\right) \cdot d_{bh} \cdot t_a \qquad A_{nv} = 2.836\ in^2$$

Net area subjected to tension

$$A_{nt} := \left(2 \cdot l_{oa} + t_g - 2 \cdot g - d_{bh}\right) \cdot t_a \qquad A_{nt} = 1.148\ in^2$$

Nominal strength in block shear

$$R_{n1} := 0.6 \cdot F_{ua} \cdot A_{nv} + F_{ua} \cdot A_{nt}$$

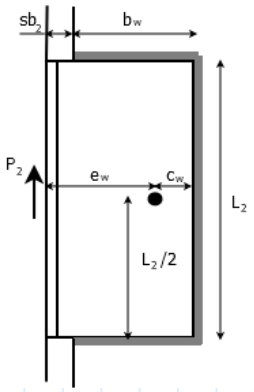
$$R_{n2} := 0.6 \cdot F_{ya} \cdot A_{gv} + F_{ua} \cdot A_{nt}$$

$$R_n := min\left(R_{n1}, R_{n2}\right) \qquad R_n = 165.3\ kip$$

Interaction ratio in block shear

$$I_{26} := \frac{P_2}{0.75\ R_n} \qquad I_{26} = 0.2$$

Weld check at connection 2



Length of horizontal run of weld

$$b_w := l_{ia} - sb_2 \qquad b_w = 2.5\ in$$

Centroid of weld group

$$c_w := \frac{b_w^{\,2}}{2 \cdot b_w + L_2} \qquad c_w = 0.51\ in$$

Eccentricity of shear force

$$e_w := l_{ia} - c_w \qquad e_w = 2.49\ in$$

Polar moment of inertia of weld group

$$I_w := \frac{(2 \cdot b_w + L_1)^3}{12} - \frac{b_w^{\,2} \cdot (b_w + L_1)^2}{2 \cdot b_w + L_1} \qquad I_w = 104.688\ in^3$$

Component of weld stress along x

$$f_{wx} := \frac{P_2 \cdot e_w \cdot L_2}{4 \cdot I_w} \qquad f_{wx} = 1.067\ \frac{kip}{in}$$

Component of weld stress along y

$$f_{wy} := \frac{P_2}{2 \cdot (2 \cdot b_w + L_2)} + \frac{P_2 \cdot e_w \cdot (b_w - c_w)}{2\ I_w} \qquad f_{wy} = 1.596\ \frac{kip}{in}$$

Resultant weld stress

$$f_w := \sqrt{f_{wx}^{\,2} + f_{wy}^{\,2}} \qquad f_w = 1.92\ \frac{kip}{in}$$

Nominal weld strength

$$R_n := 0.6 \cdot F_{EXX} \cdot \frac{\sqrt{2}}{2} \cdot w \qquad R_n = 7.425\ \frac{kip}{in}$$

Interaction ratio for weld check

$$I_{27} := \frac{f_w}{0.75\ R_n} \qquad I_{27} = 0.345$$

Gusset rupture at weld at connection 2

Minimum web thickness to match weld strength

$$t_{g.min} := \frac{2 \cdot f_w}{0.75 \cdot 0.6 \cdot F_{up}} \qquad t_{g.min} = 0.147\ in$$

Interaction ratio in web rupture

$$I_{28} := \frac{t_{g.min}}{t_g} \qquad I_{28} = 0.294$$

Validation Results

The calculated ratios are compared with the output of Osoconn and if it is within a tolerance of 1% the result is deemed to be OK.

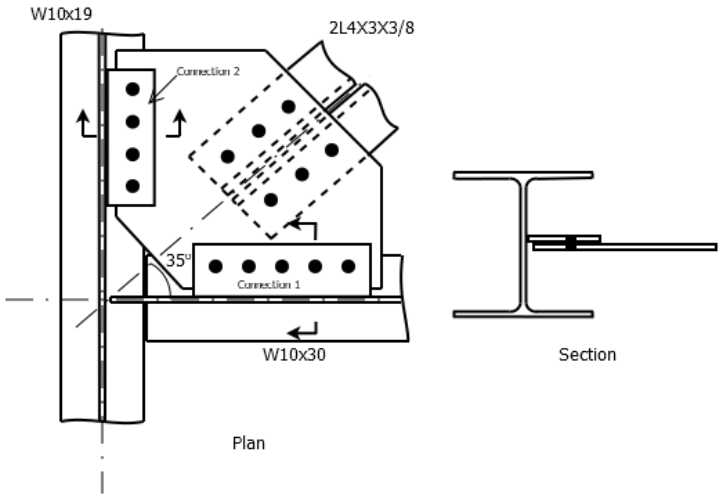
Table 2: Validation problem 1 results

	Interaction Ratio		
Check	Calculated	Osoconn	Result
Bolt shear at brace check	0.441	0.441	OK
Bolt bearing at brace check	0.381	0.381	OK
Bolt bearing at gusset check	0.572	0.572	OK
Brace tension rupture check	0.234	0.234	OK
Brace block shear check	0.297	0.297	OK
Gusset tension yielding check	0.374	0.374	OK
Gusset tension rupture check	0.333	0.333	OK
Bolt shear at connection 1	0.312	0.312	OK
Bolt bearing at clip angle at connection 1	0.321	0.321	OK
Bolt bearing at beam web at connection 1	0.171	0.171	OK
Gusset shear yielding at connection 1	0.208	0.208	OK
Gusset plate block shear at connection 1	0.186	0.186	OK
Gusset flexure yielding at connection 1	0.126	0.126	OK
Clip angle shear yielding at connection 1	0.211	0.211	OK
Clip angle shear rupture at connection 1	0.285	0.285	OK
Clip angle block shear at connection 1	0.2	0.2	OK
Weld check at connection 1	0.345	0.345	OK
Gusset rupture at weld at connection 1	0.294	0.294	OK
Bolt shear at connection 2	0.312	0.312	OK
Bolt bearing at clip angle at connection 2	0.321	0.321	OK
Bolt bearing at beam web at connection 2	0.149	0.149	OK
Gusset shear yielding at connection 2	0.208	0.208	OK
Gusset plate block shear at connection 2	0.187	0.187	OK
Gusset flexure yielding at connection 2	0.127	0.127	OK
Clip angle shear yielding at connection 2	0.211	0.211	OK
Clip angle shear rupture at connection 2	0.285	0.285	OK
Clip angle block shear at connection 2	0.2	0.2	OK
Weld check at connection 2	0.345	0.345	OK
Gusset rupture at weld at connection 2	0.294	0.294	OK

2.3 Validation Problem 2

Problem Statement

Design a horizontal brace connection for a double angle 2L4X3X3/8 brace, with their short leg back to back and vertical, framing into the junction between a W10X19 and a W10X30 using the LRFD method. The brace has an angle of 35 degrees with the W10X30 beam. The brace has an axial force of 45kip. The beams, angles and plates are of grade ASTM A36. The bolts are ASTM 3125 A325 bearing type.



Design Inputs

Material Properties

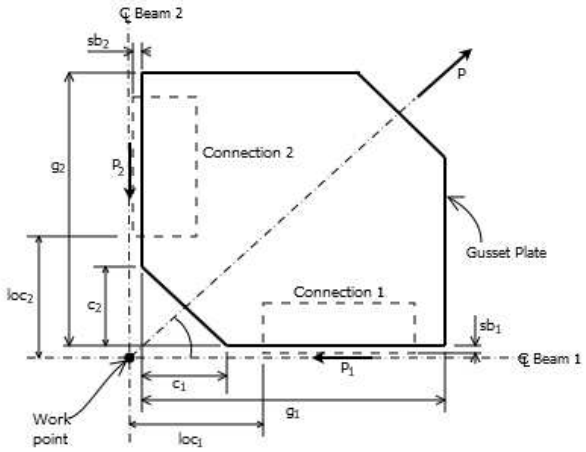
Material grade for plate	ASTM A36
Yield strength	$F_{yp} := 36\ ksi$
Tensile strength	$F_{up} := 58\ ksi$
Material grade of beam	ASTM A36
Yield strength	$F_{yb} := 36\ ksi$
Tensile strength	$F_{ub} := 58\ ksi$
Material grade of angles	ASTM A36
Yield strength	$F_{ya} := 36\ ksi$
Tensile strength	$F_{ua} := 58\ ksi$
Material grade for weld electrode	E70XX
Tensile strength	$F_{EXX} := 70\ ksi$
Material specification for bolts	ASTM 3125 A325
Tensile strength	$F_{nt} := 90\ ksi$
Shear strength	$F_{nv} := 54\ ksi$
Young's modulus for steel	$E := 29000\ ksi$

Design Forces

Axial force in brace	$P := 45\ kip$

Connection Geometry

Brace section	2L4X3X3/8
Thickness	$t_{br} := 0.375\ in$
Outstanding leg length	$l_{obr} := 3\ in$
Horizontal leg length	$l_{ibr} := 4\ in$
Gross cross section area	$A_{br} := 4.98\ in^2$
Centroid of brace back to back leg	$x'_{br} := 0.775\ in$
Brace angle with from beam at connection 1	$\theta_{br} := 35\ deg$
Back to back leg spacing	$s_{br} := 0.25\ in$
Beam section at connection 1	W10X30
Section depth	$d_{xb1} := 10.5\ in$
Flange width	$b_{fb1} := 5.81\ in$
Flange thickness	$t_{fb1} := 0.51\ in$
Web thickness	$t_{wb1} := 0.3\ in$
Distance from outer face to fillet edge	$k_{bdet1} := 1.125\ in$
Beam section at connection 2	W10X19
Section depth	$d_{xb2} := 10.2\ in$
Flange width	$b_{fb2} := 4.02\ in$
Flange thickness	$t_{fb2} := 0.395\ in$
Web thickness	$t_{wb2} := 0.25\ in$
Distance from outer face to fillet edge	$k_{bdet2} := 0.695\ in$
Shear tab thickness	$t_s := 0.5\ in$
Shear tab width	$w_s := 3.5\ in$



Gusset plate thickness	$t_g := 0.5\ in$
Gusset dimension along connection 1	$g_1 := 20\ in$
Gusset dimension along connection 2	$g_2 := 20\ in$
Gusset cutout at connection 1	$c_1 := 4\ in$
Gusset cutout at connection 2	$c_2 := 4\ in$

Bolt diameter $d_b := \frac{7}{8}\ in$

Bolt hole diameter $d_{bh} := \frac{15}{16}\ in$

Number of bolts per row on brace $n_{br} := 3$
Number of bolts at clip at beam 1 $n_1 := 5$
Number of bolts at clip at beam 2 $n_2 := 4$
Bolt spacing $s := 2.5\ in$
Bolt gage on brace $g_{br} := 1.75\ in$
Bolt gage on shear tab $g_s := 1.75\ in$
Shear tab location for connection 1 $loc_1 := 6\ in$
Shear tab location for connection 2 $loc_2 := 6\ in$
Bolt edge distance on brace $ed_1 := 1.25\ in$
Bolt edge distance on gusset $ed_2 := 1.25\ in$
Bolt edge distance on shear tab $ed_3 := 1.125\ in$

Shear tab to beam weld thickness $w := 0.25\ in$

Connection setback at connection 1 $sb_1 := 0.5\ in$
Connection setback at connection 2 $sb_2 := 0.5\ in$

Design Calculations

Connection forces

Shear per bolt at brace connection

$$P_b := \frac{P}{2 \cdot n_{br}} \qquad P_b = 7.5\ kip$$

Component of brace force along connection 1

$$P_1 := P \cdot \cos(\theta_{br}) \qquad P_1 = 36.862\ kip$$

Force per bolt along connection 1

$$P_{b1} := \frac{P_1}{n_1} \qquad P_{b1} = 7.372\ kip$$

Component of brace force along connection 2

$$P_2 := P \cdot \sin(\theta_{br}) \qquad P_2 = 25.811\ kip$$

Force per bolt along connection 2

$$P_{b2} := \frac{P_2}{n_2} \qquad P_{b2} = 6.453\ kip$$

Bolt shear at brace to gusset connection

Area of bolt

$$A_b := \frac{\pi \cdot d_b^{\,2}}{4} \qquad A_b = 0.601\ in^2$$

Nominal shear strength of bolt

$$R_n := F_{nv} \cdot A_b \qquad R_n = 32.471\ kip$$

Interaction ratio in bolt shear

$$I_0 := \frac{P_b}{0.75\ R_n} \qquad I_0 = 0.308$$

Bolt bearing on brace check

Minimum clear distance for bearing check

$$l_{c1} := min\left(s - d_{bh}, ed_1 - 0.5 \cdot d_{bh}\right) \qquad l_{c1} = 0.02\ \textit{m}$$

Nominal strength in bearing

$$R_n := min\left(1.2 \cdot l_{c1} \cdot t_{br} \cdot F_{ua}, 2.4 \cdot d_b \cdot t_{br} \cdot F_{ua}\right) \qquad R_n = 20.391\ \textit{kip}$$

Interaction ratio in bolt bearing at brace

$$I_1 := \frac{P_b}{0.75 \cdot R_n} \qquad I_1 = 0.49$$

Bolt bearing on gusset check

Minimum clear distance for bearing on gusset

$$l_{c2} := min\left(s - d_{bh}, ed_2 - 0.5 \cdot d_{bh}\right) \qquad l_{c1} = 0.02\ \textit{m}$$

Nominal strength in bearing

$$R_n := min\left(1.2 \cdot l_{c2} \cdot t_g \cdot F_{up}, 2.4 \cdot d_b \cdot t_g \cdot F_{up}\right) \qquad R_n = 27.188\ \textit{kip}$$

Interaction ratio in bolt bearing at gusset

$$I_2 := \frac{P_b}{0.75 \cdot R_n} \qquad I_2 = 0.368$$

Brace tension rupture check

Net cross section area of brace

$$A_{nbr} := A_{br} - 2 \cdot d_{bh} \cdot t_{br} \qquad A_{nbr} = 4.277\ \textit{in}^2$$

Length of connection

$$l_{br} := s \cdot \left(n_{br} - 1\right) \qquad l_{br} = 5\ \textit{in}$$

Shear lag factor

$$U := 1 - \frac{x'_{br}}{l_{br}} \qquad U = 0.845$$

Brace strength in tension rupture

$$P_n := F_{ua} \cdot U \cdot A_{nbr} \qquad P_n = 209.61\ \textit{kip}$$

Interaction ratio for brace tension rupture

$$I_3 := \frac{P}{0.75 \cdot P_n} \qquad I_3 = 0.286$$

Brace block shear check

Gross area in shear

$$A_{gv} := 2 \cdot \left(\left(n_{br} - 1\right) \cdot s + ed_1\right) \cdot t_{br} \qquad A_{gv} = 4.688\ \textit{in}^2$$

Net area in shear

$$A_{nv} := A_{gv} - 2 \cdot \left(n_{br} - 0.5\right) \cdot d_{bh} \cdot t_{br} \qquad A_{nv} = 2.93\ \textit{in}^2$$

Net area in tension

$$A_{nt} := 2 \cdot \left(l_{ibr} - g_{br} - 0.5 \cdot d_{bh}\right) \cdot t_{br} \qquad A_{nt} = 1.336\ in^2$$

Nominal strength block shear

$$R_{n1} := 0.6 \cdot F_{ua} \cdot A_{nv} + F_{ua} \cdot A_{nt}$$

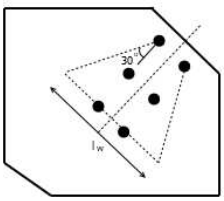
$$R_{n2} := 0.6 \cdot F_{ya} \cdot A_{gv} + F_{ua} \cdot A_{nt}$$

$$R_n := min\left(R_{n1}, R_{n2}\right) \qquad R_n = 178.734\ kip$$

Interaction ratio in block shear

$$I_4 := \frac{P}{0.75 \cdot R_n} \qquad I_4 = 0.336$$

Gusset tension yielding check



Length of Whitmore section

$$l_w := 2 \cdot l_{br} \cdot \tan\left(30\ deg\right) + 2 \cdot g_{br} + s_{br} \qquad l_w = 9.524\ in$$

Nominal strength of gusset in yielding

$$P_n := F_{yp} \cdot l_w \cdot t_g \qquad P_n = 171.423\ kip$$

Interaction ratio in tension yielding

$$I_5 := \frac{P}{0.9 \cdot P_n} \qquad I_5 = 0.292$$

Gusset tension rupture check

Net area of gusset in tension

$$A_{ng} := \left(l_w - 2 \cdot d_{bh}\right) \cdot t_g \qquad A_{ng} = 3.824\ in^2$$

Nominal strength of gusset in rupture

$$P_n := F_{up} \cdot A_{ng} \qquad P_n = 221.807\ kip$$

Interaction ratio in tension rupture

$$I_6 := \frac{P}{0.75 \cdot P_n} \qquad I_6 = 0.271$$

Gusset block shear check

Gross area in shear

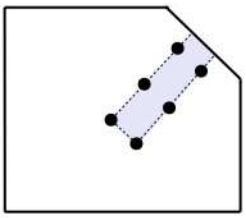
$$A_{gv} := 2\ \left(\left(n_{br} - 1\right) \cdot s + ed_2\right) \cdot t_g \qquad A_{gv} = 6.25\ in^2$$

Net area in shear

$$A_{nv} := A_{gv} - (2 \cdot n_{br} - 1) \cdot d_{bh} \cdot t_g \qquad A_{nv} = 3.906\ in^2$$

Net area in tension

$$A_{nt} := (2\ g_{br} + s_{br} - d_{bh}) \cdot t_g \qquad A_{nt} = 1.406\ in^2$$



Nominal strength block shear

$$R_{n1} := 0.6 \cdot F_{up} \cdot A_{nv} + F_{up} \cdot A_{nt}$$

$$R_{n2} := 0.6 \cdot F_{yp} \cdot A_{gv} + F_{up} \cdot A_{nt}$$

$$R_n := min(R_{n1}, R_{n2}) \qquad R_n = 216.563\ kip$$

Interaction ratio in block shear

$$I_7 := \frac{P}{0.75\ R_n} \qquad I_7 = 0.277$$

Bolt shear at connection 1

Polar moment of inertia of bolt group

$$I_{po} := 2 \cdot \sum_{i=1}^{0.5\,(n_1 - 1)} (i \cdot s)^2$$

$$I_{pe} := 2 \cdot \sum_{i=1}^{0.5\,n_1} ((i - 0.5) \cdot s)^2$$

$$I_p := \text{if}(\text{mod}(n_1, 2) = 1, I_{po}, I_{pe}) \qquad I_p = 62.5\ in^2$$

Distance of most remote bolt from CG

$$c := 0.5\ (n_1 - 1) \cdot s \qquad c = 5\ in$$

Maximum shear in bolt

$$P_s := \sqrt{\left(\frac{P_1}{n_1}\right)^2 + \left(\frac{P_1 \cdot g_s \cdot c}{I_p}\right)^2} \qquad P_s = 8.999\ kip$$

Nominal shear strength of bolt

$$R_n := F_{nv} \cdot A_b \qquad R_n = 32.471\ kip$$

Interaction ratio in bolt shear

$$I_8 := \frac{P_{b1}}{0.75\ R_n} \qquad I_8 = 0.303$$

Bolt bearing at shear tab at connection 1

Clear distance between bolt holes/ hole and edge

$$l_c := min\left(s - d_{bh}, ed_3 - 0.5 \cdot d_{bh}\right) \qquad l_c = 0.656\ in$$

Nominal strength in bearing

$$R_n := min\left(1.2 \cdot l_c \cdot t_s \cdot F_{up}, 2.4 \cdot d_b \cdot t_s \cdot F_{up}\right) \qquad R_n = 22.838\ kip$$

Interaction ratio in bolt bearing

$$I_9 := \frac{P_{b1}}{0.75\ R_n} \qquad I_9 = 0.43$$

Bolt bearing at gusset at connection 1

Length of shear tab

$$L_1 := \left(n_1 - 1\right) \cdot s + 2\ ed_3 \qquad L_1 = 12.25\ in$$

Distance of gusset outer edge from work point

$$loc_{go} := g_1 + sb_2 + 0.5 \cdot t_{wb2} \qquad loc_{go} = 20.625\ in$$

Distance of gusset inner edge from work point

$$loc_{gi} := c_1 + sb_2 + 0.5 \cdot t_{wb2} - \mathbf{if}\left(c_2 = 0, 0, \left(g_s - sb_1\right) \cdot \frac{c_1}{c_2}\right) \qquad loc_{gi} = 3.375\ in$$

Outer edge distance for bolt on gusset

$$ed_{go} := loc_{go} - loc_1 - L_1 + ed_3 \qquad ed_{go} = 3.5\ in$$

Inner edge distance for bolt on gusset

$$ed_{gi} := loc_1 - loc_{gi} + ed_3 \qquad ed_{gi} = 3.75\ in$$

Minimum edge distance for clip on gusset

$$ed_g := min\left(ed_{go}, ed_{gi}\right) \qquad ed_g = 3.5\ in$$

Clear distance between bolt holes/ hole and edge

$$l_c := min\left(s - d_{bh}, ed_g - 0.5 \cdot d_{bh}\right) \qquad l_c = 1.563\ in$$

Nominal strength in bearing

$$R_n := min\left(1.2 \cdot l_c \cdot t_g \cdot F_{up}, 2.4 \cdot d_b \cdot t_g \cdot F_{up}\right) \qquad R_n = 54.375\ kip$$

Interaction ratio in bolt bearing

$$I_{10} := \frac{P_{b1}}{0.75\ R_n} \qquad I_{10} = 0.181$$

Gusset shear yielding at connection 1

Gross area in shear

$$A_g := \left(g_1 - c_1\right) \cdot t_g \qquad A_g = 8\ in^2$$

Nominal shear strength of gusset in yielding

$$R_n := 0.6 \cdot F_{yp} \cdot A_g \qquad R_n = 172.8\ kip$$

Interaction ratio in gusset yieldling

$$I_{11} := \frac{P_1}{R_n} \qquad I_{11} = 0.213$$

Gusset shear rupture at connection 1

Net area in shear

$$A_n := A_g - n_1 \cdot d_{bh} \cdot t_g \qquad A_n = 5.656\ in^2$$

Nominal shear strength of gusset in rupture

$$R_n := 0.6 \cdot F_{up} \cdot A_n \qquad R_n = 196.838\ kip$$

Interaction ratio in shear rupture

$$I_{12} := \frac{P_1}{0.75\ R_n} \qquad I_{12} = 0.25$$

Gusset plate block shear at connection 1

Gross area subjected to block shear

$$A_{gv} := \left(L_1 - 2\ ed_3 + ed_g\right) \cdot t_g \qquad A_{gv} = 6.75\ in^2$$

Net area subjected to block shear

$$A_{nv} := A_{gv} - \left(n_1 - 0.5\right) \cdot d_{bh} \cdot t_g \qquad A_{nv} = 4.641\ in^2$$

Net area subjected to tension

$$A_{nt} := \left(g_s - sb_1 - 0.5\ d_{bh}\right) \cdot t_g \qquad A_{nt} = 0.391\ in^2$$

Nominal strength in block shear

$$R_{n1} := 0.6 \cdot F_{ua} \cdot A_{nv} + F_{ua} \cdot A_{nt}$$

$$R_{n2} := 0.6 \cdot F_{ya} \cdot A_{gv} + F_{ua} \cdot A_{nt}$$

$$R_n := min\left(R_{n1}, R_{n2}\right) \qquad R_n = 168.456\ kip$$

Interaction ratio in block shear

$$I_{13} := \frac{P_1}{0.75\ R_n} \qquad I_{13} = 0.292$$

Gusset flexure yielding at connection 1

Eccentricity of force at connection 1

$$ec_1 := c_2 + sb_1 + 0.5\ t_{wb1} \qquad ec_1 = 4.65\ in$$

Nominal moment strenght of gusset

$$M_n := \frac{F_{yp} \cdot t_g \cdot {g_1}^2}{4} \qquad M_n = 150\ kip \cdot ft$$

Interaction ratio in gusset flexure

$$I_{14} := \frac{P_1 \cdot ec_1}{0.9 \cdot M_n} \qquad I_{14} = 0.106$$

Shear tab shear yielding at connection 1

Gross area in shear

$$A_{gv} := L_1 \cdot t_s \qquad A_{gv} = 6.125\ in^2$$

Nominal strength in shear yielding

$$R_n := 0.6 \cdot F_{yp} \cdot A_{gv} \qquad R_n = 132.3\ kip$$

Interaction ratio in shear yielding

$$I_{15} := \frac{P_1}{R_n} \qquad I_{15} = 0.279$$

Shear tab shear rupture at connection 1

Net area in shear

$$A_{nv} := A_{gv} - n_1 \cdot d_{bh} \cdot t_s \qquad A_{nv} = 3.781\ in^2$$

Nominal strength in shear rupture

$$R_n := 0.6 \cdot F_{ua} \cdot A_{nv} \qquad R_n = 131.588\ kip$$

Interaction ratio in shear rupture

$$I_{16} := \frac{P_1}{0.75\ R_n} \qquad I_{16} = 0.374$$

Shear tab block shear at connection 1

Gross area subjected to block shear

$$A_{gv} := \left(L_1 - ed_3\right) \cdot t_s \qquad A_{gv} = 5.563\ in^2$$

Net area subjected to block shear

$$A_{nv} := A_{gv} - \left(n_1 - 0.5\right) \cdot d_{bh} \cdot t_s \qquad A_{nv} = 3.453\ in^2$$

Net area subjected to tension

$$A_{nt} := \left(w_s - g_s - 0.5\ d_{bh}\right) \cdot t_s \qquad A_{nt} = 0.641\ in^2$$

Nominal strength in block shear

$$R_{n1} := 0.6 \cdot F_{ua} \cdot A_{nv} + F_{ua} \cdot A_{nt}$$

$$R_{n2} := 0.6 \cdot F_{ya} \cdot A_{gv} + F_{ua} \cdot A_{nt}$$

$$R_n := min\left(R_{n1}, R_{n2}\right) \qquad R_n = 157.306\ kip$$

Interaction ratio in block shear

$$I_{17} := \frac{P_1}{0.75\ R_n} \qquad I_{17} = 0.312$$

Shear tab flexure yielding at connection 1

Nominal flexure strenght of shear tab

$$M_n := \frac{F_{yp} \cdot t_s \cdot {L_1}^2}{4} \qquad M_n = 56.273\ kip \cdot ft$$

Interaction ratio in shear tab flexure

$$I_{18} := \frac{P_1 \cdot g_s}{0.9\ M_n} \qquad I_{18} = 0.106$$

Weld check at connection 1

Polar moment of inertia of weld group

$$I_w := \frac{L_1^{\,3}}{12} \qquad I_w = 153.189\ in^3$$

Weld stress along weld

$$f_{wx} := \frac{P_1}{2 \cdot L_1} \qquad f_{wx} = 1.505\ \frac{kip}{in}$$

Max weld stress transverse to weld

$$f_{wy} := \frac{P_1 \cdot g_s \cdot L_1}{4\ I_w} \qquad f_{wy} = 1.29\ \frac{kip}{in}$$

Resultant weld stress

$$f_w := \sqrt{f_{wx}^{\,2} + f_{wy}^{\,2}} \qquad f_w = 1.982\ \frac{kip}{in}$$

Nominal weld strength

$$R_n := 0.6 \cdot F_{EXX} \cdot \frac{\sqrt{2}}{2} \cdot w \qquad R_n = 7.425\ \frac{kip}{in}$$

Interaction ratio for weld check

$$I_{19} := \frac{f_w}{0.75\ R_n} \qquad I_{19} = 0.356$$

Shear tab rupture at weld at connection 1

Minimum shear tab thickness to match weld strength

$$t_{s.min} := \frac{2\ f_w}{0.75 \cdot 0.6 \cdot F_{up}} \qquad t_{s.min} = 0.152\ in$$

Interaction ratio in web rupture

$$I_{20} := \frac{t_{s.min}}{t_s} \qquad I_{20} = 0.304$$

Web rupture at weld at connection 1

Minimum web thickness to match weld strength

$$t_{w.min} := \frac{f_w}{0.75 \cdot 0.6 \cdot F_{ub}} \qquad t_{w.min} = 0.076\ in$$

Interaction ratio in web rupture

$$I_{21} := \frac{t_{w.min}}{t_{wb1}} \qquad I_{21} = 0.253$$

Bolt shear at connection 2

Polar moment of inertia of bolt group

$$I_{po} := 2 \cdot \sum_{i=1}^{0.5\,(n_2 - 1)} (i \cdot s)^2$$

$$I_{pe} := 2 \cdot \sum_{i=1}^{0.5\, n_2} \left((i - 0.5) \cdot s \right)^2$$

$$I_p := \text{if}\left(\text{mod}\left(n_2, 2 \right) = 1, I_{po}, I_{pe} \right) \qquad I_p = 31.25\ in^2$$

Distance of most remote bolt from CG

$$c := 0.5\ \left(n_2 - 1 \right) \cdot s \qquad c = 3.75\ in$$

Maximum shear in bolt

$$P_s := \sqrt{\left(\frac{P_2}{n_2} \right)^2 + \left(\frac{P_2 \cdot g_s \cdot c}{I_p} \right)^2} \qquad P_s = 8.427\ kip$$

Nominal shear strength of bolt

$$R_n := F_{nv} \cdot A_b \qquad R_n = 32.471\ kip$$

Interaction ratio in bolt shear

$$I_{22} := \frac{P_{b2}}{0.75\ R_n} \qquad I_{22} = 0.265$$

Bolt bearing at shear tab at connection 2

Clear distance between bolt holes/ hole and edge

$$l_c := min\left(s - d_{bh}, ed_3 - 0.5 \cdot d_{bh} \right) \qquad l_c = 0.656\ in$$

Nominal strength in bearing

$$R_n := min\left(1.2 \cdot l_c \cdot t_s \cdot F_{up}, 2.4 \cdot d_b \cdot t_s \cdot F_{up} \right) \qquad R_n = 22.838\ kip$$

Interaction ratio in bolt bearing

$$I_{23} := \frac{P_{b2}}{0.75\ R_n} \qquad I_{23} = 0.377$$

Bolt bearing at gusset at connection 2

Length of shear tab

$$L_2 := \left(n_2 - 1 \right) \cdot s + 2\ ed_3 \qquad L_2 = 9.75\ in$$

Distance of gusset outer edge from work point

$$loc_{go} := g_2 + sb_1 + 0.5 \cdot t_{wb1} \qquad loc_{go} = 20.65\ in$$

Distance of gusset inner edge from work point

$$loc_{gi} := c_2 + sb_1 + 0.5 \cdot t_{wb1} - \text{if}\left(c_1 = 0, 0, \left(g_s - sb_2 \right) \cdot \frac{c_2}{c_1} \right) \qquad loc_{gi} = 3.4\ in$$

Outer edge distance for bolt on gusset

$$ed_{go} := loc_{go} - loc_2 - L_2 + ed_3 \qquad ed_{go} = 6.025\ in$$

Inner edge distance for bolt on gusset

$$ed_{gi} := loc_2 - loc_{gi} + ed_3 \qquad ed_{gi} = 3.725\ in$$

Minimum edge distance for clip on gusset

$ed_g := min(ed_{go}, ed_{gi})$ $ed_g = 3.725\ in$

Clear distance between bolt holes/ hole and edge

$l_c := min(s - d_{bh}, ed_g - 0.5 \cdot d_{bh})$ $l_c = 1.563\ in$

Nominal strength in bearing

$R_n := min(1.2 \cdot l_c \cdot t_g \cdot F_{up}, 2.4 \cdot d_b \cdot t_g \cdot F_{up})$ $R_n = 54.375\ kip$

Interaction ratio in bolt bearing

$I_{24} := \frac{P_{b2}}{0.75\ R_n}$ $I_{24} = 0.158$

Gusset shear yielding at connection 2

Gross area in shear

$A_g := (g_2 - c_2) \cdot t_g$ $A_g = 8\ in^2$

Nominal shear strength of gusset in yielding

$R_n := 0.6 \cdot F_{yp} \cdot A_g$ $R_n = 172.8\ kip$

Interaction ratio in gusset yieldling

$I_{25} := \frac{P_2}{R_n}$ $I_{25} = 0.149$

Gusset shear rupture at connection 2

Net area in shear

$A_n := A_g - n_2 \cdot d_{bh} \cdot t_g$ $A_n = 6.125\ in^2$

Nominal shear strength of gusset in rupture

$R_n := 0.6 \cdot F_{up} \cdot A_n$ $R_n = 213.15\ kip$

Interaction ratio in shear rupture

$I_{26} := \frac{P_2}{0.75\ R_n}$ $I_{26} = 0.161$

Gusset plate block shear at connection 2

Gross area subjected to block shear

$A_{gv} := (L_2 - 2\ ed_3 + ed_g) \cdot t_g$ $A_{gv} = 5.613\ in^2$

Net area subjected to block shear

$A_{nv} := A_{gv} - (n_2 - 0.5) \cdot d_{bh} \cdot t_g$ $A_{nv} = 3.972\ in^2$

Net area subjected to tension

$A_{nt} := (g_s - sb_2 - 0.5\ d_{bh}) \cdot t_g$ $A_{nt} = 0.391\ in^2$

Nominal strength in block shear

$R_{n1} := 0.6 \cdot F_{ua} \cdot A_{nv} + F_{ua} \cdot A_{nt}$

$R_{n2} := 0.6 \cdot F_{ya} \cdot A_{gv} + F_{ua} \cdot A_{nt}$

$$R_n := min\left(R_{n1}, R_{n2}\right) \qquad R_n = 143.886\ kip$$

Interaction ratio in block shear

$$I_{27} := \frac{P_2}{0.75\ R_n} \qquad I_{27} = 0.239$$

Gusset flexure yielding at connection 2

Eccentricity of force at connection 2

$$ec_2 := c_1 + sb_2 + 0.5 \cdot t_{wb2} \qquad ec_2 = 4.625\ in$$

Nominal moment strenght of gusset

$$M_n := \frac{F_{yp} \cdot t_g \cdot {g_2}^2}{4} \qquad M_n = 150\ kip \cdot ft$$

Interaction ratio in gusset flexure

$$I_{28} := \frac{P_2 \cdot ec_2}{0.9 \cdot M_n} \qquad I_{28} = 0.074$$

Shear tab shear yielding at connection 2

Gross area in shear

$$A_{gv} := L_2 \cdot t_s \qquad A_{gv} = 4.875\ in^2$$

Nominal strength in shear yielding

$$R_n := 0.6 \cdot F_{yp} \cdot A_{gv} \qquad R_n = 105.3\ kip$$

Interaction ratio in shear yielding

$$I_{29} := \frac{P_2}{R_n} \qquad I_{29} = 0.245$$

Shear tab shear rupture at connection 2

Net area in shear

$$A_{nv} := A_{gv} - n_2 \cdot d_{bh} \cdot t_s \qquad A_{nv} = 3\ in^2$$

Nominal strength in shear rupture

$$R_n := 0.6 \cdot F_{ua} \cdot A_{nv} \qquad R_n = 104.4\ kip$$

Interaction ratio in shear rupture

$$I_{30} := \frac{P_2}{0.75\ R_n} \qquad I_{30} = 0.33$$

Shear tab block shear at connection 2

Gross area subjected to block shear

$$A_{gv} := \left(L_2 - ed_3\right) \cdot t_s \qquad A_{gv} = 4.313\ in^2$$

Net area subjected to block shear

$$A_{nv} := A_{gv} - \left(n_2 - 0.5\right) \cdot d_{bh} \cdot t_s \qquad A_{nv} = 2.672\ in^2$$

Net area subjected to tension

$$A_{nt} := \left(w_s - g_s - 0.5\ d_{bh}\right) \cdot t_s \qquad A_{nt} = 0.641\ in^2$$

Nominal strength in block shear

$$R_{n1} := 0.6 \cdot F_{ua} \cdot A_{nv} + F_{ua} \cdot A_{nt}$$

$$R_{n2} := 0.6 \cdot F_{ya} \cdot A_{gv} + F_{ua} \cdot A_{nt}$$

$$R_n := min\left(R_{n1}, R_{n2}\right) \qquad R_n = 130.138\ kip$$

Interaction ratio in block shear

$$I_{31} := \frac{P_2}{0.75\ R_n} \qquad I_{31} = 0.264$$

Shear tab flexure yielding at connection 2

Nominal moment strenght of gusset

$$M_n := \frac{F_{yp} \cdot t_s \cdot {L_2}^2}{4} \qquad M_n = 48.333\ kN \cdot m$$

Interaction ratio in gusset flexure

$$I_{32} := \frac{P_2 \cdot g_s}{0.9\ M_n} \qquad I_{32} = 0.117$$

Weld check at connection 2

Polar moment of inertia of weld group

$$I_w := \frac{{L_2}^3}{12} \qquad I_w = 77.238\ in^3$$

Weld stress along weld

$$f_{wx} := \frac{P_2}{2 \cdot L_2} \qquad f_{wx} = 1.324\ \frac{kip}{in}$$

Max weld stress transverse to weld

$$f_{wy} := \frac{P_2 \cdot g_s \cdot L_2}{4\ I_w} \qquad f_{wy} = 1.425\ \frac{kip}{in}$$

Resultant weld stress

$$f_w := \sqrt{{f_{wx}}^2 + {f_{wy}}^2} \qquad f_w = 1.945\ \frac{kip}{in}$$

Nominal weld strength

$$R_n := 0.6 \cdot F_{EXX} \cdot \frac{\sqrt{2}}{2} \cdot w \qquad R_n = 7.425\ \frac{kip}{in}$$

Interaction ratio for weld check

$$I_{33} := \frac{f_w}{0.75\ R_n} \qquad I_{33} = 0.349$$

Shear tab rupture at weld at connection 2

Minimum shear tab thickness to match weld strength

$$t_{s.min} := \frac{2\ f_w}{0.75 \cdot 0.6 \cdot F_{up}} \qquad t_{s.min} = 0.149\ in$$

Interaction ratio in web rupture

$$I_{34} := \frac{t_{s.min}}{t_s} \qquad I_{34} = 0.298$$

Web rupture at weld at connection 2

Minimum web thickness to match weld strength

$$t_{w.min} := \frac{f_w}{0.75 \cdot 0.6 \cdot F_{ub}} \qquad t_{w.min} = 0.075\ in$$

Interaction ratio in web rupture

$$I_{35} := \frac{t_{w.min}}{t_{wb2}} \qquad I_{35} = 0.298$$

Validation Results

The calculated ratios are compared with the output of Osoconn and if it is within a tolerance of 1% the result is deemed to be OK.

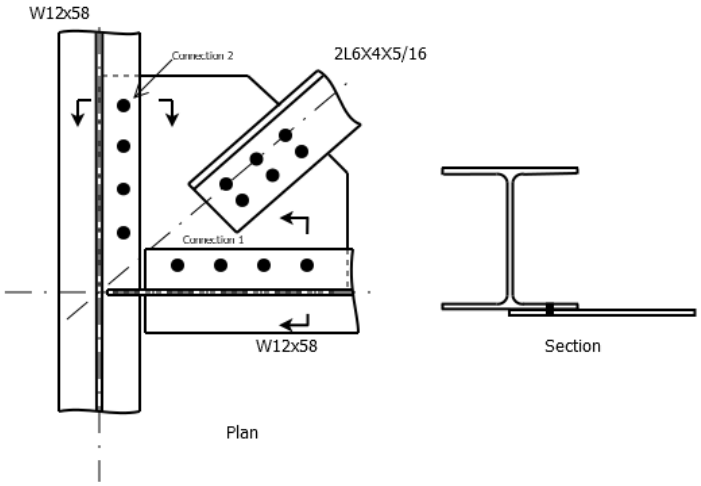
Table 3: Validation problem 2 results

	Interaction Ratio		
Check	Calculated	Osoconn	Result
Bolt shear at brace to gusset connection	0.308	0.308	OK
Bolt bearing on brace check	0.49	0.49	OK
Bolt bearing on gusset check	0.368	0.368	OK
Brace tension rupture check	0.286	0.286	OK
Brace block shear check	0.336	0.336	OK
Gusset tension yielding check	0.292	0.292	OK
Gusset tension rupture check	0.271	0.271	OK
Gusset block shear check	0.277	0.277	OK
Bolt shear at connection 1	0.303	0.303	OK
Bolt bearing at shear tab at connection 1	0.43	0.43	OK
Bolt bearing at gusset at connection 1	0.181	0.181	OK
Gusset shear yielding at connection 1	0.213	0.213	OK
Gusset shear rupture at connection 1	0.25	0.25	OK
Gusset plate block shear at connection 1	0.292	0.292	OK
Gusset flexure yieldsing at connection 1	0.106	0.106	OK
Shear tab shear yielding at connection 1	0.279	0.279	OK
Shear tab shear rupture at connection 1	0.374	0.374	OK
Shear tab block shear at connection 1	0.312	0.312	OK
Shear tab flexure yielding at connection 1	0.106	0.106	OK
Weld check at connection 1	0.356	0.356	OK
Shear tab rupture at weld at connection 1	0.304	0.304	OK
Web rupture at weld at connection 1	0.253	0.253	OK
Bolt shear at connection 2	0.265	0.265	OK
Bolt bearing at shear tab at connection 2	0.377	0.377	OK
Bolt bearing at gusset at connection 2	0.158	0.158	OK
Gusset shear yielding at connection 2	0.149	0.149	OK
Gusset shear rupture at connection 2	0.161	0.161	OK
Gusset plate block shear at connection 2	0.239	0.239	OK
Gusset flexure yielding at connection 2	0.074	0.074	OK
Shear tab shear yielding at connection 2	0.245	0.245	OK
Shear tab shear rupture at connection 2	0.33	0.33	OK
Shear tab block shear at connection 2	0.264	0.264	OK
Shear tab flexure yielding at connection 2	0.117	0.117	OK
Weld check at connection 2	0.349	0.349	OK
Shear tab rupture at weld at connection 2	0.298	0.298	OK
Web rupture at weld at connection 2	0.298	0.298	OK

2.4 Validation Problem 3

Problem Statement

Design a horizontal brace connection for a double angle 2L6X4X5/16 brace, with their back to back leg horizontal, framing into the junction between two W12X58 and a W12X58 using the LRFD method. The brace has an angle of 55 degrees. The brace has an axial force of 65kip. The beams are of grad ASTM A992, angles and plates are of grade ASTM A36. The bolts are ASTM 3125 A490 slip critical type.



Design Inputs

Material Properties

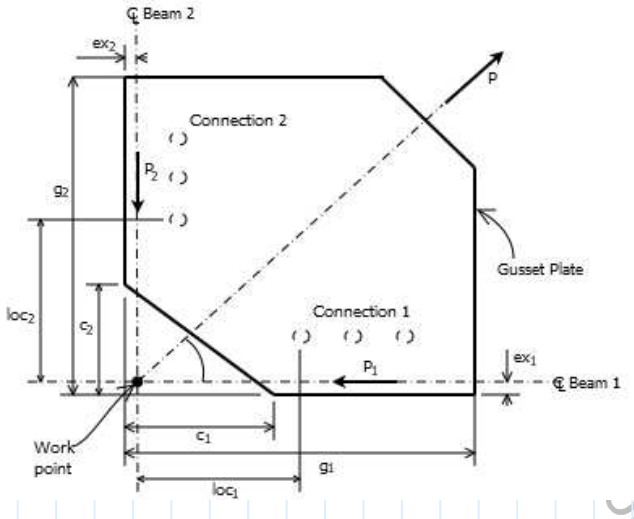
Material grade for plate	ASTM A36
Yield strength	$F_{yp} := 36\ ksi$
Tensile strength	$F_{up} := 58\ ksi$
Material grade of beam	ASTM A992
Yield strength	$F_{yb} := 50\ ksi$
Tensile strength	$F_{ub} := 65\ ksi$
Material grade of angles	ASTM A36
Yield strength	$F_{ya} := 36\ ksi$
Tensile strength	$F_{ua} := 58\ ksi$
Material grade for weld electrode	E70XX
Tensile strength	$F_{EXX} := 70\ ksi$
Material specification for bolts	ASTM 3125 A490
Tensile strength	$F_{nt} := 113\ ksi$
Shear strength	$F_{nv} := 68\ ksi$
Young's modulus for steel	$E := 29000\ ksi$

Design Forces

Axial force in brace	$P := 65\ kip$

Connection Geometry

Brace section	2L6X4X5/16
Thickness	$t_{br} := 0.313\ in$
Outstanding leg length	$l_{obr} := 4\ in$
Back-to-back leg length	$l_{ibr} := 6\ in$
Gross cross section area	$A_{br} := 6.06\ in^2$
Centroid of brace outstanding leg	$x'_{br} := 0.908\ in$
Brace angle with horizontal	$\theta_{br} := 55\ deg$
Beam section at connection 1	W12X58
Section depth	$d_{xb1} := 12.2\ in$
Flange width	$b_{fb1} := 10\ in$
Flange thickness	$t_{fb1} := 0.64\ in$
Web thickness	$t_{wb1} := 0.36\ in$
Distance from outer face to fillet edge	$k_{bdet1} := 1.5\ in$
Beam section at connection 2	W12X58
Section depth	$d_{xb2} := 12.2\ in$
Flange width	$b_{fb2} := 10\ in$
Flange thickness	$t_{fb2} := 0.64\ in$
Web thickness	$t_{wb2} := 0.36\ in$
Distance from outer face to fillet edge	$k_{bdet2} := 1.5\ in$



Gusset plate thickness	$t_g := 0.5\ in$
Gusset dimension along connection 1	$g_1 := 15\ in$
Gusset dimension along connection 2	$g_2 := 15\ in$
Gusset cutout at connection 1	$c_1 := 0\ in$
Gusset cutout at connection 2	$c_2 := 0\ in$
Gusset extension at connection 1	$ex_1 := 0.5\ in$
Gusset extension at connection 2	$ex_2 := 0.5\ in$
Bolt diameter	$d_b := 1\ in$
Bolt hole diameter	$d_{bh} := 1.063\ in$

Slip coefficient (class A surface) $\mu := 0.3$

Bolt pretension $T_{pre} := 64\ kip$

Number of bolts per row on brace $n_{br} := 3$

Number of bolts at beam 1 flange $n_1 := 3$

Number of bolts at beam 2 flange $n_2 := 3$

Bolt spacing $s := 3\ in$

Bolt row spacing $s_r := 1.75\ in$

Bolt gage on brace $g_{br} := 2\ in$

Bolt gage on beam 1 $g_{bm1} := 3\ in$

Bolt gage on beam 2 $g_{bm2} := 3\ in$

Bolt location for connection 1 $loc_1 := 6\ in$

Bolt location for connection 2 $loc_2 := 6\ in$

Bolt edge distance on brace $ed_1 := 1.5\ in$

Bolt edge distance on gusset $ed_2 := 1.5\ in$

Bolt edge distance on gusset at connection 1 $ed_3 := 1.5\ in$

Bolt edge distance on gusset at connection 2 $ed_4 := 1.5\ in$

Beam bottom flange cope length at connection 1 $cp_1 := 4\ in$

Beam bottom flange cope length at connection 2 $cp_2 := 0\ in$

Setback of beam at connection 1 $sbb_1 := 0.5\ in$

Setback of beam at connection 2 $sbb_2 := 0\ in$

Design Calculations

Connection forces

Shear per bolt at brace connection

$$P_b := \frac{P}{2\ n_{br}} \qquad P_b = 10.833\ kip$$

Component of brace force along connection 1

$$P_1 := P \cdot \cos(\theta_{br}) \qquad P_1 = 37.282\ kip$$

Force per bolt along connection 1

$$P_{b1} := \frac{P_1}{n_1} \qquad P_{b1} = 12.427\ kip$$

Component of brace force along connection 2

$$P_2 := P \cdot \sin(\theta_{br}) \qquad P_2 = 53.245\ kip$$

Force per bolt along connection 2

$$P_{b2} := \frac{P_2}{n_2} \qquad P_{b2} = 17.748\ kip$$

Bolt shear at brace to gusset connection

Nominal slip resistance of bolt

$$R_n := \mu \cdot 1.13 \cdot T_{pre} \cdot 2 \qquad R_n = 43.392\ kip$$

Interaction ratio in bolt shear

$$I_0 := \frac{P_b}{R_n} \qquad I_0 = 0.25$$

Bolt bearing on brace check

Minimum clear distance for bearing check

$$l_{c1} := min\left(s - d_{bh}, ed_1 - 0.5 \cdot d_{bh}\right) \qquad l_{c1} = 0.969\ in$$

Nominal strength in bearing

$$R_n := min\left(1.2 \cdot l_{c1} \cdot t_{br} \cdot F_{ua}, 2.4 \cdot d_b \cdot t_{br} \cdot F_{ua}\right) \qquad R_n = 21.099\ kip$$

Interaction ratio in bolt bearing at brace

$$I_1 := \frac{0.5\ P_b}{0.75 \cdot R_n} \qquad I_1 = 0.342$$

Bolt bearing on gusset check

Minimum clear distance for bearing on gusset

$$l_{c2} := min\left(s - d_{bh}, ed_2 - 0.5 \cdot d_{bh}\right) \qquad l_{c1} = 0.969\ in$$

Nominal strength in bearing

$$R_n := min\left(1.2 \cdot l_{c2} \cdot t_g \cdot F_{up}, 2.4 \cdot d_b \cdot t_g \cdot F_{up}\right) \qquad R_n = 33.704\ kip$$

Interaction ratio in bolt bearing at gusset

$$I_2 := \frac{P_b}{0.75 \cdot R_n} \qquad I_2 = 0.429$$

Brace tension rupture check

Net cross section area of brace

$$A_{nbr} := A_{br} - 4 \cdot d_{bh} \cdot t_{br} \qquad A_{nbr} = 4.729\ in^2$$

Length of connection

$$l_{br} := s \cdot \left(n_{br} - 1\right) \qquad l_{br} = 6\ in$$

Shear lag factor

$$U := 1 - \frac{x'_{br}}{l_{br}} \qquad U = 0.849$$

Brace strength in tension rupture

$$P_n := F_{ua} \cdot U \cdot A_{nbr} \qquad P_n = 232.78\ kip$$

Interaction ratio for brace tension rupture

$$I_3 := \frac{P}{0.75 \cdot P_n} \qquad I_3 = 0.372$$

Brace block shear check

Gross area in shear

$$A_{gv} := 2 \cdot \left(\left(n_{br} - 1 \right) \cdot s + ed_1 \right) \cdot t_{br} \qquad A_{gv} = 4.695 \ in^2$$

Net area in shear

$$A_{nv} := A_{gv} - 2 \cdot \left(n_{br} - 0.5 \right) \cdot d_{bh} \cdot t_{br} \qquad A_{nv} = 3.031 \ in^2$$

Net area in tension

$$A_{nt} := 2 \cdot \left(l_{ibr} - g_{br} - 1.5 \cdot d_{bh} \right) \cdot t_{br} \qquad A_{nt} = 1.506 \ in^2$$

Nominal strength block shear

$$R_{n1} := 0.6 \cdot F_{ua} \cdot A_{nv} + F_{ua} \cdot A_{nt}$$

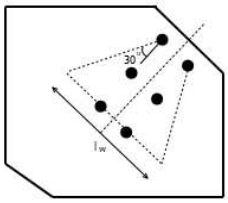
$$R_{n2} := 0.6 \cdot F_{ya} \cdot A_{gv} + F_{ua} \cdot A_{nt}$$

$$R_n := min \left(R_{n1}, R_{n2} \right) \qquad R_n = 188.751 \ kip$$

Interaction ratio in block shear

$$I_4 := \frac{P}{0.75 \cdot R_n} \qquad I_4 = 0.459$$

Gusset tension yielding check



Length of Whitmore section

$$l_w := 2 \cdot l_{br} \cdot \tan \left(30 \ deg \right) + s_r \qquad l_w = 8.678 \ in$$

Nominal strength of gusset in yielding

$$P_n := F_{yp} \cdot l_w \cdot t_g \qquad P_n = 156.208 \ kip$$

Interaction ratio in tension yielding

$$I_5 := \frac{P}{0.9 \cdot P_n} \qquad I_5 = 0.462$$

Gusset tension rupture check

Net area of gusset in tension

$$A_{ng} := \left(l_w - 2 \ d_{bh} \right) \cdot t_g \qquad A_{ng} = 3.276 \ in^2$$

Nominal strength of gusset in rupture

$$P_n := F_{up} \cdot A_{ng} \qquad P_n = 190.014 \ kip$$

Interaction ratio in tension rupture

$$I_6 := \frac{P}{0.75 \cdot P_n} \qquad I_6 = 0.456$$

Gusset block shear check

Gross area in shear

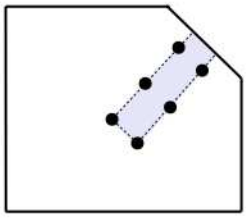
$$A_{gv} := 2\ \left(\left(n_{br} - 1\right) \cdot s + ed_2\right) \cdot t_g \qquad A_{gv} = 7.5\ in^2$$

Net area in shear

$$A_{nv} := A_{gv} - \left(2 \cdot n_{br} - 1\right) \cdot d_{bh} \cdot t_g \qquad A_{nv} = 4.843\ in^2$$

Net area in tension

$$A_{nt} := \left(s_r - d_{bh}\right) \cdot t_g \qquad A_{nt} = 0.344\ in^2$$



Nominal strength block shear

$$R_{n1} := 0.6 \cdot F_{up} \cdot A_{nv} + F_{up} \cdot A_{nt}$$

$$R_{n2} := 0.6 \cdot F_{yp} \cdot A_{gv} + F_{up} \cdot A_{nt}$$

$$R_n := min\left(R_{n1}, R_{n2}\right) \qquad R_n = 181.923\ kip$$

Interaction ratio in block shear

$$I_7 := \frac{P}{0.75\ R_n} \qquad I_7 = 0.476$$

Bolt shear at connection 1

Nominal slip resistance of bolt

$$R_n := \mu \cdot 1.13 \cdot T_{pre} \qquad R_n = 21.696\ kip$$

Interaction ratio in bolt shear

$$I_8 := \frac{P_{b1}}{R_n} \qquad I_8 = 0.573$$

Bolt bearing at gusset plate at connection 1

Length of connection 1

$$L_1 := \left(n_1 - 1\right) \cdot s \qquad L_1 = 6\ in$$

Distance of gusset outer edge from work point

$$loc_{go} := g_1 - ex_2 \qquad loc_{go} = 14.5\ in$$

Distance of gusset inner edge from work point

$$loc_{gi} := c_1 - ex_2 - \text{if}\left(c_2 = 0, 0, \left(g_{bm1} + ex_1\right) \cdot \frac{c_1}{c_2}\right) \qquad loc_{gi} = -0.5\ in$$

Outer edge distance for clip on gusset

$$ed_{go} := loc_{go} - loc_1 - L_1 \qquad ed_{go} = 2.5\ in$$

Inner edge distance for clip on gusset

$$ed_{gi} := loc_1 - loc_{gi} \qquad ed_{gi} = 6.5\ in$$

Minimum edge distance for clip on gusset

$$ed_g := min\left(ed_{go}, ed_{gi}\right) \qquad ed_g = 2.5\ in$$

Clear distance between bolt holes/ hole and edge

$$l_c := min\left(s - d_{bh}, ed_g - 0.5 \cdot d_{bh}\right) \qquad l_c = 1.937\ in$$

Nominal strength in bearing

$$R_n := min\left(1.2 \cdot l_c \cdot t_g \cdot F_{up}, 2.4 \cdot d_b \cdot t_g \cdot F_{up}\right) \qquad R_n = 67.408\ kip$$

Interaction ratio in bolt bearing

$$I_9 := \frac{P_{b1}}{0.75\ R_n} \qquad I_9 = 0.246$$

Bolt bearing at beam flange at connection 1

Edge distance of bolt to beam flange edge

$$ed_b := loc_1 - cp_1 - sbb_1 - 0.5\ t_{wb2} \qquad ed_b = 1.32\ in$$

Clear distance between bolt holes/ hole and edge

$$l_c := min\left(s - d_{bh}, ed_b - 0.5 \cdot d_{bh}\right) \qquad l_c = 0.788\ in$$

Nominal strength in bearing

$$R_n := min\left(1.2 \cdot l_c \cdot t_{fb1} \cdot F_{ub}, 2.4 \cdot d_b \cdot t_{fb1} \cdot F_{ub}\right) \qquad R_n = 39.362\ kip$$

Interaction ratio in bolt bearing

$$I_{10} := \frac{P_{b1}}{0.75\ R_n} \qquad I_{10} = 0.421$$

Gusset shear yielding at connection 1

Gross area in shear

$$A_g := \left(g_1 - c_1\right) \cdot t_g \qquad A_g = 7.5\ in^2$$

Nominal shear strength of gusset in shear yielding

$$R_n := 0.6 \cdot F_{yp} \cdot A_g \qquad R_n = 162\ kip$$

Interaction ratio in shear yieldling

$$I_{11} := \frac{P_1}{R_n} \qquad I_{11} = 0.23$$

Gusset shear rupture at connection 1

Net area in shear

$$A_n := A_g - n_1 \cdot d_{bh} \cdot t_g \qquad A_n = 5.906\ in^2$$

Nominal shear strength of gusset in rupture

$$R_n := 0.6 \cdot F_{up} \cdot A_n \qquad R_n = 205.511\ kip$$

Interaction ratio in shear rupture

$$I_{12} := \frac{P_1}{0.75\ R_n} \qquad I_{12} = 0.242$$

Gusset plate block shear at connection 1

Gross area subjected to block shear

$$A_{gv} := \left(L_1 + ed_g\right) \cdot t_g \qquad A_{gv} = 4.25\ in^2$$

Net area subjected to block shear

$$A_{nv} := A_{gv} - \left(n_1 - 0.5\right) \cdot d_{bh} \cdot t_g \qquad A_{nv} = 2.921\ in^2$$

Net area subjected to tension

$$A_{nt} := \left(g_{bm1} + ex_1 - 0.5\ d_{bh}\right) \cdot t_g \qquad A_{nt} = 1.484\ in^2$$

Nominal strength in block shear

$$R_{n1} := 0.6 \cdot F_{ua} \cdot A_{nv} + F_{ua} \cdot A_{nt}$$

$$R_{n2} := 0.6 \cdot F_{ya} \cdot A_{gv} + F_{ua} \cdot A_{nt}$$

$$R_n := min\left(R_{n1}, R_{n2}\right) \qquad R_n = 177.887\ kip$$

Interaction ratio in block shear

$$I_{13} := \frac{P_1}{0.75\ R_n} \qquad I_{13} = 0.279$$

Gusset flexure yielding at connection 1

Eccentricity of force at connection 1

$$ec_1 := \max\left(c_2 - ex_1, 0\right) \qquad ec_1 = 0\ in$$

Nominal moment strenght of gusset

$$M_n := \frac{F_{yp} \cdot t_g \cdot g_1^{\ 2}}{4} \qquad M_n = 84.375\ kip \cdot ft$$

Interaction ratio in gusset flexure

$$I_{14} := \frac{P_1 \cdot ec_1}{0.9 \cdot M_n} \qquad I_{14} = 0$$

Bolt shear at connection 2

Nominal slip resistance of bolt

$$R_n := \mu \cdot 1.13 \cdot T_{pre} \qquad R_n = 21.696\ kip$$

Interaction ratio in bolt shear

$$I_{15} := \frac{P_{b2}}{R_n} \qquad I_{15} = 0.818$$

Bolt bearing at gusset plate at connection 2

Length of connection 2

$$L_2 := (n_2 - 1) \cdot s \qquad L_2 = 6\ in$$

Distance of gusset outer edge from work point

$$loc_{go} := g_2 - ex_1 \qquad loc_{go} = 14.5\ in$$

Distance of gusset inner edge from work point

$$loc_{gi} := c_2 - ex_1 - \mathbf{if}\left(c_1 = 0, 0, (g_{bm2} + ex_2) \cdot \frac{c_2}{c_1}\right) \qquad loc_{gi} = -0.5\ in$$

Outer edge distance for clip on gusset

$$ed_{go} := loc_{go} - loc_2 - L_2 \qquad ed_{go} = 2.5\ in$$

Inner edge distance for clip on gusset

$$ed_{gi} := loc_2 - loc_{gi} \qquad ed_{gi} = 6.5\ in$$

Minimum edge distance for clip on gusset

$$ed_g := min(ed_{go}, ed_{gi}) \qquad ed_g = 2.5\ in$$

Clear distance between bolt holes/ hole and edge

$$l_c := min(s - d_{bh}, ed_g - 0.5 \cdot d_{bh}) \qquad l_c = 1.937\ in$$

Nominal strength in bearing

$$R_n := min(1.2 \cdot l_c \cdot t_g \cdot F_{up}, 2.4 \cdot d_b \cdot t_g \cdot F_{up}) \qquad R_n = 67.408\ kip$$

Interaction ratio in bolt bearing

$$I_{16} := \frac{P_{b2}}{0.75\ R_n} \qquad I_{16} = 0.351$$

Bolt bearing at beam flange at connection 2

Edge distance of bolt to beam flange edge

$$ed_b := loc_2 - cp_2 - sbb_2 - 0.5\ t_{wb2} \qquad ed_b = 5.82\ in$$

Clear distance between bolt holes/ hole and edge

$$l_c := min(s - d_{bh}, ed_b - 0.5 \cdot d_{bh}) \qquad l_c = 1.937\ in$$

Nominal strength in bearing

$$R_n := min(1.2 \cdot l_c \cdot t_{fb2} \cdot F_{ub}, 2.4 \cdot d_b \cdot t_{fb2} \cdot F_{ub}) \qquad R_n = 96.695\ kip$$

Interaction ratio in bolt bearing

$$I_{17} := \frac{P_{b2}}{0.75\ R_n} \qquad I_{17} = 0.245$$

Gusset shear yielding at connection 2

Gross area in shear

$$A_g := (g_2 - c_2) \cdot t_g \qquad A_g = 7.5\ in^2$$

Nominal shear strength of gusset in yielding

$$R_n := 0.6 \cdot F_{yp} \cdot A_g \qquad R_n = 162\ kip$$

Interaction ratio in gusset yieldling

$$I_{18} := \frac{P_2}{R_n} \qquad I_{18} = 0.329$$

Gusset shear rupture at connection 2

Net area in shear

$$A_n := A_g - n_2 \cdot d_{bh} \cdot t_g \qquad A_n = 5.906\ in^2$$

Nominal shear strength of gusset in rupture

$$R_n := 0.6 \cdot F_{up} \cdot A_n \qquad R_n = 205.511\ kip$$

Interaction ratio in shear rupture

$$I_{19} := \frac{P_2}{0.75\ R_n} \qquad I_{19} = 0.345$$

Gusset plate block shear at connection 2

Gross area subjected to block shear

$$A_{gv} := (L_2 + ed_g) \cdot t_g \qquad A_{gv} = 4.25\ in^2$$

Net area subjected to block shear

$$A_{nv} := A_{gv} - (n_2 - 0.5) \cdot d_{bh} \cdot t_g \qquad A_{nv} = 2.921\ in^2$$

Net area subjected to tension

$$A_{nt} := (g_{bm2} + ex_2 - 0.5\ d_{bh}) \cdot t_g \qquad A_{nt} = 1.484\ in^2$$

Nominal strength in block shear

$$R_{n1} := 0.6 \cdot F_{ua} \cdot A_{nv} + F_{ua} \cdot A_{nt}$$

$$R_{n2} := 0.6 \cdot F_{ya} \cdot A_{gv} + F_{ua} \cdot A_{nt}$$

$$R_n := min(R_{n1}, R_{n2}) \qquad R_n = 177.887\ kip$$

Interaction ratio in block shear

$$I_{20} := \frac{P_2}{0.75\ R_n} \qquad I_{20} = 0.399$$

Gusset flexure yielding at connection 2

Eccentricity of force at connection 2

$$ec_2 := \max(c_1 - ex_2, 0) \qquad ec_2 = 0\ in$$

Nominal moment strenght of gusset

$$M_n := \frac{F_{yp} \cdot t_g \cdot g_2^{\,2}}{4} \qquad M_n = 84.375\ \mathit{kip \cdot ft}$$

Interaction ratio in gusset flexure

$$I_{21} := \frac{P_2 \cdot ec_2}{0.9 \cdot M_n} \qquad I_{21} = 0$$

Validation Results

The calculated ratios are compared with the output of Osoconn and if it is within a tolerance of 1% the result is deemed to be OK.

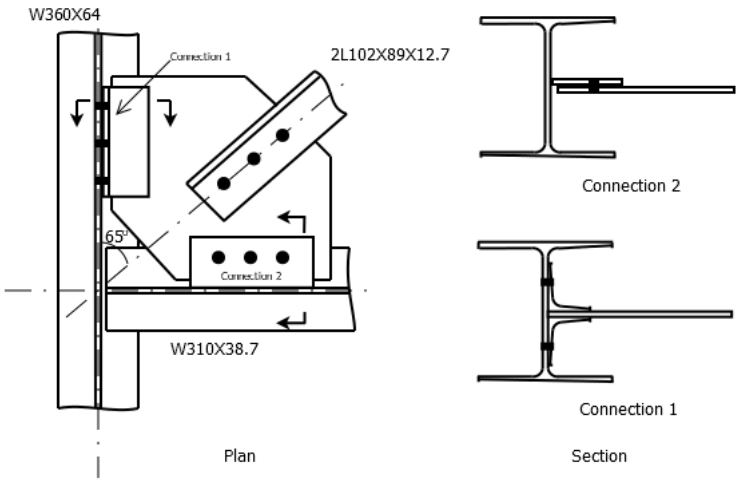
Table 4: Validation problem 3 results

	Interaction Ratio		
Check	Calculated	Osoconn	Result
Bolt shear at brace check	0.25	0.25	OK
Bolt bearing at brace check	0.342	0.342	OK
Bolt bearing at gusset check	0.429	0.428	OK
Brace tension rupture check	0.372	0.372	OK
Brace block shear check	0.459	0.459	OK
Gusset tension yielding check	0.462	0.462	OK
Gusset tension rupture check	0.456	0.456	OK
Gusset block shear check	0.476	0.476	OK
Bolt shear at connection 1	0.573	0.573	OK
Bolt bearing at gusset plate at connection 1	0.246	0.246	OK
Bolt bearing at beam flange at connection 1	0.421	0.421	OK
Gusset shear yielding at connection 1	0.23	0.23	OK
Gusset shear rupture at connection 1	0.242	0.242	OK
Gusset plate block shear at connection 1	0.279	0.279	OK
Gusset flexure yielding at connection 1	0.0	0.0	OK
Bolt shear at connection 2	0.818	0.818	OK
Bolt bearing at gusset plate at connection 2	0.351	0.351	OK
Bolt bearing at beam flange at connection 2	0.245	0.245	OK
Gusset shear yielding at connection 2	0.329	0.329	OK
Gusset shear rupture at connection 2	0.345	0.345	OK
Gusset plate block shear at connection 2	0.399	0.399	OK
Gusset flexure yielding at connection 2	0.0	0.0	OK

2.5 Validation Problem 4

Problem Statement

Design a horizontal brace connection for a double angle 2L102X89X12.7 brace, with their back to back leg horizontal, framing into the junction between a W360X64 and a W310X38.7 using the ASD method. The brace has an angle of 65 degrees with the W360 beam. The brace has an axial force of 105kN. The beams are ASTM A992, angles and plates are of grade ASTM A36. The bolts are ASTM 3125 A325 slip critical type.



Design Inputs

Material Properties

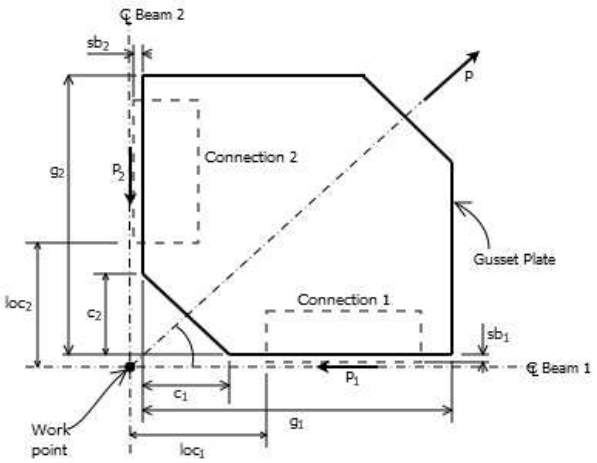
Material grade for plate	ASTM A36
Yield strength	$F_{yp} := 250\ MPa$
Tensile strength	$F_{up} := 400\ MPa$
Material grade of beam	ASTM A992
Yield strength	$F_{yb} := 345\ MPa$
Tensile strength	$F_{ub} := 450\ MPa$
Material grade of angles	ASTM A36
Yield strength	$F_{ya} := 250\ MPa$
Tensile strength	$F_{ua} := 400\ MPa$
Material grade for weld electrode	E70XX
Tensile strength	$F_{EXX} := 482\ MPa$
Material specification for bolts	ASTM 3125 A325
Tensile strength	$F_{nt} := 620\ MPa$
Shear strength	$F_{nv} := 372\ MPa$
Young's modulus for steel	$E := 200000\ MPa$

Design Forces

Axial force in brace	$P := 105\ kN$

Connection Geometry

Brace section	2L102X89X12.7
Thickness	$t_{br} := 12.7\ mm$
Outstanding leg length	$l_{obr} := 88.9\ mm$
Back-to-back leg length	$l_{ibr} := 102\ mm$
Gross cross section area	$A_{br} := 4520\ mm^2$
Centroid of brace outstanding leg	$x'_{br} := 25.2\ mm$
Brace angle with horizontal	$\theta_{br} := 65\ deg$
Beam section at connection 1	W360X64
Section depth	$d_{xb1} := 348\ mm$
Flange width	$b_{fb1} := 203\ mm$
Flange thickness	$t_{fb1} := 13.5\ mm$
Web thickness	$t_{wb1} := 7.75\ mm$
Distance from outer face to fillet edge	$k_{bdet1} := 34.9\ mm$
Beam section at connection 2	W310X38.7
Section depth	$d_{xb2} := 310\ mm$
Flange width	$b_{fb2} := 165\ mm$
Flange thickness	$t_{fb2} := 9.65\ mm$
Web thickness	$t_{wb2} := 5.84\ mm$
Distance from outer face to fillet edge	$k_{bdet2} := 27\ mm$
Clip angle section	L89X89X9.5
Thickness	$t_a := 9.53\ mm$
Outstanding leg length	$l_{oa} := 88.9\ mm$
Welded leg length	$l_{ia} := 88.9\ mm$
Shear tab thickness	$t_s := 12\ mm$
Shear tab width	$w_s := 100\ mm$



Gusset plate thickness	$t_g := 12\ mm$
Gusset dimension along connection 1	$g_1 := 500\ mm$

Gusset dimension along connection 2 $g_2 := 500\ mm$
Gusset cutout at connection 1 $c_1 := 125\ mm$
Gusset cutout at connection 2 $c_2 := 125\ mm$

Bolt diameter $d_b := 24\ mm$
Bolt hole diameter $d_{bh} := 27\ mm$
Slip coefficient (class A surface) $\mu := 0.3$
Bolt pretension $T_{pre} := 205\ kN$
Number of bolts per row on brace $n_{br} := 4$
Number of bolts at clip at beam 1 $n_1 := 4$
Number of bolts at clip at beam 2 $n_2 := 4$
Bolt spacing $s := 70\ mm$
Bolt gage on brace $g_{br} := 55\ mm$
Bolt gage on shear tab $g_s := 50\ mm$
Bolt gage on clip $g := 45\ mm$

Location of connection 1 from work point $loc_1 := 150\ mm$
Location of connection 2 from work point $loc_2 := 150\ mm$

Bolt edge distance on brace $ed_1 := 35\ mm$
Bolt edge distance on gusset $ed_2 := 35\ mm$
Bolt edge distance on clip $ed_3 := 35\ mm$

Clip to gusset weld thickness $w := 6\ mm$

Connection setback at connection 1 $sb_1 := 12\ mm$
Connection setback at connection 2 $sb_2 := 12\ mm$

Design Calculations

Connection forces

Shear per bolt at brace connection

$$P_b := \frac{P}{n_{br}} \qquad P_b = 26.25\ kN$$

Component of brace force along connection 1

$$P_1 := P \cdot \cos(\theta_{br}) \qquad P_1 = 44.375\ kN$$

Force per bolt along connection 1

$$P_{b1} := \frac{P_1}{2 \cdot n_1} \qquad P_{b1} = 5.547\ kN$$

Component of brace force along connection 2

$$P_2 := P \cdot \sin(\theta_{br}) \qquad P_2 = 95.162\ kN$$

Force per bolt along connection 2

$$P_{b2} := \frac{P_2}{n_2} \qquad P_{b2} = 23.791\ kN$$

Bolt shear at brace to gusset connection

Nominal slip resistance of bolt

$$R_n := \mu \cdot 1.13 \cdot T_{pre} \cdot 2 \qquad R_n = 138.99\ kN$$

Interaction ratio in bolt shear

$$I_0 := \frac{1.5\ P_b}{R_n} \qquad I_0 = 0.283$$

Bolt bearing on brace check

Minimum clear distance for bearing check

$$l_{c1} := min\left(s - d_{bh}, ed_1 - 0.5 \cdot d_{bh}\right) \qquad l_{c1} = 21.5\ mm$$

Nominal strength in bearing

$$R_n := min\left(1.2 \cdot l_{c1} \cdot t_{br} \cdot F_{ua}, 2.4 \cdot d_b \cdot t_{br} \cdot F_{ua}\right) \qquad R_n = 131.064\ kN$$

Interaction ratio in bolt bearing at brace

$$I_1 := \frac{2.0 \cdot 0.5\ P_b}{R_n} \qquad I_1 = 0.2$$

Bolt bearing on gusset check

Minimum clear distance for bearing on gusset

$$l_{c2} := min\left(s - d_{bh}, ed_2 - 0.5 \cdot d_{bh}\right) \qquad l_{c1} = 21.5\ mm$$

Nominal strength in bearing

$$R_n := min\left(1.2 \cdot l_{c2} \cdot t_g \cdot F_{up}, 2.4 \cdot d_b \cdot t_g \cdot F_{up}\right) \qquad R_n = 123.84\ kN$$

Interaction ratio in bolt bearing at gusset

$$I_2 := \frac{2.0\ P_b}{R_n} \qquad I_2 = 0.424$$

Brace tension rupture check

Net cross section area of brace

$$A_{nbr} := A_{br} - 2 \cdot d_{bh} \cdot t_{br} \qquad A_{nbr} = 3834.2\ mm^2$$

Length of connection

$$l_{br} := s \cdot \left(n_{br} - 1\right) \qquad l_{br} = 210\ mm$$

Shear lag factor

$$U := 1 - \frac{x'_{br}}{l_{br}} \qquad U = 0.88$$

Brace strength in tension rupture

$$P_n := F_{ua} \cdot U \cdot A_{nbr} \qquad P_n = 1349.638\ kN$$

Interaction ratio for brace tension rupture

$$I_3 := \frac{2.0\ P}{P_n} \qquad I_3 = 0.156$$

Brace block shear check

Gross area in shear

$$A_{gv} := 2 \cdot \left(\left(n_{br} - 1 \right) \cdot s + ed_1 \right) \cdot t_{br} \qquad A_{gv} = 6223 \ mm^2$$

Net area in shear

$$A_{nv} := A_{gv} - 2 \cdot \left(n_{br} - 0.5 \right) \cdot d_{bh} \cdot t_{br} \qquad A_{nv} = 3822.7 \ mm^2$$

Net area in tension

$$A_{nt} := 2 \cdot \left(l_{ibr} - g_{br} - 0.5 \cdot d_{bh} \right) \cdot t_{br} \qquad A_{nt} = 850.9 \ mm^2$$

Nominal strength block shear

$$R_{n1} := 0.6 \cdot F_{ua} \cdot A_{nv} + F_{ua} \cdot A_{nt}$$

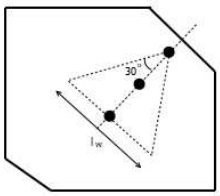
$$R_{n2} := 0.6 \cdot F_{ya} \cdot A_{gv} + F_{ua} \cdot A_{nt}$$

$$R_n := min \left(R_{n1}, R_{n2} \right) \qquad R_n = 1257.808 \ kN$$

Interaction ratio in block shear

$$I_4 := \frac{2.0 \ P}{R_n} \qquad I_4 = 0.167$$

Gusset tension yielding check



Length of Whitmore section

$$l_w := 2 \cdot l_{br} \cdot \tan \left(30 \ deg \right) \qquad l_w = 242.487 \ mm$$

Nominal strength of gusset in yielding

$$P_n := F_{yp} \cdot l_w \cdot t_g \qquad P_n = 727.461 \ kN$$

Interaction ratio in tension yielding

$$I_5 := \frac{1.67 \ P}{P_n} \qquad I_5 = 0.241$$

Gusset tension rupture check

Net area of gusset in tension

$$A_{ng} := \left(l_w - d_{bh} \right) \cdot t_g \qquad A_{ng} = 2585.845 \ mm^2$$

Nominal strength of gusset in rupture

$$P_n := F_{up} \cdot A_{ng} \qquad P_n = 1034.338 \ kN$$

Interaction ratio in tension rupture

$$I_6 := \frac{2.0 \ P}{P_n} \qquad I_6 = 0.203$$

Bolt shear at connection 1

Nominal slip resistance of bolt

$$R_n := \mu \cdot 1.13 \cdot T_{pre} \qquad R_n = 69.495\ kN$$

Interaction ratio in bolt shear

$$I_7 := \frac{1.5\ P_{b1}}{R_n} \qquad I_7 = 0.12$$

Bolt bearing at clip angle at connection 1

Clear distance between bolt holes/ hole and edge

$$l_c := min\left(s - d_{bh}, ed_3 - 0.5 \cdot d_{bh}\right) \qquad l_c = 21.5\ mm$$

Nominal strength in bearing

$$R_n := min\left(1.2 \cdot l_c \cdot t_a \cdot F_{ua}, 2.4 \cdot d_b \cdot t_a \cdot F_{ua}\right) \qquad R_n = 98.35\ kN$$

Interaction ratio in bolt bearing

$$I_8 := \frac{2.0\ P_{b1}}{R_n} \qquad I_8 = 0.113$$

Bolt bearing at beam web at connection 1

Nominal strength in bearing

$$R_n := min\left(1.2 \cdot \left(s - d_{bh}\right) \cdot t_{wb1} \cdot F_{ub}, 2.4 \cdot d_b \cdot t_{wb1} \cdot F_{ub}\right) \qquad R_n = 179.955\ kN$$

Interaction ratio in bolt bearing

$$I_9 := \frac{2.0\ P_{b1}}{R_n} \qquad I_9 = 0.062$$

Gusset shear yielding at connection 1

Nominal shear strength of gusset in yielding

$$R_n := 0.6 \cdot F_{yp} \cdot \left(g_1 - c_1\right) \cdot t_g \qquad R_n = 675\ kN$$

Interaction ratio in gusset yieldling

$$I_{10} := \frac{1.5\ P_1}{R_n} \qquad I_{10} = 0.099$$

Gusset plate block shear at connection 1

Length of clip angle

$$L_1 := \left(n_1 - 1\right) \cdot s + 2\ ed_3 \qquad L_1 = 280\ mm$$

Distance of gusset outer edge from work point

$$loc_{go} := g_1 + sb_2 + 0.5 \cdot t_{wb2} \qquad loc_{go} = 514.92\ mm$$

Distance of gusset inner edge from work point

$$loc_{gi} := c_1 + sb_2 + 0.5 \cdot t_{wb2} - \mathbf{if}\left(c_2 = 0, 0, \left(l_{ia} - sb_1\right) \cdot \frac{c_1}{c_2}\right) \qquad loc_{gi} = 63.02\ mm$$

Outer edge distance for clip on gusset

$$ed_{go} := loc_{go} - loc_1 - L_1 \qquad ed_{go} = 84.92\ mm$$

Inner edge distance for clip on gusset

$$ed_{gi} := loc_1 - loc_{gi} \qquad ed_{gi} = 86.98\ mm$$

Minimum edge distance for clip on gusset

$$ed_g := min\left(ed_{go}, ed_{gi}\right) \qquad ed_g = 84.92\ mm$$

Gross area subjected to block shear

$$A_{gv} := \left(L_1 + ed_g\right) \cdot t_g \qquad A_{gv} = 4379.04\ mm^2$$

Net area subjected to tension

$$A_{nt} := \left(l_{ia} - sb_1\right) \cdot t_g \qquad A_{nt} = 922.8\ mm^2$$

Nominal strength in block shear

$$R_n := 0.6 \cdot F_{ya} \cdot A_{gv} + F_{ua} \cdot A_{nt} \qquad R_n = 1025.976\ kN$$

Interaction ratio in block shear

$$I_{11} := \frac{2.0\ P_1}{R_n} \qquad I_{11} = 0.087$$

Gusset flexure yielding at connection 1

Eccentricity of force at connection 1

$$ec_1 := c_2 + sb_1 + 0.5\ t_{wb1} \qquad ec_1 = 140.875\ mm$$

Nominal moment strength of gusset

$$M_n := \frac{F_{yp} \cdot t_g \cdot g_1^{\ 2}}{4} \qquad M_n = 187.5\ kN \cdot m$$

Interaction ratio in gusset flexure

$$I_{12} := \frac{1.67 \cdot P_1 \cdot ec_1}{M_n} \qquad I_{12} = 0.056$$

Clip angle shear yielding at connection 1

Gross area in shear

$$A_{gv} := 2 \cdot L_1 \cdot t_a \qquad A_{gv} = 5336.8\ mm^2$$

Nominal strength in shear yielding

$$R_n := 0.6 \cdot F_{ya} \cdot A_{gv} \qquad R_n = 800.52\ kN$$

Interaction ratio in shear yielding

$$I_{13} := \frac{1.5\ P_1}{R_n} \qquad I_{13} = 0.083$$

Clip angle shear rupture at connection 1

Net area in shear

$$A_{nv} := A_{gv} - 2 \cdot n_1 \cdot d_{bh} \cdot t_a \qquad A_{nv} = 3278.32\ mm^2$$

Nominal strength in shear rupture

$$R_n := 0.6 \cdot F_{ua} \cdot A_{nv} \qquad R_n = 786.797\ kN$$

Interaction ratio in shear rupture

$$I_{14} := \frac{2.0\ P_1}{R_n} \qquad I_{14} = 0.113$$

Clip angle block shear at connection 1

Gross area subjected to block shear

$$A_{gv} := 2 \cdot \left(L_1 - ed_3\right) \cdot t_a \qquad A_{gv} = 4669.7\ mm^2$$

Net area subjected to block shear

$$A_{nv} := A_{gv} - 2 \cdot \left(n_1 - 0.5\right) \cdot d_{bh} \cdot t_a \qquad A_{nv} = 2868.53\ mm^2$$

Net area subjected to tension

$$A_{nt} := \left(2 \cdot l_{oa} + t_g - 2 \cdot g - d_{bh}\right) \cdot t_a \qquad A_{nt} = 693.784\ mm^2$$

Nominal strength in block shear

$$R_{n1} := 0.6 \cdot F_{ua} \cdot A_{nv} + F_{ua} \cdot A_{nt}$$

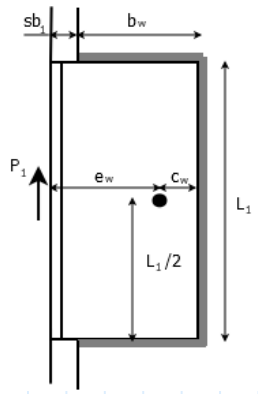
$$R_{n2} := 0.6 \cdot F_{ya} \cdot A_{gv} + F_{ua} \cdot A_{nt}$$

$$R_n := min\left(R_{n1}, R_{n2}\right) \qquad R_n = 965.961\ kN$$

Interaction ratio in block shear

$$I_{15} := \frac{2.0\ P_1}{R_n} \qquad I_{15} = 0.092$$

Weld check at connection 1



Length of horizontal run of weld

$$b_w := l_{ia} - sb_1 \qquad b_w = 76.9\ mm$$

Centroid of weld group

$$c_w := \frac{{b_w}^2}{2 \cdot b_w + L_1} \qquad c_w = 13.632\ mm$$

Eccentricity of shear force

$$e_w := l_{ia} - c_w \qquad e_w = 75.268\ mm$$

Polar moment of inertia of weld group

$$I_w := \frac{(2 \cdot b_w + L_1)^3}{12} - \frac{b_w^{\,2} \cdot (b_w + L_1)^2}{2 \cdot b_w + L_1} \qquad I_w = 5066.369\ cm^3$$

Component of weld stress along x

$$f_{wx} := \frac{P_1 \cdot e_w \cdot L_1}{4 \cdot I_w} \qquad f_{wx} = 0.046\ \frac{kN}{mm}$$

Component of weld stress along y

$$f_{wy} := \frac{P_1}{2 \cdot (2 \cdot b_w + L_1)} + \frac{P_1 \cdot e_w \cdot (b_w - c_w)}{2\ I_w} \qquad f_{wy} = 0.072\ \frac{kN}{mm}$$

Resultant weld stress

$$f_w := \sqrt{f_{wx}^{\,2} + f_{wy}^{\,2}} \qquad f_w = 0.086\ \frac{kN}{mm}$$

Nominal weld strength

$$R_n := 0.6 \cdot F_{EXX} \cdot \frac{\sqrt{2}}{2} \cdot w \qquad R_n = 1.227\ \frac{kN}{mm}$$

Interaction ratio for weld check

$$I_{16} := \frac{2.0\ f_w}{R_n} \qquad I_{16} = 0.139$$

Gusset rupture at weld at connection 1

Minimum web thickness to match weld strength

$$t_{g.min} := \frac{2.0 \cdot 2 \cdot f_w}{0.6 \cdot F_{up}} \qquad t_{g.min} = 1.425\ mm$$

Interaction ratio in web rupture

$$I_{17} := \frac{t_{g.min}}{t_g} \qquad I_{17} = 0.119$$

Bolt shear at connection 2

Polar moment of inertia of bolt group

$$I_{po} := 2 \cdot \sum_{i=1}^{0.5\,(n_2 - 1)} (i \cdot s)^2$$

$$I_{pe} := 2 \cdot \sum_{i=1}^{0.5\,n_2} ((i - 0.5) \cdot s)^2$$

$$I_p := \text{if}\left(\text{mod}(n_2, 2) = 1, I_{po}, I_{pe}\right) \qquad I_p = 245\ cm^2$$

Distance of most remote bolt from CG

$$c := 0.5\ (n_2 - 1) \cdot s \qquad c = 105\ mm$$

Maximum shear in bolt

$$P_s := \sqrt{\left(\frac{P_2}{n_2}\right)^2 + \left(\frac{P_2 \cdot g_s \cdot c}{I_p}\right)^2} \qquad P_s = 31.334\ kN$$

Nominal shear strength of bolt

$$R_n := \mu \cdot 1.13 \cdot T_{pre} \qquad R_n = 69.495\ kN$$

Interaction ratio in bolt shear

$$I_{18} := \frac{1.5\ P_{b2}}{R_n} \qquad I_{18} = 0.514$$

Bolt bearing at shear tab at connection 2

Clear distance between bolt holes/ hole and edge

$$l_c := min\left(s - d_{bh}, ed_3 - 0.5 \cdot d_{bh}\right) \qquad l_c = 21.5\ mm$$

Nominal strength in bearing

$$R_n := min\left(1.2 \cdot l_c \cdot t_s \cdot F_{up}, 2.4 \cdot d_b \cdot t_s \cdot F_{up}\right) \qquad R_n = 123.84\ kN$$

Interaction ratio in bolt bearing

$$I_{19} := \frac{2.0\ P_{b2}}{R_n} \qquad I_{19} = 0.384$$

Bolt bearing at gusset at connection 2

Length of shear tab

$$L_2 := \left(n_2 - 1\right) \cdot s + 2\ ed_3 \qquad L_1 = 280\ mm$$

Distance of gusset outer edge from work point

$$loc_{go} := g_2 + sb_1 + 0.5 \cdot t_{wb1} \qquad loc_{go} = 515.875\ mm$$

Distance of gusset inner edge from work point

$$loc_{gi} := c_2 + sb_1 + 0.5 \cdot t_{wb1} - \mathbf{if}\left(c_1 = 0, 0, \left(g_s - sb_2\right) \cdot \frac{c_2}{c_1}\right) \qquad loc_{gi} = 102.875\ mm$$

Outer edge distance for bolt on gusset

$$ed_{go} := loc_{go} - loc_2 - L_2 + ed_3 \qquad ed_{go} = 120.875\ mm$$

Inner edge distance for bolt on gusset

$$ed_{gi} := loc_2 - loc_{gi} + ed_3 \qquad ed_{gi} = 82.125\ mm$$

Minimum edge distance for clip on gusset

$$ed_g := min\left(ed_{go}, ed_{gi}\right) \qquad ed_g = 82.125\ mm$$

Clear distance between bolt holes/ hole and edge

$$l_c := min\left(s - d_{bh}, ed_g - 0.5 \cdot d_{bh}\right) \qquad l_c = 43\ mm$$

Nominal strength in bearing

$$R_n := min\left(1.2 \cdot l_c \cdot t_g \cdot F_{up}, 2.4 \cdot d_b \cdot t_g \cdot F_{up}\right) \qquad R_n = 247.68\ kN$$

Interaction ratio in bolt bearing

$$I_{20} := \frac{2.0\ P_{b2}}{R_n} \qquad I_{20} = 0.192$$

Gusset shear yielding at connection 2

Gross area in shear

$$A_g := \left(g_2 - c_2\right) \cdot t_g \qquad A_g = 4500\ mm^2$$

Nominal shear strength of gusset in yielding

$$R_n := 0.6 \cdot F_{yp} \cdot A_g \qquad R_n = 675\ kN$$

Interaction ratio in gusset yieldling

$$I_{21} := \frac{1.5\ P_2}{R_n} \qquad I_{21} = 0.211$$

Gusset shear rupture at connection 2

Net area in shear

$$A_n := A_g - n_2 \cdot d_{bh} \cdot t_g \qquad A_n = 3204\ mm^2$$

Nominal shear strength of gusset in rupture

$$R_n := 0.6 \cdot F_{up} \cdot A_n \qquad R_n = 768.96\ kN$$

Interaction ratio in shear rupture

$$I_{22} := \frac{2.0\ P_2}{R_n} \qquad I_{22} = 0.248$$

Gusset plate block shear at connection 2

Gross area subjected to block shear

$$A_{gv} := \left(L_2 - 2\ ed_3 + ed_g\right) \cdot t_g \qquad A_{gv} = 3505.5\ mm^2$$

Net area subjected to block shear

$$A_{nv} := A_{gv} - \left(n_2 - 0.5\right) \cdot d_{bh} \cdot t_g \qquad A_{nv} = 2371.5\ mm^2$$

Net area subjected to tension

$$A_{nt} := \left(g_s - sb_2 - 0.5\ d_{bh}\right) \cdot t_g \qquad A_{nt} = 294\ mm^2$$

Nominal strength in block shear

$$R_{n1} := 0.6 \cdot F_{ua} \cdot A_{nv} + F_{ua} \cdot A_{nt}$$

$$R_{n2} := 0.6 \cdot F_{ya} \cdot A_{gv} + F_{ua} \cdot A_{nt}$$

$$R_n := min\left(R_{n1}, R_{n2}\right) \qquad R_n = 643.425\ kN$$

Interaction ratio in block shear

$$I_{23} := \frac{2.0\ P_2}{R_n} \qquad I_{23} = 0.296$$

Gusset flexure yielding at connection 2

Eccentricity of force at connection 2

$$ec_2 := c_1 + sb_2 + 0.5 \cdot t_{wb2} \qquad ec_2 = 139.92\ mm$$

Nominal moment strenght of gusset

$$M_n := \frac{F_{yp} \cdot t_g \cdot g_2^{\ 2}}{4} \qquad M_n = 187.5\ kN \cdot m$$

Interaction ratio in gusset flexure

$$I_{24} := \frac{1.67\ (P_2 \cdot ec_2)}{M_n} \qquad I_{24} = 0.119$$

Shear tab shear yielding at connection 2

Gross area in shear

$$A_{gv} := L_2 \cdot t_s \qquad A_{gv} = 3360\ mm^2$$

Nominal strength in shear yielding

$$R_n := 0.6 \cdot F_{yp} \cdot A_{gv} \qquad R_n = 504\ kN$$

Interaction ratio in shear yielding

$$I_{25} := \frac{1.5\ P_2}{R_n} \qquad I_{25} = 0.283$$

Shear tab shear rupture at connection 2

Net area in shear

$$A_{nv} := A_{gv} - n_2 \cdot d_{bh} \cdot t_s \qquad A_{nv} = 2064\ mm^2$$

Nominal strength in shear rupture

$$R_n := 0.6 \cdot F_{ua} \cdot A_{nv} \qquad R_n = 495.36\ kN$$

Interaction ratio in shear rupture

$$I_{26} := \frac{2.0\ P_2}{R_n} \qquad I_{26} = 0.384$$

Shear tab block shear at connection 2

Gross area subjected to block shear

$$A_{gv} := (L_2 - ed_3) \cdot t_s \qquad A_{gv} = 2940\ mm^2$$

Net area subjected to block shear

$$A_{nv} := A_{gv} - (n_2 - 0.5) \cdot d_{bh} \cdot t_s \qquad A_{nv} = 1806\ mm^2$$

Net area subjected to tension

$$A_{nt} := (w_s - g_s - 0.5\ d_{bh}) \cdot t_s \qquad A_{nt} = 438\ mm^2$$

Nominal strength in block shear

$$R_{n1} := 0.6 \cdot F_{ua} \cdot A_{nv} + F_{ua} \cdot A_{nt}$$

$$R_{n2} := 0.6 \cdot F_{ya} \cdot A_{gv} + F_{ua} \cdot A_{nt}$$

$$R_n := min(R_{n1}, R_{n2}) \qquad R_n = 608.64\ kN$$

Interaction ratio in block shear

$$I_{27} := \frac{2.0\ P_2}{R_n} \qquad I_{27} = 0.313$$

Shear tab flexure yielding at connection 2

Nominal moment strenght of gusset

$$M_n := \frac{F_{yp} \cdot t_s \cdot L_2^{\,2}}{4} \qquad M_n = 58.8\ kN \cdot m$$

Interaction ratio in gusset flexure

$$I_{28} := \frac{1.67\ P_2 \cdot g_s}{M_n} \qquad I_{28} = 0.135$$

Weld check at connection 2

Polar moment of inertia of weld group

$$I_w := \frac{L_2^{\,3}}{12} \qquad I_w = 1829.333\ cm^3$$

Weld stress along weld

$$f_{wx} := \frac{P_2}{2 \cdot L_2} \qquad f_{wx} = 0.17\ \frac{kN}{mm}$$

Max weld stress transverse to weld

$$f_{wy} := \frac{P_2 \cdot g_s \cdot L_2}{4\ I_w} \qquad f_{wy} = 0.182\ \frac{kN}{mm}$$

Resultant weld stress

$$f_w := \sqrt{f_{wx}^{\,2} + f_{wy}^{\,2}} \qquad f_w = 0.249\ \frac{kN}{mm}$$

Nominal weld strength

$$R_n := 0.6 \cdot F_{EXX} \cdot \frac{\sqrt{2}}{2} \cdot w \qquad R_n = 1.227\ \frac{kN}{mm}$$

Interaction ratio for weld check

$$I_{29} := \frac{2.0\ f_w}{R_n} \qquad I_{29} = 0.406$$

Shear tab rupture at weld at connection 2

Minimum shear tab thickness to match weld strength

$$t_{s.min} := \frac{2.0 \cdot 2\ f_w}{0.6 \cdot F_{up}} \qquad t_{s.min} = 4.151\ mm$$

Interaction ratio in web rupture

$$I_{30} := \frac{t_{s.min}}{t_s} \qquad I_{30} = 0.346$$

Web rupture at weld at connection 2

Minimum web thickness to match weld strength

$$t_{w.min} := \frac{2.0\ f_w}{0.6 \cdot F_{ub}} \qquad t_{w.min} = 1.845\ mm$$

Interaction ratio in web rupture

$$I_{31} := \frac{t_{w.min}}{t_{wb2}} \qquad I_{31} = 0.316$$

Validation Results

The calculated ratios are compared with the output of Osoconn and if it is within a tolerance of 1% the result is deemed to be OK.

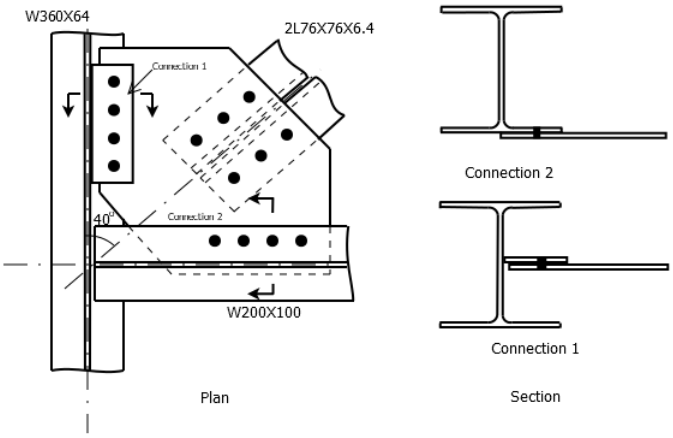
Table 5: Validation problem 4 results

	Interaction Ratio		
Check	Calculated	Osoconn	Result
Bolt shear check at brace	0.283	0.283	OK
Bolt bearing at brace check	0.2	0.2	OK
Bolt bearing at gusset check	0.424	0.424	OK
Brace tension rupture check	0.156	0.156	OK
Brace block shear check	0.167	0.167	OK
Gusset tension yielding check	0.241	0.241	OK
Gusset tension rupture check	0.203	0.203	OK
Bolt shear at connection 1	0.12	0.12	OK
Bolt bearing at clip angle at connection 1	0.113	0.113	OK
Bolt bearing at beam web at connection 1	0.062	0.062	OK
Gusset shear yielding at connection 1	0.099	0.099	OK
Gusset plate block shear at connection 1	0.087	0.087	OK
Gusset flexure yielding at connection 1	0.056	0.056	OK
Clip angle shear yielding at connection 1	0.083	0.083	OK
Clip angle shear rupture at connection 1	0.113	0.113	OK
Clip angle block shear at connection 1	0.092	0.092	OK
Weld check at connection 1	0.139	0.139	OK
Gusset rupture at weld at connection 1	0.119	0.119	OK
Bolt shear at connection 2	0.514	0.514	OK
Bolt bearing at shear tab at connection 2	0.384	0.384	OK
Bolt bearing at gusset at connection 2	0.192	0.192	OK
Gusset shear yielding at connection 2	0.211	0.211	OK
Gusset shear rupture at connection 2	0.248	0.248	OK
Gusset plate block shear at connection 2	0.296	0.296	OK
Gusset flexure yielding at connection 2	0.119	0.119	OK
Shear tab shear yielding at connection 2	0.283	0.283	OK
Shear tab shear rupture at connection 2	0.384	0.384	OK
Shear tab block shear at connection 2	0.313	0.313	OK
Shear tab flexure yielding at connection 2	0.135	0.135	OK
Weld check at connection 2	0.406	0.406	OK
Shear tab rupture at weld at connection 2	0.346	0.346	OK
Web rupture at weld at connection 2	0.316	0.316	OK

2.6 Validation Problem 5

Problem Statement

Design a horizontal brace connection for a double angle 2L76X76X6.4 brace, with their short leg back to back and vertical, framing into the junction between a W360X64 and a W200X100 using the ASD method. The brace has an angle of 40 degrees with the W360 beam. The brace has an axial force of 46 kN. The beams, angles and plates are of grade ASTM A36. The bolts are ASTM 3125 A490 bearing type.



Design Inputs

Material Properties

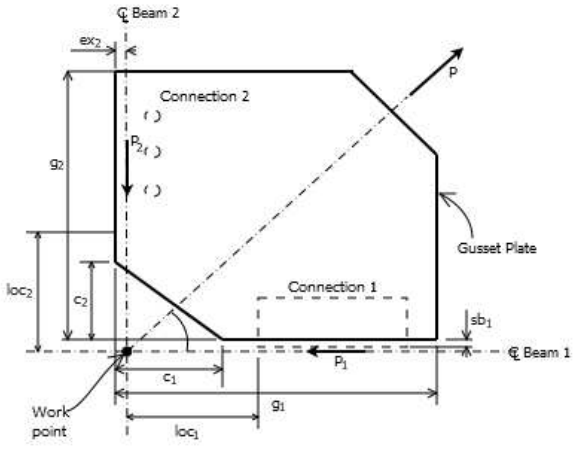
Material grade for plate	ASTM A36
Yield strength	$F_{yp} := 250\ MPa$
Tensile strength	$F_{up} := 400\ MPa$
Material grade of beam	ASTM A36
Yield strength	$F_{yb} := 250\ MPa$
Tensile strength	$F_{ub} := 400\ MPa$
Material grade of angles	ASTM A36
Yield strength	$F_{ya} := 250\ MPa$
Tensile strength	$F_{ua} := 400\ MPa$
Material grade for weld electrode	E70XX
Tensile strength	$F_{EXX} := 482\ MPa$
Material specification for bolts	ASTM 3125 A490
Tensile strength	$F_{nt} := 780\ MPa$
Shear strength	$F_{nv} := 469\ MPa$
Young's modulus for steel	$E := 200000\ MPa$

Design Forces

Axial force in brace	$P := 46\ kN$

Connection Geometry

Brace section	2L76X76X6.4
Thickness	$t_{br} := 6.35\ mm$
Horizontal leg length	$l_{obr} := 76.2\ mm$
Back-to-back leg length	$l_{ibr} := 76.2\ mm$
Gross cross section area	$A_{br} := 1858\ mm^2$
Centroid of brace back to back leg	$x'_{br} := 21.2\ mm$
Brace angle with from beam at connection 1	$\theta_{br} := 40\ deg$
Back to back leg spacing	$s_{br} := 6\ mm$
Beam section at connection 1	W360X64
Section depth	$d_{xb1} := 348\ mm$
Flange width	$b_{fb1} := 203\ mm$
Flange thickness	$t_{fb1} := 13.5\ mm$
Web thickness	$t_{wb1} := 7.75\ mm$
Distance from outer face to fillet edge	$k_{bdet1} := 34.9\ mm$
Beam section at connection 2	W200X100
Section depth	$d_{xb2} := 229\ mm$
Flange width	$b_{fb2} := 210\ mm$
Flange thickness	$t_{fb2} := 23.7\ mm$
Web thickness	$t_{wb2} := 14.5\ mm$
Distance from outer face to fillet edge	$k_{bdet2} := 41.3\ mm$
Shear tab thickness	$t_s := 10\ mm$
Shear tab width	$w_s := 100\ mm$



Gusset plate thickness	$t_g := 12\ mm$
Gusset dimension along connection 1	$g_1 := 500\ mm$
Gusset dimension along connection 2	$g_2 := 500\ mm$
Gusset cutout at connection 1	$c_1 := 125\ mm$
Gusset cutout at connection 2	$c_2 := 125\ mm$
Gusset extention at connection 2	$ex_2 := 10\ mm$

Bolt diameter $d_b := 20\ mm$

Bolt hole diameter $d_{bh} := 22\ mm$

Number of bolts per row on brace $n_{br} := 3$

Number of bolts at connection 1 $n_1 := 4$

Number of bolts at connection 2 $n_2 := 4$

Bolt spacing $s := 60\ mm$

Bolt gage on brace $g_{br} := 45\ mm$

Bolt gage on shear tab $g_s := 50\ mm$

Bolt gage on beam 2 $g_{bm2} := 3\ in$

Shear tab location for connection 1 $loc_1 := 200\ mm$

Bolt location for connection 2 $loc_2 := 200\ mm$

Bolt edge distance on brace $ed_1 := 35\ mm$

Bolt edge distance on gusset $ed_2 := 35\ mm$

Bolt edge distance on shear tab $ed_3 := 35\ mm$

Shear tab to beam weld thickness $w := 6\ mm$

Connection setback at connection 1 $sb_1 := 12\ mm$

Beam bottom flange cope length at connection 2 $cp_2 := 0\ mm$

Setback of beam at connection 2 $sbb_2 := 12\ mm$

Design Calculations

Connection forces

Shear per bolt at brace connection

$$P_b := \frac{P}{2 \cdot n_{br}} \qquad P_b = 7.667\ kN$$

Component of brace force along connection 1

$$P_1 := P \cdot \cos(\theta_{br}) \qquad P_1 = 35.238\ kN$$

Force per bolt along connection 1

$$P_{b1} := \frac{P_1}{n_1} \qquad P_{b1} = 8.81\ kN$$

Component of brace force along connection 2

$$P_2 := P \cdot \sin(\theta_{br}) \qquad P_2 = 29.568\ kN$$

Force per bolt along connection 2

$$P_{b2} := \frac{P_2}{n_2} \qquad P_{b2} = 7.392\ kN$$

Bolt shear at brace check

Area of bolt

$$A_b := \frac{\pi \cdot d_b^{\,2}}{4} \qquad A_b = 314.159\ mm^2$$

Nominal shear strength of bolt

$$R_n := F_{nv} \cdot A_b \qquad R_n = 147.341\ kN$$

Interaction ratio in bolt shear

$$I_0 := \frac{2.0\ P_b}{R_n} \qquad I_0 = 0.104$$

Bolt bearing at brace check

Minimum clear distance for bearing check

$$l_{c1} := min\left(s - d_{bh}, ed_1 - 0.5 \cdot d_{bh}\right) \qquad l_{c1} = 24\ mm$$

Nominal strength in bearing

$$R_n := min\left(1.2 \cdot l_{c1} \cdot t_{br} \cdot F_{ua}, 2.4 \cdot d_b \cdot t_{br} \cdot F_{ua}\right) \qquad R_n = 73.152\ kN$$

Interaction ratio in bolt bearing at brace

$$I_1 := \frac{2.0\ P_b}{R_n} \qquad I_1 = 0.21$$

Bolt bearing at gusset check

Minimum clear distance for bearing on gusset

$$l_{c2} := min\left(s - d_{bh}, ed_2 - 0.5 \cdot d_{bh}\right) \qquad l_{c1} = 24\ mm$$

Nominal strength in bearing

$$R_n := min\left(1.2 \cdot l_{c2} \cdot t_g \cdot F_{up}, 2.4 \cdot d_b \cdot t_g \cdot F_{up}\right) \qquad R_n = 138.24\ kN$$

Interaction ratio in bolt bearing at gusset

$$I_2 := \frac{2.0\ P_b}{R_n} \qquad I_2 = 0.111$$

Tension rupture at brace to gusset connection

Net cross section area of brace

$$A_{nbr} := A_{br} - 2 \cdot d_{bh} \cdot t_{br} \qquad A_{nbr} = 1578.6\ mm^2$$

Length of connection

$$l_{br} := s \cdot \left(n_{br} - 1\right) \qquad l_{br} = 120\ mm$$

Shear lag factor

$$U := 1 - \frac{x'_{br}}{l_{br}} \qquad U = 0.823$$

Brace strength in tension rupture

$$P_n := F_{ua} \cdot U \cdot A_{nbr} \qquad P_n = 519.886\ kN$$

Interaction ratio for brace tension rupture

$$I_3 := \frac{2.0\ P}{P_n} \qquad I_3 = 0.177$$

Brace block shear check

Gross area in shear

$$A_{gv} := 2 \cdot \left(\left(n_{br} - 1 \right) \cdot s + ed_1 \right) \cdot t_{br} \qquad A_{gv} = 1968.5 \ mm^2$$

Net area in shear

$$A_{nv} := A_{gv} - 2 \cdot \left(n_{br} - 0.5 \right) \cdot d_{bh} \cdot t_{br} \qquad A_{nv} = 1270 \ mm^2$$

Net area in tension

$$A_{nt} := 2 \cdot \left(l_{ibr} - g_{br} - 0.5 \cdot d_{bh} \right) \cdot t_{br} \qquad A_{nt} = 256.54 \ mm^2$$

Nominal strength block shear

$$R_{n1} := 0.6 \cdot F_{ua} \cdot A_{nv} + F_{ua} \cdot A_{nt}$$

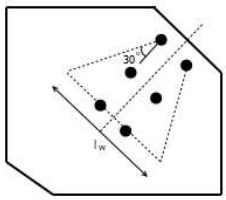
$$R_{n2} := 0.6 \cdot F_{ya} \cdot A_{gv} + F_{ua} \cdot A_{nt}$$

$$R_n := min \left(R_{n1}, R_{n2} \right) \qquad R_n = 397.891 \ kN$$

Interaction ratio in block shear

$$I_4 := \frac{2.0 \ P}{R_n} \qquad I_4 = 0.231$$

Gusset tension yielding check



Length of Whitmore section

$$l_w := 2 \cdot l_{br} \cdot \tan \left(30 \ deg \right) + 2 \cdot g_{br} + s_{br} \qquad l_w = 234.564 \ mm$$

Nominal strength of gusset in yielding

$$P_n := F_{yp} \cdot l_w \cdot t_g \qquad P_n = 703.692 \ kN$$

Interaction ratio in tension yielding

$$I_5 := \frac{1.67 \ P}{P_n} \qquad I_5 = 0.109$$

Gusset tension rupture check

Net area of gusset in tension

$$A_{ng} := \left(l_w - 2 \cdot d_{bh} \right) \cdot t_g \qquad A_{ng} = 2286.769 \ mm^2$$

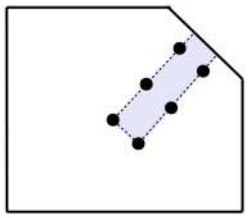
Nominal strength of gusset in rupture

$$P_n := F_{up} \cdot A_{ng} \qquad P_n = 914.708 \ kN$$

Interaction ratio in tension rupture

$$I_6 := \frac{2.0\ P}{P_n} \qquad I_6 = 0.101$$

Gusset block shear check



Gross area in shear

$$A_{gv} := 2\ \left(\left(n_{br} - 1\right) \cdot s + ed_2\right) \cdot t_g \qquad A_{gv} = 3720\ mm^2$$

Net area in shear

$$A_{nv} := A_{gv} - \left(2 \cdot n_{br} - 1\right) \cdot d_{bh} \cdot t_g \qquad A_{nv} = 2400\ mm^2$$

Net area in tension

$$A_{nt} := \left(2\ g_{br} + s_{br} - d_{bh}\right) \cdot t_g \qquad A_{nt} = 888\ mm^2$$

Nominal strength block shear

$$R_{n1} := 0.6 \cdot F_{up} \cdot A_{nv} + F_{up} \cdot A_{nt}$$

$$R_{n2} := 0.6 \cdot F_{yp} \cdot A_{gv} + F_{up} \cdot A_{nt}$$

$$R_n := min\left(R_{n1}, R_{n2}\right) \qquad R_n = 913.2\ kN$$

Interaction ratio in block shear

$$I_7 := \frac{2.0\ P}{R_n} \qquad I_7 = 0.101$$

Bolt shear at connection 1

Polar moment of inertia of bolt group

$$I_{po} := 2 \cdot \sum_{i=1}^{0.5\ (n_1 - 1)} \left(i \cdot s\right)^2$$

$$I_{pe} := 2 \cdot \sum_{i=1}^{0.5\ n_1} \left(\left(i - 0.5\right) \cdot s\right)^2$$

$$I_p := \mathbf{if}\left(\mathrm{mod}\left(n_1, 2\right) = 1, I_{po}, I_{pe}\right) \qquad I_p = 18000\ mm^2$$

Distance of most remote bolt from CG

$$c := 0.5\ \left(n_1 - 1\right) \cdot s \qquad c = 90\ mm$$

Maximum shear in bolt

$$P_s := \sqrt{\left(\frac{P_1}{n_1}\right)^2 + \left(\frac{P_1 \cdot g_s \cdot c}{I_p}\right)^2} \qquad P_s = 12.459\ kN$$

Nominal shear strength of bolt

$$R_n := F_{nv} \cdot A_b \qquad R_n = 147.341\ kN$$

Interaction ratio in bolt shear

$$I_8 := \frac{2.0\ P_{b1}}{R_n} \qquad I_8 = 0.12$$

Bolt bearing at shear tab at connection 1

Clear distance between bolt holes/ hole and edge

$$l_c := min\left(s - d_{bh}, ed_3 - 0.5 \cdot d_{bh}\right) \qquad l_c = 24\ mm$$

Nominal strength in bearing

$$R_n := min\left(1.2 \cdot l_c \cdot t_s \cdot F_{up}, 2.4 \cdot d_b \cdot t_s \cdot F_{up}\right) \qquad R_n = 115.2\ kN$$

Interaction ratio in bolt bearing

$$I_9 := \frac{2.0\ P_{b1}}{R_n} \qquad I_9 = 0.153$$

Bolt bearing at gusset at connection 1

Length of shear tab

$$L_1 := \left(n_1 - 1\right) \cdot s + 2\ ed_3 \qquad L_1 = 250\ mm$$

Distance of gusset outer edge from work point

$$loc_{go} := g_1 - ex_2 \qquad loc_{go} = 490\ mm$$

Distance of gusset inner edge from work point

$$loc_{gi} := c_1 - ex_2 - \mathbf{if}\left(c_2 = 0, 0, \left(g_s - sb_1\right) \cdot \frac{c_1}{c_2}\right) \qquad loc_{gi} = 77\ mm$$

Outer edge distance for bolt on gusset

$$ed_{go} := loc_{go} - loc_1 - L_1 + ed_3 \qquad ed_{go} = 75\ mm$$

Inner edge distance for bolt on gusset

$$ed_{gi} := loc_1 - loc_{gi} + ed_3 \qquad ed_{gi} = 158\ mm$$

Minimum edge distance for clip on gusset

$$ed_g := min\left(ed_{go}, ed_{gi}\right) \qquad ed_g = 75\ mm$$

Clear distance between bolt holes/ hole and edge

$$l_c := min\left(s - d_{bh}, ed_g - 0.5 \cdot d_{bh}\right) \qquad l_c = 38\ mm$$

Nominal strength in bearing

$$R_n := min\left(1.2 \cdot l_c \cdot t_g \cdot F_{up}, 2.4 \cdot d_b \cdot t_g \cdot F_{up}\right) \qquad R_n = 218.88\ kN$$

Interaction ratio in bolt bearing

$$I_{10} := \frac{2.0\ P_{b1}}{R_n} \qquad I_{10} = 0.08$$

Gusset shear yielding at connection 1

Gross area in shear

$$A_g := (g_1 - c_1) \cdot t_g \qquad A_g = 4500\ mm^2$$

Nominal shear strength of gusset in yielding

$$R_n := 0.6 \cdot F_{yp} \cdot A_g \qquad R_n = 675\ kN$$

Interaction ratio in gusset yieldling

$$I_{11} := \frac{1.5\ P_1}{R_n} \qquad I_{11} = 0.078$$

Gusset shear rupture at connection 1

Net area in shear

$$A_n := A_g - n_1 \cdot d_{bh} \cdot t_g \qquad A_n = 5.338\ in^2$$

Nominal shear strength of gusset in rupture

$$R_n := 0.6 \cdot F_{up} \cdot A_n \qquad R_n = 185.818\ kip$$

Interaction ratio in shear rupture

$$I_{12} := \frac{2.0\ P_1}{R_n} \qquad I_{12} = 0.085$$

Gusset plate block shear at connection 1

Gross area subjected to block shear

$$A_{gv} := (L_1 - 2\ ed_3 + ed_g) \cdot t_g \qquad A_{gv} = 3060\ mm^2$$

Net area subjected to block shear

$$A_{nv} := A_{gv} - (n_1 - 0.5) \cdot d_{bh} \cdot t_g \qquad A_{nv} = 2136\ mm^2$$

Net area subjected to tension

$$A_{nt} := (g_s - sb_1 - 0.5\ d_{bh}) \cdot t_g \qquad A_{nt} = 324\ mm^2$$

Nominal strength in block shear

$$R_{n1} := 0.6 \cdot F_{ua} \cdot A_{nv} + F_{ua} \cdot A_{nt}$$

$$R_{n2} := 0.6 \cdot F_{ya} \cdot A_{gv} + F_{ua} \cdot A_{nt}$$

$$R_n := min(R_{n1}, R_{n2}) \qquad R_n = 588.6\ kN$$

Interaction ratio in block shear

$$I_{13} := \frac{2.0\ P_1}{R_n} \qquad I_{13} = 0.12$$

Gusset flexure yielding at connection 1

Eccentricity of force at connection 1

$$ec_1 := c_1 + sb_1 \qquad ec_1 = 137\ mm$$

Nominal moment strenght of gusset

$$M_n := \frac{F_{yp} \cdot t_g \cdot g_1^{\,2}}{4} \qquad M_n = 187.5\ kN \cdot m$$

Interaction ratio in gusset flexure

$$I_{14} := \frac{1.67\ (P_1 \cdot ec_1)}{M_n} \qquad I_{14} = 0.043$$

Shear tab shear yielding at connection 1

Gross area in shear

$$A_{gv} := L_1 \cdot t_s \qquad A_{gv} = 2500\ mm^2$$

Nominal strength in shear yielding

$$R_n := 0.6 \cdot F_{yp} \cdot A_{gv} \qquad R_n = 375\ kN$$

Interaction ratio in shear yielding

$$I_{15} := \frac{1.5 P_1}{R_n} \qquad I_{15} = 0.141$$

Shear tab shear rupture at connection 1

Net area in shear

$$A_{nv} := A_{gv} - n_1 \cdot d_{bh} \cdot t_s \qquad A_{nv} = 1620\ mm^2$$

Nominal strength in shear rupture

$$R_n := 0.6 \cdot F_{ua} \cdot A_{nv} \qquad R_n = 388.8\ kN$$

Interaction ratio in shear rupture

$$I_{16} := \frac{2.0\ P_1}{R_n} \qquad I_{16} = 0.181$$

Shear tab block shear at connection 1

Gross area subjected to block shear

$$A_{gv} := (L_1 - ed_3) \cdot t_s \qquad A_{gv} = 2150\ mm^2$$

Net area subjected to block shear

$$A_{nv} := A_{gv} - (n_1 - 0.5) \cdot d_{bh} \cdot t_s \qquad A_{nv} = 1380\ mm^2$$

Net area subjected to tension

$$A_{nt} := (w_s - g_s - 0.5\ d_{bh}) \cdot t_s \qquad A_{nt} = 390\ mm^2$$

Nominal strength in block shear

$$R_{n1} := 0.6 \cdot F_{ua} \cdot A_{nv} + F_{ua} \cdot A_{nt}$$

$$R_{n2} := 0.6 \cdot F_{ya} \cdot A_{gv} + F_{ua} \cdot A_{nt}$$

$$R_n := min\left(R_{n1}, R_{n2}\right) \qquad R_n = 478.5\ kN$$

Interaction ratio in block shear

$$I_{17} := \frac{2.0\ P_1}{R_n} \qquad I_{17} = 0.147$$

Shear tab flexure yielding at connection 1

Nominal moment strenght of gusset

$$M_n := \frac{F_{yp} \cdot t_s \cdot L_1^{\ 2}}{4} \qquad M_n = 39.063\ kN \cdot m$$

Interaction ratio in gusset flexure

$$I_{18} := \frac{1.67\ P_1 \cdot g_s}{M_n} \qquad I_{18} = 0.075$$

Weld check at connection 1

Polar moment of inertia of weld group

$$I_w := \frac{L_1^{\ 3}}{12} \qquad I_w = 1302.083\ cm^3$$

Weld stress along weld

$$f_{wx} := \frac{P_1}{2 \cdot L_1} \qquad f_{wx} = 0.07\ \frac{kN}{mm}$$

Max weld stress transverse to weld

$$f_{wy} := \frac{P_1 \cdot g_s \cdot L_1}{4\ I_w} \qquad f_{wy} = 0.085\ \frac{kN}{mm}$$

Resultant weld stress

$$f_w := \sqrt{f_{wx}^{\ 2} + f_{wy}^{\ 2}} \qquad f_w = 0.11\ \frac{kN}{mm}$$

Nominal weld strength

$$R_n := 0.6 \cdot F_{EXX} \cdot \frac{\sqrt{2}}{2} \cdot w \qquad R_n = 1.227\ \frac{kN}{mm}$$

Interaction ratio for weld check

$$I_{19} := \frac{2.0\ f_w}{R_n} \qquad I_{19} = 0.179$$

Shear tab rupture at weld at connection 1

Minimum shear tab thickness to match weld strength

$$t_{s.min} := \frac{2.0 \cdot 2\ f_w}{0.6 \cdot F_{up}} \qquad t_{s.min} = 1.835\ mm$$

Interaction ratio in web rupture

$$I_{20} := \frac{t_{s.min}}{t_s} \qquad I_{20} = 0.183$$

Web rupture at weld at connection 1

Minimum web thickness to match weld strength

$$t_{w.min} := \frac{2.0\ f_w}{0.6 \cdot F_{ub}} \qquad t_{w.min} = 0.917\ mm$$

Interaction ratio in web rupture

$$I_{21} := \frac{t_{w.min}}{t_{wb1}} \qquad I_{21} = 0.118$$

Bolt shear at connection 2

Nominal shear strength of bolt

$$R_n := F_{nv} \cdot A_b \qquad R_n = 147.341\ kN$$

Interaction ratio in bolt shear

$$I_{22} := \frac{2.0\ P_{b2}}{R_n} \qquad I_{22} = 0.1$$

Bolt bearing at gusset plate at connection 2

Length of connection 2

$$L_2 := (n_2 - 1) \cdot s \qquad L_2 = 180\ mm$$

Distance of gusset outer edge from work point

$$loc_{go} := g_2 + sb_1 + 0.5 \cdot t_{wb1} \qquad loc_{go} = 515.875\ mm$$

Distance of gusset inner edge from work point

$$loc_{gi} := c_2 + sb_1 + 0.5 \cdot t_{wb1} - \text{if}\left(c_1 = 0, 0, (g_{bm2} + ex_2) \cdot \frac{c_2}{c_1}\right) \qquad loc_{gi} = 54.675\ mm$$

Outer edge distance for clip on gusset

$$ed_{go} := loc_{go} - loc_2 - L_2 \qquad ed_{go} = 135.875\ mm$$

Inner edge distance for clip on gusset

$$ed_{gi} := loc_2 - loc_{gi} \qquad ed_{gi} = 145.325\ mm$$

Minimum edge distance for clip on gusset

$$ed_g := min(ed_{go}, ed_{gi}) \qquad ed_g = 135.875\ mm$$

Clear distance between bolt holes/ hole and edge

$$l_c := min(s - d_{bh}, ed_g - 0.5 \cdot d_{bh}) \qquad l_c = 38\ mm$$

Nominal strength in bearing

$$R_n := min(1.2 \cdot l_c \cdot t_g \cdot F_{up}, 2.4 \cdot d_b \cdot t_g \cdot F_{up}) \qquad R_n = 218.88\ kN$$

Interaction ratio in bolt bearing

$$I_{23} := \frac{2.0\ P_{b2}}{R_n} \qquad I_{23} = 0.068$$

Bolt bearing at beam web at connection 2

Edge distance of bolt to beam flange edge

$$ed_b := loc_2 - cp_2 - sbb_2 - 0.5\ t_{wb2} \qquad ed_b = 7.116\ in$$

Clear distance between bolt holes/ hole and edge

$$l_c := min\left(s - d_{bh}, ed_b - 0.5 \cdot d_{bh}\right) \qquad l_c = 1.496\ in$$

Nominal strength in bearing

$$R_n := min\left(1.2 \cdot l_c \cdot t_{fb2} \cdot F_{ub}, 2.4 \cdot d_b \cdot t_{fb2} \cdot F_{ub}\right) \qquad R_n = 97.182\ kip$$

Interaction ratio in bolt bearing

$$I_{24} := \frac{2.0\ P_{b2}}{R_n} \qquad I_{24} = 0.034$$

Gusset shear yielding at connection 2

Gross area in shear

$$A_g := \left(g_2 - c_2\right) \cdot t_g \qquad A_g = 4500\ mm^2$$

Nominal shear strength of gusset in yielding

$$R_n := 0.6 \cdot F_{yp} \cdot A_g \qquad R_n = 675\ kN$$

Interaction ratio in gusset yieldling

$$I_{25} := \frac{1.5\ P_2}{R_n} \qquad I_{25} = 0.066$$

Gusset shear rupture at connection 2

Net area in shear

$$A_n := A_g - n_2 \cdot d_{bh} \cdot t_g \qquad A_n = 3444\ mm^2$$

Nominal shear strength of gusset in rupture

$$R_n := 0.6 \cdot F_{up} \cdot A_n \qquad R_n = 826.56\ kN$$

Interaction ratio in shear rupture

$$I_{26} := \frac{2.0\ P_2}{R_n} \qquad I_{26} = 0.072$$

Gusset plate block shear at connection 2

Gross area subjected to block shear

$$A_{gv} := \left(L_2 + ed_g\right) \cdot t_g \qquad A_{gv} = 3790.5\ mm^2$$

Net area subjected to block shear

$$A_{nv} := A_{gv} - \left(n_2 - 0.5\right) \cdot d_{bh} \cdot t_g \qquad A_{nv} = 2866.5\ mm^2$$

Net area subjected to tension

$$A_{nt} := \left(g_{bm2} + ex_2 - 0.5\ d_{bh}\right) \cdot t_g \qquad A_{nt} = 902.4\ mm^2$$

Nominal strength in block shear

$$R_{n1} := 0.6 \cdot F_{ua} \cdot A_{nv} + F_{ua} \cdot A_{nt}$$

$$R_{n2} := 0.6 \cdot F_{ya} \cdot A_{gv} + F_{ua} \cdot A_{nt}$$

$$R_n := min\left(R_{n1}, R_{n2}\right) \qquad R_n = 929.535\ \textbf{kN}$$

Interaction ratio in block shear

$$I_{27} := \frac{2.0\ P_2}{R_n} \qquad I_{27} = 0.064$$

Gusset flexure yielding at connection 2

Eccentricity of force at connection 2

$$ec_2 := \max\left(c_1 - ex_2, 0\right) \qquad ec_2 = 115\ \textbf{mm}$$

Nominal moment strenght of gusset

$$M_n := \frac{F_{yp} \cdot t_g \cdot {g_2}^2}{4} \qquad M_n = 187.5\ \textbf{kN} \cdot \textbf{m}$$

Interaction ratio in gusset flexure

$$I_{28} := \frac{1.67\ \left(P_2 \cdot ec_2\right)}{M_n} \qquad I_{28} = 0.03$$

Validation Results

The calculated ratios are compared with the output of Osoconn and if it is within a tolerance of 1% the result is deemed to be OK.

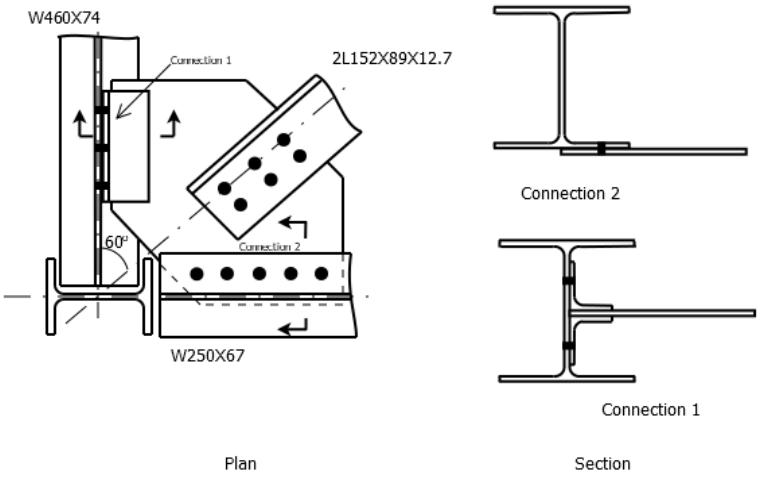
Table 6: Validation problem 5 results

	Interaction Ratio		
Check	Calculated	Osoconn	Result
Bolt shear at brace check	0.104	0.104	OK
Bolt bearing at brace check	0.21	0.21	OK
Bolt bearing at gusset check	0.111	0.111	OK
Brace tension rupture check	0.177	0.177	OK
Brace block shear check	0.231	0.231	OK
Gusset tension yielding check	0.109	0.109	OK
Gusset tension rupture check	0.101	0.101	OK
Gusset block shear check	0.101	0.101	OK
Bolt shear at connection 1	0.12	0.12	OK
Bolt bearing at shear tab at connection 1	0.153	0.153	OK
Bolt bearing at gusset at connection 1	0.08	0.08	OK
Gusset shear yielding at connection 1	0.078	0.078	OK
Gusset shear rupture at connection 1	0.085	0.085	OK
Gusset plate block shear at connection 1	0.12	0.125	OK
Gusset flexure yielding at connection 1	0.043	0.044	OK
Shear tab shear yielding at connection 1	0.141	0.141	OK
Shear tab shear rupture at connection 1	0.181	0.181	OK
Shear tab block shear at connection 1	0.147	0.147	OK
Shear tab flexure yielding at connection 1	0.075	0.075	OK
Weld check at connection 1	0.179	0.179	OK
Shear tab rupture at weld check	0.183	0.183	OK
Web rupture at weld at connection 1	0.118	0.118	OK
Bolt shear at connection 2	0.1	0.1	OK
Bolt bearing at gusset plate at connection 2	0.068	0.068	OK
Bolt bearing at beam web at connection 2	0.034	0.034	OK
Gusset shear yielding at connection 2	0.066	0.066	OK
Gusset shear rupture at connection 2	0.072	0.072	OK
Gusset plate block shear at connection 2	0.064	0.068	OK
Gusset flexure yielding at connection 2	0.03	0.026	OK

2.7 Validation Problem 6

Problem Statement

Design a horizontal brace connection for a double angle 2L152X89X12.7 brace, with their back to back leg horizontal, framing into the junction between two W460X74 and a W250X67 using the ASD method. The brace has an angle of 60 degrees with the W460. The brace has an axial force of 190kN. The beams are of grad ASTM A992, angles and plates are of grade ASTM A36. The bolts are ASTM 3125 A325 slip critical type.



Design Inputs

Material Properties

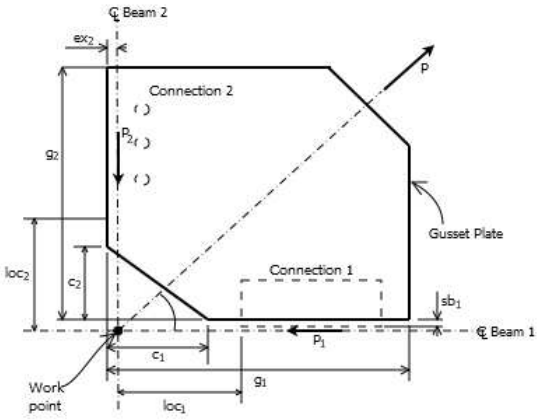
Material grade for plate	ASTM A36
Yield strength	$F_{yp} := 250\ MPa$
Tensile strength	$F_{up} := 400\ MPa$
Material grade of beam	ASTM A992
Yield strength	$F_{yb} := 345\ MPa$
Tensile strength	$F_{ub} := 450\ MPa$
Material grade of angles	ASTM A36
Yield strength	$F_{ya} := 250\ MPa$
Tensile strength	$F_{ua} := 400\ MPa$
Material grade for weld electrode	E70XX
Tensile strength	$F_{EXX} := 482\ MPa$
Material specification for bolts	ASTM 3125 A325
Tensile strength	$F_{nt} := 620\ ksi$
Shear strength	$F_{nv} := 372\ ksi$
Young's modulus for steel	$E := 200000\ MPa$

Design Forces

Axial force in brace	$P := 190\ kN$

Connection Geometry

Brace section	2L152X89X12.7
Thickness	$t_{br} := 12.7\ mm$
Outstanding leg length	$l_{obr} := 88.9\ mm$
Back-to-back leg length	$l_{ibr} := 152\ mm$
Gross cross section area	$A_{br} := 5800\ mm^2$
Centroid of brace outstanding leg	$x'_{br} := 21.1\ mm$
Brace angle with horizontal	$\theta_{br} := 60\ deg$
Beam section at connection 1	W460X74
Section depth	$d_{xb1} := 457\ mm$
Flange width	$b_{fb1} := 191\ mm$
Flange thickness	$t_{fb1} := 14.5\ mm$
Web thickness	$t_{wb1} := 9.02\ mm$
Distance from outer face to fillet edge	$k_{bdet1} := 31.8\ mm$
Beam section at connection 2	W250X67
Section depth	$d_{xb2} := 257\ mm$
Flange width	$b_{fb2} := 204\ mm$
Flange thickness	$t_{fb2} := 15.7\ mm$
Web thickness	$t_{wb2} := 8.89\ mm$
Distance from outer face to fillet edge	$k_{bdet2} := 33.3\ mm$



Gusset plate thickness	$t_g := 16\ mm$
Gusset dimension along connection 1	$g_1 := 500\ mm$
Gusset dimension along connection 2	$g_2 := 500\ mm$
Gusset cutout at connection 1	$c_1 := 150\ mm$
Gusset cutout at connection 2	$c_2 := 150\ mm$
Gusset extension at connection 2	$ex_2 := 25\ mm$
Clip angle section	L89X89X9.5
Thickness	$t_a := 9.53\ mm$
Outstanding leg length	$l_{oa} := 88.9\ mm$
Welded leg length	$l_{ia} := 88.9\ mm$

Bolt diameter $d_b := 22\ mm$

Bolt hole diameter $d_{bh} := 24\ mm$

Slip coefficient (class A surface) $\mu := 0.3$

Bolt pretension $T_{pre} := 176\ kN$

Number of bolts per row on brace $n_{br} := 3$

Number of bolts at connection 1 $n_1 := 3$

Number of bolts at connection 2 $n_2 := 5$

Bolt spacing $s := 70\ mm$

Bolt row spacing $s_r := 70\ mm$

Bolt gage on brace $g_{br} := 50\ mm$

Bolt gage on clip $g := 45\ mm$

Bolt gage on beam 2 $g_{bm2} := 50\ mm$

Location of connection 1 from work point $loc_1 := 200\ mm$

Location of connection 2 from work point $loc_2 := 200\ mm$

Bolt edge distance on brace $ed_1 := 30\ mm$

Bolt edge distance on gusset $ed_2 := 30\ mm$

Bolt edge distance on clip $ed_3 := 35\ mm$

Clip to gusset weld thickness $w := 6\ mm$

Connection setback at connection 1 $sb_1 := 12\ mm$

Beam bottom flange cope length at connection 2 $cp_2 := 0\ mm$

Setback of beam at connection 2 $sbb_2 := 12\ mm$

Design Calculations

Connection forces

Shear per bolt at brace connection

$$P_b := \frac{P}{2\ n_{br}} \qquad P_b = 31.667\ kN$$

Component of brace force along connection 1

$$P_1 := P \cdot \cos\left(\theta_{br}\right) \qquad P_1 = 95\ kN$$

Force per bolt along connection 1

$$P_{b1} := \frac{P_1}{2\ n_1} \qquad P_{b1} = 15.833\ kN$$

Component of brace force along connection 2

$$P_2 := P \cdot \sin\left(\theta_{br}\right) \qquad P_2 = 164.545\ kN$$

Force per bolt along connection 2

$$P_{b2} := \frac{P_2}{n_2} \qquad P_{b2} = 32.909\ kN$$

Bolt shear at brace to gusset connection

Nominal slip resistance of bolt

$$R_n := \mu \cdot 1.13 \cdot T_{pre} \cdot 2 \qquad R_n = 119.328\ kN$$

Interaction ratio in bolt shear

$$I_0 := \frac{1.5\ P_b}{R_n} \qquad I_0 = 0.398$$

Bolt bearing on brace check

Minimum clear distance for bearing check

$$l_{c1} := min\left(s - d_{bh}, ed_1 - 0.5 \cdot d_{bh}\right) \qquad l_{c1} = 18\ mm$$

Nominal strength in bearing

$$R_n := min\left(1.2 \cdot l_{c1} \cdot t_{br} \cdot F_{ua}, 2.4 \cdot d_b \cdot t_{br} \cdot F_{ua}\right) \qquad R_n = 109.728\ kN$$

Interaction ratio in bolt bearing at brace

$$I_1 := \frac{2.0 \cdot 0.5\ P_b}{R_n} \qquad I_1 = 0.289$$

Bolt bearing on gusset check

Minimum clear distance for bearing on gusset

$$l_{c2} := min\left(s - d_{bh}, ed_2 - 0.5 \cdot d_{bh}\right) \qquad l_{c1} = 18\ mm$$

Nominal strength in bearing

$$R_n := min\left(1.2 \cdot l_{c2} \cdot t_g \cdot F_{up}, 2.4 \cdot d_b \cdot t_g \cdot F_{up}\right) \qquad R_n = 138.24\ kN$$

Interaction ratio in bolt bearing at gusset

$$I_2 := \frac{2.0\ P_b}{R_n} \qquad I_2 = 0.458$$

Brace tension rupture check

Net cross section area of brace

$$A_{nbr} := A_{br} - 4 \cdot d_{bh} \cdot t_{br} \qquad A_{nbr} = 4580.8\ mm^2$$

Length of connection

$$l_{br} := s \cdot \left(n_{br} - 1\right) \qquad l_{br} = 140\ mm$$

Shear lag factor

$$U := 1 - \frac{x'_{br}}{l_{br}} \qquad U = 0.849$$

Brace strength in tension rupture

$$P_n := F_{ua} \cdot U \cdot A_{nbr} \qquad P_n = 1556.163\ kN$$

Interaction ratio for brace tension rupture

$$I_3 := \frac{2.0\ P}{P_n} \qquad I_3 = 0.244$$

Brace block shear check

Gross area in shear

$$A_{gv} := 2 \cdot \left(\left(n_{br} - 1 \right) \cdot s + ed_1 \right) \cdot t_{br} \qquad A_{gv} = 4318 \ mm^2$$

Net area in shear

$$A_{nv} := A_{gv} - 2 \cdot \left(n_{br} - 0.5 \right) \cdot d_{bh} \cdot t_{br} \qquad A_{nv} = 2794 \ mm^2$$

Net area in tension

$$A_{nt} := 2 \cdot \left(l_{ibr} - g_{br} - 1.5 \cdot d_{bh} \right) \cdot t_{br} \qquad A_{nt} = 1676.4 \ mm^2$$

Nominal strength block shear

$$R_{n1} := 0.6 \cdot F_{ua} \cdot A_{nv} + F_{ua} \cdot A_{nt}$$

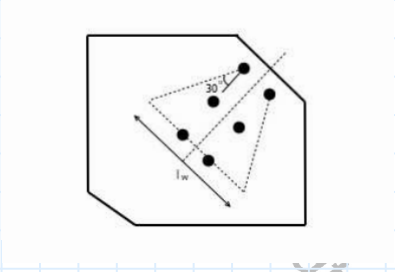
$$R_{n2} := 0.6 \cdot F_{ya} \cdot A_{gv} + F_{ua} \cdot A_{nt}$$

$$R_n := min \left(R_{n1}, R_{n2} \right) \qquad R_n = 1318.26 \ kN$$

Interaction ratio in block shear

$$I_4 := \frac{2.0 \ P}{R_n} \qquad I_4 = 0.288$$

Gusset tension yielding check



Length of Whitmore section

$$l_w := 2 \cdot l_{br} \cdot \tan \left(30 \ deg \right) + s_r \qquad l_w = 231.658 \ mm$$

Nominal strength of gusset in yielding

$$P_n := F_{yp} \cdot l_w \cdot t_g \qquad P_n = 926.632 \ kN$$

Interaction ratio in tension yielding

$$I_5 := \frac{1.67 \ P}{P_n} \qquad I_5 = 0.342$$

Gusset tension rupture check

Net area of gusset in tension

$$A_{ng} := \left(l_w - 2 \ d_{bh} \right) \cdot t_g \qquad A_{ng} = 2938.529 \ mm^2$$

Nominal strength of gusset in rupture

$$P_n := F_{up} \cdot A_{ng} \qquad P_n = 1175.412 \ kN$$

Interaction ratio in tension rupture

$$I_6 := \frac{2.0\ P}{P_n} \qquad I_6 = 0.323$$

Gusset block shear check

Gross area in shear

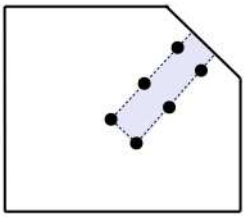
$$A_{gv} := 2\ \left(\left(n_{br} - 1\right) \cdot s + ed_2\right) \cdot t_g \qquad A_{gv} = 5440\ mm^2$$

Net area in shear

$$A_{nv} := A_{gv} - \left(2 \cdot n_{br} - 1\right) \cdot d_{bh} \cdot t_g \qquad A_{nv} = 3520\ mm^2$$

Net area in tension

$$A_{nt} := \left(s_r - d_{bh}\right) \cdot t_g \qquad A_{nt} = 736\ mm^2$$



Nominal strength block shear

$$R_{n1} := 0.6 \cdot F_{up} \cdot A_{nv} + F_{up} \cdot A_{nt}$$

$$R_{n2} := 0.6 \cdot F_{yp} \cdot A_{gv} + F_{up} \cdot A_{nt}$$

$$R_n := min\left(R_{n1}, R_{n2}\right) \qquad R_n = 1110.4\ kN$$

Interaction ratio in block shear

$$I_7 := \frac{2.0\ P}{R_n} \qquad I_7 = 0.342$$

Bolt shear at connection 1

Nominal slip resistance of bolt

$$R_n := \mu \cdot 1.13 \cdot T_{pre} \qquad R_n = 59.664\ kN$$

Interaction ratio in bolt shear

$$I_8 := \frac{1.5\ P_{b1}}{R_n} \qquad I_8 = 0.398$$

Bolt bearing at clip angle at connection 1

Clear distance between bolt holes/ hole and edge

$$l_c := min\left(s - d_{bh}, ed_3 - 0.5 \cdot d_{bh}\right) \qquad l_c = 23\ mm$$

Nominal strength in bearing

$$R_n := min\left(1.2 \cdot l_c \cdot t_a \cdot F_{ua}, 2.4 \cdot d_b \cdot t_a \cdot F_{ua}\right) \qquad R_n = 105.211\ kN$$

Interaction ratio in bolt bearing

$$I_9 := \frac{2.0\ P_{b1}}{R_n} \qquad I_9 = 0.301$$

Bolt bearing at beam web at connection 1

Nominal strength in bearing

$$R_n := min\left(1.2 \cdot \left(s - d_{bh}\right) \cdot t_{wb1} \cdot F_{ub}, 2.4 \cdot d_b \cdot t_{wb1} \cdot F_{ub}\right) \qquad R_n = 214.315\ kN$$

Interaction ratio in bolt bearing

$$I_{10} := \frac{2.0\ P_{b1}}{R_n} \qquad I_{10} = 0.148$$

Gusset shear yielding at connection 1

Nominal shear strength of gusset in yielding

$$R_n := 0.6 \cdot F_{yp} \cdot \left(g_1 - c_1\right) \cdot t_g \qquad R_n = 840\ kN$$

Interaction ratio in gusset yieldling

$$I_{11} := \frac{1.5\ P_1}{R_n} \qquad I_{11} = 0.17$$

Gusset plate block shear at connection 1

Length of gusset to column clip

$$L_1 := \left(n_1 - 1\right) \cdot s + 2\ ed_3 \qquad L_1 = 210\ mm$$

Distance of gusset outer edge from work point

$$loc_{go} := g_1 - ex_2 \qquad loc_{go} = 475\ mm$$

Distance of gusset inner edge from work point

$$loc_{gi} := c_1 - ex_2 - \mathbf{if}\left(c_2 = 0, 0, \left(l_{ia} - sb_1\right) \cdot \frac{c_1}{c_2}\right) \qquad loc_{gi} = 48.1\ mm$$

Outer edge distance for clip on gusset

$$ed_{go} := loc_{go} - loc_1 - L_1 \qquad ed_{go} = 65\ mm$$

Inner edge distance for clip on gusset

$$ed_{gi} := loc_1 - loc_{gi} \qquad ed_{gi} = 151.9\ mm$$

Minimum edge distance for clip on gusset

$$ed_g := min\left(ed_{go}, ed_{gi}\right) \qquad ed_g = 65\ mm$$

Gross area subjected to block shear

$$A_{gv} := \left(L_1 + ed_g\right) \cdot t_g \qquad A_{gv} = 4400\ mm^2$$

Net area subjected to tension

$$A_{nt} := \left(l_{ia} - sb_1\right) \cdot t_g \qquad A_{nt} = 1230.4\ mm^2$$

Nominal strength in block shear

$$R_n := 0.6 \cdot F_{ya} \cdot A_{gv} + F_{ua} \cdot A_{nt} \qquad R_n = 1152.16\ kN$$

Interaction ratio in block shear

$$I_{12} := \frac{2.0\ P_1}{R_n} \qquad I_{12} = 0.165$$

Gusset flexure yielding at connection 1

Eccentricity of force at connection 1

$$ec_1 := c_2 + sb_1 + 0.5\ t_{wb1} \qquad ec_1 = 6.556\ in$$

Nominal moment strenght of gusset

$$M_n := \frac{F_{yp} \cdot t_g \cdot g_1^{\ 2}}{4} \qquad M_n = 250\ kN \cdot m$$

Interaction ratio in gusset flexure

$$I_{13} := \frac{1.67\ (P_1 \cdot ec_1)}{M_n} \qquad I_{13} = 0.106$$

Clip angle shear yielding at connection 1

Length of gusset to column clip

$$L_1 := (n_1 - 1) \cdot s + 2\ ed_3 \qquad L_1 = 210\ mm$$

Gross area in shear

$$A_{gv} := 2 \cdot L_1 \cdot t_a \qquad A_{gv} = 4002.6\ mm^2$$

Nominal strength in shear yielding

$$R_n := 0.6 \cdot F_{ya} \cdot A_{gv} \qquad R_n = 600.39\ kN$$

Interaction ratio in shear yielding

$$I_{14} := \frac{1.5\ P_1}{R_n} \qquad I_{14} = 0.237$$

Clip angle shear rupture at connection 1

Net area in shear

$$A_{nv} := A_{gv} - 2 \cdot n_1 \cdot d_{bh} \cdot t_a \qquad A_{nv} = 2630.28\ mm^2$$

Nominal strength in shear rupture

$$R_n := 0.6 \cdot F_{ua} \cdot A_{nv} \qquad R_n = 631.267\ kN$$

Interaction ratio in shear rupture

$$I_{15} := \frac{2.0\ P_1}{R_n} \qquad I_{15} = 0.301$$

Clip angle block shear at connection 1

Gross area subjected to block shear

$$A_{gv} := 2 \cdot (L_1 - ed_3) \cdot t_a \qquad A_{gv} = 3335.5\ mm^2$$

Net area subjected to block shear

$$A_{nv} := A_{gv} - 2 \cdot (n_1 - 0.5) \cdot d_{bh} \cdot t_a \qquad A_{nv} = 2191.9\ mm^2$$

Net area subjected to tension

$$A_{nt} := \left(2 \cdot l_{oa} + t_g - 2 \cdot g - d_{bh}\right) \cdot t_a \qquad A_{nt} = 760.494\ mm^2$$

Nominal strength in block shear

$$R_{n1} := 0.6 \cdot F_{ua} \cdot A_{nv} + F_{ua} \cdot A_{nt}$$

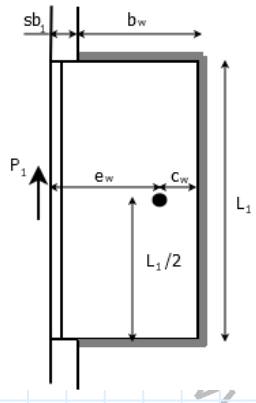
$$R_{n2} := 0.6 \cdot F_{ya} \cdot A_{gv} + F_{ua} \cdot A_{nt}$$

$$R_n := min\left(R_{n1}, R_{n2}\right) \qquad R_n = 804.523\ kN$$

Interaction ratio in block shear

$$I_{16} := \frac{2.0\ P_1}{R_n} \qquad I_{16} = 0.236$$

Weld check at connection 1



Length of horizontal run of weld

$$b_w := l_{ia} - sb_1 \qquad b_w = 76.9\ mm$$

Centroid of weld group

$$c_w := \frac{{b_w}^2}{2 \cdot b_w + L_1} \qquad c_w = 16.255\ mm$$

Eccentricity of shear force

$$e_w := l_{ia} - c_w \qquad e_w = 72.645\ mm$$

Polar moment of inertia of weld group

$$I_w := \frac{\left(2 \cdot b_w + L_1\right)^3}{12} - \frac{{b_w}^2 \cdot \left(b_w + L_1\right)^2}{2 \cdot b_w + L_1} \qquad I_w = 2674.44\ cm^3$$

Component of weld stress along x

$$f_{wx} := \frac{P_1 \cdot e_w \cdot L_1}{4 \cdot I_w} \qquad f_{wx} = 0.135\ \frac{kN}{mm}$$

Component of weld stress along y

$$f_{wy} := \frac{P_1}{2 \cdot \left(2 \cdot b_w + L_1\right)} + \frac{P_1 \cdot e_w \cdot \left(b_w - c_w\right)}{2\ I_w} \qquad f_{wy} = 0.209\ \frac{kN}{mm}$$

Resultant weld stress

$$f_w := \sqrt{f_{wx}^{\ 2} + f_{wy}^{\ 2}} \qquad f_w = 0.249\ \frac{kN}{mm}$$

Nominal weld strength

$$R_n := 0.6 \cdot F_{EXX} \cdot \frac{\sqrt{2}}{2} \cdot w \qquad R_n = 1.227\ \frac{kN}{mm}$$

Interaction ratio for weld check

$$I_{17} := \frac{2.0\ f_w}{R_n} \qquad I_{17} = 0.406$$

Gusset rupture at weld at connection 1

Minimum web thickness to match weld strength

$$t_{g.min} := \frac{2.0 \cdot 2 \cdot f_w}{0.6 \cdot F_{up}} \qquad t_{g.min} = 4.148\ mm$$

Interaction ratio in web rupture

$$I_{18} := \frac{t_{g.min}}{t_g} \qquad I_{18} = 0.259$$

Bolt shear at connection 2

Nominal slip resistance of bolt

$$R_n := \mu \cdot 1.13 \cdot T_{pre} \qquad R_n = 13.413\ kip$$

Interaction ratio in bolt shear

$$I_{19} := \frac{1.5\ P_{b2}}{R_n} \qquad I_{19} = 0.827$$

Bolt bearing at gusset plate at connection 2

Length of connection 2

$$L_2 := (n_2 - 1) \cdot s \qquad L_2 = 11.024\ in$$

Distance of gusset outer edge from work point

$$loc_{go} := g_2 + sb_1 + 0.5\ t_{wb1} \qquad loc_{go} = 20.335\ in$$

Distance of gusset inner edge from work point

$$loc_{gi} := c_2 + sb_1 + 0.5\ t_{wb1} - \mathbf{if}\left(c_1 = 0, 0, (g_{bm2} + ex_2) \cdot \frac{c_2}{c_1}\right) \qquad loc_{gi} = 3.603\ in$$

Outer edge distance for clip on gusset

$$ed_{go} := loc_{go} - loc_2 - L_2 \qquad ed_{go} = 1.437\ in$$

Inner edge distance for clip on gusset

$$ed_{gi} := loc_2 - loc_{gi} \qquad ed_{gi} = 4.271\ in$$

Minimum edge distance for clip on gusset

$$ed_g := min(ed_{go}, ed_{gi}) \qquad ed_g = 1.437\ in$$

Clear distance between bolt holes/ hole and edge

$$l_c := min(s - d_{bh}, ed_g - 0.5 \cdot d_{bh}) \qquad l_c = 0.965\ in$$

Nominal strength in bearing

$$R_n := min\left(1.2 \cdot l_c \cdot t_g \cdot F_{up}, 2.4 \cdot d_b \cdot t_g \cdot F_{up}\right) \qquad R_n = 42.317\ kip$$

Interaction ratio in bolt bearing

$$I_{20} := \frac{2.0\ P_{b2}}{R_n} \qquad I_{20} = 0.35$$

Bolt bearing at beam flange at connection 2

Edge distance of bolt to beam flange edge

$$ed_b := loc_2 - cp_2 - sbb_2 - 0.5\ t_{wb2} \qquad ed_b = 183.555\ mm$$

Clear distance between bolt holes/ hole and edge

$$l_c := min\left(s - d_{bh}, ed_b - 0.5 \cdot d_{bh}\right) \qquad l_c = 46\ mm$$

Nominal strength in bearing

$$R_n := min\left(1.2 \cdot l_c \cdot t_{fb2} \cdot F_{ub}, 2.4 \cdot d_b \cdot t_{fb2} \cdot F_{ub}\right) \qquad R_n = 373.032\ kN$$

Interaction ratio in bolt bearing

$$I_{21} := \frac{2.0\ P_{b2}}{R_n} \qquad I_{21} = 0.176$$

Gusset shear yielding at connection 2

Gross area in shear

$$A_g := \left(g_2 - c_2\right) \cdot t_g \qquad A_g = 8.68\ in^2$$

Nominal shear strength of gusset in yielding

$$R_n := 0.6 \cdot F_{yp} \cdot A_g \qquad R_n = 188.84\ kip$$

Interaction ratio in gusset yieldling

$$I_{22} := \frac{1.5\ P_2}{R_n} \qquad I_{22} = 0.294$$

Gusset shear rupture at connection 2

Net area in shear

$$A_n := A_g - n_2 \cdot d_{bh} \cdot t_g \qquad A_n = 5.704\ in^2$$

Nominal shear strength of gusset in rupture

$$R_n := 0.6 \cdot F_{up} \cdot A_n \qquad R_n = 198.551\ kip$$

Interaction ratio in shear rupture

$$I_{23} := \frac{2.0\ P_2}{R_n} \qquad I_{23} = 0.373$$

Gusset plate block shear at connection 2

Gross area subjected to block shear

$$A_{gv} := \left(L_2 + ed_g\right) \cdot t_g \qquad A_{gv} = 5064.16\ mm^2$$

Net area subjected to block shear

$$A_{nv} := A_{gv} - \left(n_2 - 0.5\right) \cdot d_{bh} \cdot t_g \qquad A_{nv} = 3336.16\ mm^2$$

Net area subjected to tension

$$A_{nt} := \left(g_{bm2} + ex_2 - 0.5\ d_{bh}\right) \cdot t_g \qquad A_{nt} = 1008\ mm^2$$

Nominal strength in block shear

$$R_{n1} := 0.6 \cdot F_{ua} \cdot A_{nv} + F_{ua} \cdot A_{nt}$$

$$R_{n2} := 0.6 \cdot F_{ya} \cdot A_{gv} + F_{ua} \cdot A_{nt}$$

$$R_n := min\left(R_{n1}, R_{n2}\right) \qquad R_n = \left(1.163 \cdot 10^3\right)\ kN$$

Interaction ratio in block shear

$$I_{24} := \frac{2.0\ P_2}{R_n} \qquad I_{24} = 0.283$$

Gusset flexure yielding at connection 2

Eccentricity of force at connection 2

$$ec_2 := \max\left(c_1 - ex_2, 0\right) \qquad ec_2 = 125\ mm$$

Nominal moment strenght of gusset

$$M_n := \frac{F_{yp} \cdot t_g \cdot {g_2}^2}{4} \qquad M_n = 250\ kN \cdot m$$

Interaction ratio in gusset flexure

$$I_{25} := \frac{1.67\ \left(P_2 \cdot ec_2\right)}{M_n} \qquad I_{25} = 0.137$$

Validation Results

The calculated ratios are compared with the output of Osoconn and if it is within a tolerance of 1% the result is deemed to be OK.

Table 7: Validation problem 6 results

	Interaction Ratio		
Check	Calculated	Osoconn	Result
Bolt shear at brace check	0.398	0.398	OK
Bolt bearing at brace check	0.289	0.289	OK
Bolt bearing at gusset check	0.458	0.458	OK
Brace tension rupture check	0.244	0.244	OK
Brace block shear check	0.288	0.288	OK
Gusset tension yielding check	0.342	0.342	OK
Gusset tension rupture check	0.323	0.323	OK
Gusset block shear check	0.342	0.342	OK
Bolt shear at connection 1	0.398	0.398	OK
Bolt bearing at clip angle at connection 1	0.301	0.301	OK
Bolt bearing at beam web at connection 1	0.148	0.148	OK
Gusset shear yielding at connection 1	0.17	0.17	OK
Gusset plate block shear at connection 1	0.165	0.165	OK
Gusset flexure yielding at connection 1	0.106	0.106	OK
Clip angle shear yielding at connection 1	0.237	0.237	OK
Clip angle shear rupture at connection 1	0.301	0.301	OK
Clip angle block shear at connection 1	0.236	0.236	OK
Weld check at connection 1	0.406	0.406	OK
Gusset rupture at weld at connection 1	0.259	0.259	OK
Bolt shear at connection 2	0.827	0.827	OK
Bolt bearing at gusset plate at connection 2	0.35	0.35	OK
Bolt bearing at beam web at connection 2	0.176	0.176	OK
Gusset shear yielding at connection 2	0.294	0.294	OK
Gusset shear rupture at connection 2	0.373	0.373	OK
Gusset plate block shear at connection 2	0.283	0.283	OK
Gusset flexure yielding at connection 2	0.137	0.137	OK

3 Osoconn Output

3.1 Validation problem 1

```
Osoconn v1.1
Connection code : HB001AM10
Connection ID : HB001_1
```

Design Summary	
Connection is OK	
Maximum interaction ratio	0.572
Design Input	
Design method	LRFD
Brace axial force (P)	35.000 kip
Beam steel grade	ASTM A36
Beam yield strength	36.000 ksi
Beam tensile strength	58.000 ksi
Angle steel grade	ASTM A36
Angle yield strength	36.000 ksi
Angle tensile strength	58.000 ksi
Plate steel grade	ASTM A36
Plate yield strength	36.000 ksi
Plate tensile strength	58.000 ksi
Number of bolts in gusset to brace connection	3
Number of bolt rows in gusset to brace connection	1
Number of bolts in connection 1 (n1)	3
Number of bolts in connection 2 (n2)	3
Bolt grade	ASTM A325
Bolt nominal tensile strength	90.000 ksi
Bolt type	Friction
Bolt thread in shear plane	Yes
Bolt diameter	0.875 in
Bolt gage on brace angle	1.750 in
Bolt spacing	2.500 in
Bolt distance to edge on brace in the direction of force	1.250 in
Weld electrode	E70
Weld tensile strength	70.000 ksi
Brace section	2 X L3-1/2X3-1/2X3/8
Brace angle from beam at connection 1 (theta)	45.000 deg
Orientation of back to back legs	Horizontal
Outstanding leg type	Short Leg
Gusset plate thickness	0.500 in

Gusset dimension along connection 1	15.000 in
Gusset dimension along connection 2	15.000 in
Gusset cutout along connection 1	4.000 in
Gusset cutout along connection 2	4.000 in
Connection type at connection 1	Clip Angle
Connection type at connection 2	Clip Angle
Clip angles at connection to beam	2 X L3-1/2X3X3/8
Thickness of clip to gusset weld	0.250 in
Bolt gage on clip angle	1.750 in
Section property of beam at connection 1	W12x40
Thickness of web	0.295 in
Thickness of flange	0.515 in
Width of fange	8.010 in
Section property of beam at connection 2	W14x48
Thickness of web	0.340 in
Thickness of flange	0.595 in
Width of fange	8.030 in

Design Calculation	
Bolt shear at brace check:	
Nominal strength of bolts in shear (Rn)	79.326 kip
LRFD factor in bolt shear (phi)	1.000
Allowable strength in bolt shear	
[Ra=phi*Rn]	79.326 kip
Interaction ratio in bolt shear	
[P/Ra]	0.441
Bolt bearing at brace check:	
Shear force per bolt in brace connection (Pb)	11.667 kip
Nominal strength in bolt bearing at brace (Rn)	20.391 kip
LRFD factor in bolt bearing (phi)	0.750
Allowable strength in bolt bearing at brace	
[Ra=phi*Rn]	15.293 kip
Interaction ratio in bolt bearing at brace	
[Pb/(2*Ra)]	0.381
Bolt bearing at gusset check:	
Nominal strength in bolt bearing at gusset plate	27.188 kip
LRFD factor in bolt bearing (phi)	0.750
Allowable strength in bolt bearing at gusset	
[Ra=phi*Rn]	20.391 kip
Interaction ratio in bolt bearing at gusset plate	
[Pb/Ra]	0.572
Brace tension rupture check:	
Gross area of brace	5.000 in^2
Shear Lag Factor (U)	0.800
Net area of brace (An)	4.297 in^2

Effective area for tensile rupture	
[Ae=An*U]	3.438 in^2
Nominal strength in brace rupture (Pn)	199.375 kip
LRFD factor in tension rupture (phi)	0.750
Allowable strength in brace rupture	
[Pa=phi*Pn]	149.531 kip
Interaction ratio in brace rupture	
[P/Pa]	0.234
Brace block shear check:	
Gross area in shear	4.688 in^2
Net area in shear	2.930 in^2
Net area in tension	0.961 in^2
Nominal block shear strength at brace (Rn)	156.984 kip
LRFD factor in block shear (phi)	0.750
Alloable block shear strength at brace	
[Ra=phi*Rn]	117.738 kip
Interaction ratio in block shear at brace	
[P/Ra]	0.297
Gusset tension yielding check:	
Lenght of Whitmore section	5.774 in
Gusset plate area in tension yielding	5.000 in^2
Nominal strength in gusset yielding (Pn)	103.923 kip
LRFD factor in tension yielding	
[phi]	0.900
Allowable strength of gusset tension yielding	
[Pa=phi*Pn]	93.531 kip
Interaction ratio in gusset plate tension yielding	
[P/Pa]	0.374
Gusset tension rupture check:	
Gusset plate net area in tension	2.418 in^2
Nominal strength in gusset rupture (Pn)	140.244 kip
LRFD factor in tension rupture	
[phi]	0.750
Allowable strength of gusset tension rupture	
[Pa=phi*Pn]	105.183 kip
Interaction ratio in gusset plate tension rupture	
[P/Pa]	0.333
Connection 1 Checks	

Component of brace force along connection 1	
[P1=P*cos(theta)]	24.749 kip
Force per bolt in connection 1	
[Pb1=P1/n1]	4.125 kip
Bolt shear check:	
Nominal strength in bolt shear (Rn)	13.221 kip
LRFD factor in bolt shear (phi)	1.000
Allowable strength in bolt shear	
[Ra=phi*Rn]	13.221 kip

Interaction ratio in bolt shear	
[Pb1/Ra]	0.312
Bolt bearing at clip angle check:	
Nominal strength in bolt bearing at clip angle (Rn)	17.128 kip
LRFD factor in bolt bearing (phi)	0.750
Allowable strength in bolt bearing at clip angle	
[Ra=phi*Rn]	12.846 kip
Interaction ratio in bolt bearing at clip angle	
[Pb1/Ra]	0.321
Bolt bearing at beam web check:	
Nominal strength in bolt bearing at beam web (Rn)	32.081 kip
LRFD factor in bolt bearing (phi)	0.750
Allowable strength in bolt bearing at beam web	
[Ra=phi*Rn]	24.061 kip
Interaction ratio in bolt bearing at beam web	
[Pb1/Ra]	0.171
Gusset shear yielding check:	
Gusset plate shear area	5.500 in^2
Nominal shear strength of gusset in yielding (Rn)	118.800 kip
LRFD factor in shear yielding (phi)	1.000
Allowable shear strength of gusset in yielding	
[Ra=phi*Rn]	118.800 kip
Interaction ratio in shear yielding at gusset	
[P1/Ra]	0.208
Gusset plate block shear check:	
Gross area in shear for block shear rupture	4.835 in^2
Net area in shear for block shear rupture	4.835 in^2
Net area in tension for block shear rupture	1.250 in^2
Nominal strength in block shear at gusset (Rn)	176.936 in^2
LRFD factor in BLOCK shear (phi)	0.750
Allowable strength in block shear at gusset plate	
[Ra=phi*Rn]	132.702 kip
Interaction ratio in block shear at gusset plate	
[P1/Ra]	0.186
Gusset flexure yielding check:	
Eccentricity of force at connection (e)	4.647 in
Nominal flexure strength of gusset in yielding (Mn)	1012.500 kip in
LRFD factor in flexure yielding (phi)	0.900
Allowable flexure strength of gusset in yielding	
[Ma=phi*Mn]	911.250 kip in
Interaction ratio in flexure yielding at gusset	
[P1*e/Ma]	0.126
Clip angle shear yielding check:	
Gross area in shear	5.438 in^2
Nominal shear yielding strength of connecting element (Rn)	117.450 kip
LRFD factor in shear yielding (phi)	1.000
Allowable shear yielding strength of connecting element	

[Ra=phi*Rn]	117.450 kip
Interaction ratio in shear yielding of element	
[P1/Ra]	0.211
Clip angle shear rupture check:	
Connecting element net area in shear	3.328 in^2
Nominal shear strength of connecting element in rupture (Rn)	115.819 kip
LRFD factor in shear rupture (phi)	0.750
Allowable shear strength of connecting element in rupture	
[Ra=phi*Rn]	86.864 kip
Interaction ratio in shear rupture of connecting element	
[P1/Ra]	0.285
Clip angle block shear check:	
Gross area in shear for block shear rupture	4.594 in^2
Net area in shear for block shear rupture	2.836 in^2
Net area in tension for block shear rupture	1.148 in^2
Nominal strength in block shear at shear tab (Rn)	165.300 kip
LRFD factor in block shear (phi)	0.750
Allowable strength in block shear at connecting element	
[Ra=phi*Rn]	123.975 kip
Interaction ratio in block shear at connecting element	
[P1/Ra]	0.200
Weld check:	
Maximum stress in weld (f)	1.920 kip/in
Nominal weld strength (fn)	7.423 kip/in
LRFD factor for weld strength(phi)	0.750
Allowable weld strength	
[fa=phi*fn]	5.568 kip/in
Interaction ratio for weld strength	
[f/fa]	0.345
Gusset rupture at weld check:	
Nominal strength of gusset at weld (Rn)	17.400 kip/in
LRFD factor for rupture at weld (phi)	0.750
Allowable strength of gusset rupture at weld	
[Ra=phi*Rn]	13.050 kip/in
Interaction ratio for gusset rupture at weld	
[P1/Ra]	0.294
Connection 2 Checks	

Component of brace force along connection 2	
[P2=P*sin(theta)]	24.749 kip
Force per bolt in connection 2	
[Pb2=P2/n2]	4.125 kip
Bolt shear check:	
Nominal strength in bolt shear (Rn)	13.221 kip
LRFD factor in bolt shear (phi)	1.000
Allowable strength in bolt shear	
[Ra=phi*Rn]	13.221 kip

Interaction ratio in bolt shear	
[Pb2/Ra]	0.312
Bolt bearing at clip angle check:	
Nominal strength in bolt bearing at clip angle (Rn)	17.128 kip
LRFD factor in bolt bearing (phi)	0.750
Allowable strength in bolt bearing at clip angle	
[Ra=phi*Rn]	12.846 kip
Interaction ratio in bolt bearing at clip angle	
[Pb2/Ra]	0.321
Bolt bearing at beam web check:	
Nominal strength in bolt bearing at beam web (Rn)	36.975 kip
LRFD factor in bolt bearing (phi)	0.750
Allowable strength in bolt bearing at beam web	
[Ra=phi*Rn]	27.731 kip
Interaction ratio in bolt bearing at beam web	
[Pb2/Ra]	0.149
Gusset shear yielding check:	
Gusset plate shear area	5.500 in^2
Nominal shear strength of gusset in yielding (Rn)	118.800 kip
LRFD factor in shear yielding (phi)	1.000
Allowable shear strength of gusset in yielding	
[Ra=phi*Rn]	118.800 kip
Interaction ratio in shear yielding at gusset	
[P2/Ra]	0.208
Gusset block shear check:	
Gross area in shear for block shear rupture	4.824 in^2
Net area in shear for block shear rupture	4.824 in^2
Net area in tension for block shear rupture	1.250 in^2
Nominal strength in block shear at gusset (Rn)	176.693 in^2
LRFD factor in BLOCK shear (phi)	0.750
Allowable strength in block shear at gusset plate	
[Ra=phi*Rn]	132.520 kip
Interaction ratio in block shear at gusset plate	
[P2/Ra]	0.187
Gusset flexure yielding check:	
Eccentricity of force at connection (e)	4.670 in
Nominal flexure strength of gusset in yielding (Mn)	1012.500 kip in
LRFD factor in flexure yielding (phi)	0.900
Allowable flexure strength of gusset in yielding	
[Ma=phi*Mn]	911.250 kip in
Interaction ratio in flexure yielding at gusset	
[P1*e/Ma]	0.127
Clip angle shear yielding check:	
Gross area in shear	5.438 in^2
Nominal shear yielding strength of connecting element (Rn)	117.450 kip
LRFD factor in shear yielding (phi)	1.000
Allowable shear yielding strength of connecting element	

```
      [Ra=phi*Rn]                                                    | 117.450 kip
   Interaction ratio in shear yielding of element                    |
      [P2/Ra]                                                        | 0.211
                                                                     |
Clip angle shear rupture check:                                      |
   Connecting element net area in shear                              | 3.328 in^2
   Nominal shear strength of connecting element in rupture (Rn)      | 115.819 kip
   LRFD factor in shear rupture (phi)                                | 0.750
   Allowable shear strength of connecting element in rupture         |
      [Ra=phi*Rn]                                                    | 86.864 kip
   Interaction ratio in shear rupture of connecting element          |
      [P2/Ra]                                                        | 0.285
                                                                     |
Clip angle block shear check:                                        |
   Gross area in shear for block shear rupture                       | 4.594 in^2
   Net area in shear for block shear rupture                         | 2.836 in^2
   Net area in tension for block shear rupture                       | 1.148 in^2
   Nominal strength in block shear at shear tab (Rn)                 | 165.300 kip
   LRFD factor in block shear (phi)                                  | 0.750
   Allowable strength in block shear at connecting element           |
      [Ra=phi*Rn]                                                    | 123.975 kip
   Interaction ratio in block shear at connecting element            |
      [P2/Ra]                                                        | 0.200
                                                                     |
Weld check:                                                          |
   Maximum stress in weld (f)                                        | 1.920 kip/in
   Nominal weld strength (fn)                                        | 7.423 kip/in
   LRFD factor for weld strength(phi)                                | 0.750
   Allowable weld strength                                           |
      [fa=phi*fn]                                                    | 5.568 kip/in
   Interaction ratio for weld strength                               |
      [f/fa]                                                         | 0.345
                                                                     |
Gusset rupture at weld check:                                        |
   Nominal strength of gusset at weld (Rn)                           | 17.400 kip
   LRFD factor for rupture at weld (phi)                             | 0.750
   Allowable strength of gusset rupture at weld                      |
      [Ra=phi*Rn]                                                    | 13.050 kip
   Interaction ratio for gusset rupture at weld                      |
      [P2/Ra]                                                        | 0.294
```

3.2 Validation problem 2

```
Osoconn v1.1
Connection code : HB001AM10
Connection ID : HB001_2
-------------------------------------------------------------------------+---------------------
Design Summary                                                           |
-------------------------------------------------------------------------+---------------------
   Connection is OK                                                      |
   Maximum interaction ratio                                             | 0.490
-------------------------------------------------------------------------+---------------------
Design Input                                                             |
```

Design method	LRFD
Brace axial force (P)	45.000 kip
Beam steel grade	ASTM A36
Beam yield strength	36.000 ksi
Beam tensile strength	58.000 ksi
Angle steel grade	ASTM A36
Angle yield strength	36.000 ksi
Angle tensile strength	58.000 ksi
Plate steel grade	ASTM A36
Plate yield strength	36.000 ksi
Plate tensile strength	58.000 ksi
Number of bolts in gusset to brace connection	3
Number of bolt rows in gusset to brace connection	1
Number of bolts in connection 1 (n1)	5
Number of bolts in connection 2 (n2)	4
Bolt grade	ASTM A325
Bolt nominal tensile strength	90.000 ksi
Bolt type	Bearing
Bolt thread in shear plane	Yes
Bolt diameter	0.875 in
Bolt gage on brace angle	1.750 in
Bolt spacing	2.500 in
Bolt distance to edge on brace in the direction of force	1.250 in
Weld electrode	E70
Weld tensile strength	70.000 ksi
Brace section	2 X L4X3X3/8
Brace angle from beam at connection 1 (theta)	35.000 deg
Orientation of back to back legs	Vertical
Outstanding leg type	Short Leg
Gusset plate thickness	0.500 in
Gusset dimension along connection 1	20.000 in
Gusset dimension along connection 2	20.000 in
Gusset cutout along connection 1	4.000 in
Gusset cutout along connection 2	4.000 in
Connection type at connection 1	Shear Tab
Connection type at connection 2	Shear Tab
Thickness of shear tab	0.500 in
Thickness of shear tab to beam weld	0.250 in
Bolt gage on shear tab (gs)	1.750 in
Section property of beam at connection 1	W10X30
Thickness of web	0.300 in

Thickness of flange	0.510 in
Width of fange	5.810 in
Section property of beam at connection 2	W10X19
Thickness of web	0.250 in
Thickness of flange	0.395 in
Width of fange	4.020 in
Design Calculation	
Bolt shear at brace check:	
Nominal strength of bolts in shear (Rn)	194.853 kip
LRFD factor in bolt shear (phi)	0.750
Allowable strength in bolt shear	
[Ra=phi*Rn]	146.140 kip
Interaction ratio in bolt shear	
[P/Ra]	0.308
Bolt bearing at brace check:	
Shear force per bolt in brace connection (Pb)	7.500 kip
Nominal strength in bolt bearing at brace (Rn)	20.391 kip
LRFD factor in bolt bearing (phi)	0.750
Allowable strength in bolt bearing at brace	
[Ra=phi*Rn]	15.293 kip
Interaction ratio in bolt bearing at brace	
[Pb/Ra]	0.490
Bolt bearing at gusset check:	
Nominal strength in bolt bearing at gusset plate	27.188 kip
LRFD factor in bolt bearing (phi)	0.750
Allowable strength in bolt bearing at gusset	
[Ra=phi*Rn]	20.391 kip
Interaction ratio in bolt bearing at gusset plate	
[Pb/Ra]	0.368
Brace tension rupture check:	
Gross area of brace	4.980 in^2
Shear Lag Factor (U)	0.845
Net area of brace (An)	4.277 in^2
Effective area for tensile rupture	
[Ae=An*U]	3.614 in^2
Nominal strength in brace rupture (Pn)	209.610 kip
LRFD factor in tension rupture (phi)	0.750
Allowable strength in brace rupture	
[Pa=phi*Pn]	157.207 kip
Interaction ratio in brace rupture	
[P/Pa]	0.286
Brace block shear check:	
Gross area in shear	4.688 in^2
Net area in shear	2.930 in^2
Net area in tension	1.336 in^2
Nominal block shear strength at brace (Rn)	178.734 kip

LRFD factor in block shear (phi)	0.750
Alloable block shear strength at brace	
[Ra=phi*Rn]	134.051 kip
Interaction ratio in block shear at brace	
[P/Ra]	0.336
Gusset tension yielding check:	
Lenght of Whitmore section	9.524 in
Gusset plate area in tension yielding	4.980 in^2
Nominal strength in gusset yielding (Pn)	171.423 kip
LRFD factor in tension yielding	
[phi]	0.900
Allowable strength of gusset tension yielding	
[Pa=phi*Pn]	154.281 kip
Interaction ratio in gusset plate tension yielding	
[P/Pa]	0.292
Gusset tension rupture check:	
Gusset plate net area in tension	3.824 in^2
Nominal strength in gusset rupture (Pn)	221.807 kip
LRFD factor in tension rupture	
[phi]	0.750
Allowable strength of gusset tension rupture	
[Pa=phi*Pn]	166.355 kip
Interaction ratio in gusset plate tension rupture	
[P/Pa]	0.271
Gusset block shear check:	
Gross area in shear	6.250 in^2
Net area in shear	3.906 in^2
Net area in tension	1.406 in^2
Nominal strength of gusset in block shear (Rn)	216.562 kip
LRFD factor in block shear (phi)	0.750
Allowable strength og gusset in block shear	
[Ra=phi*Rn]	162.422 kip
Interaction ratio in block shear at gusset plate	
[P/Ra]	0.277
Connection 1 Checks	

Component of brace force along connection 1	
[P1=P*cos(theta)]	36.862 kip
Force per bolt in connection 1	
[Pb1=P1/n1]	7.372 kip
Bolt shear check:	
Nominal strength in bolt shear (Rn)	32.476 kip
LRFD factor in bolt shear (phi)	0.750
Allowable strength in bolt shear	
[Ra=phi*Rn]	24.357 kip
Interaction ratio in bolt shear	
[Pb1/Ra]	0.303

Bolt bearing at shear tab check:	
Nominal strength in bolt bearing at shear tab (Rn)	22.837 kip
LRFD factor in bolt bearing (phi)	0.750
Allowable strength in bolt bearing at shear tab	
[Ra=phi*Rn]	17.128 kip
Interaction ratio in bolt bearing at shear tab	
[Pb1/Ra]	0.430
Bolt bearing at gusset check:	
Nominal strength in bolt bearing at gusset (Rn)	54.375 kip
LRFD factor in bolt bearing (phi)	0.750
Allowable strength in bolt bearing at gusset	
[Ra=phi*Rn]	40.781 kip
Interaction ratio in bolt bearing at gusset	
[Pb1/Ra]	0.181
Gusset shear yielding check:	
Gusset plate shear area	8.000 in^2
Nominal shear strength of gusset in yielding (Rn)	172.800 kip
LRFD factor in shear yielding (phi)	1.000
Allowable shear strength of gusset in yielding	
[Ra=phi*Rn]	172.800 kip
Interaction ratio in shear yielding at gusset	
[P1/Ra]	0.213
Gusset shear rupture check:	
Gusset gross area in shear	8.000 in^2
Gusset net area in shear	5.656 in^2
Nominal shear strength of gusset in rupture (Rn)	196.837 kip
LRFD factor in shear rupture (phi)	0.750
Allowable shear strength of gusset in rupture	
[phi*Rn]	147.628 kip
Interaction ratio in shear rupture of gusset	
[P1/Ra]	0.250
Gusset plate block shear check:	
Gross area in shear for block shear rupture	6.750 in^2
Net area in shear for block shear rupture	4.641 in^2
Net area in tension for block shear rupture	0.391 in^2
Nominal strength in block shear at gusset (Rn)	168.456 in^2
LRFD factor in BLOCK shear (phi)	0.750
Allowable strength in block shear at gusset plate	
[Ra=phi*Rn]	126.342 kip
Interaction ratio in block shear at gusset plate	
[P1/Ra]	0.292
Gusset flexure yielding check:	
Eccentricity of force at connection (e)	4.650 in
Nominal flexure strength of gusset in yielding (Mn)	1800.000 kip in
LRFD factor in flexure yielding (phi)	0.900
Allowable flexure strength of gusset in yielding	
[Ma=phi*Mn]	1620.000 kip in
Interaction ratio in flexure yielding at gusset	

[P1*e/Ma]	0.106
Shear tab shear yielding check:	
Gross area in shear	6.125 in^2
Nominal shear yielding strength of connecting element (Rn)	132.300 kip
LRFD factor in shear yielding (phi)	1.000
Allowable shear yielding strength of connecting element	
[Ra=phi*Rn]	132.300 kip
Interaction ratio in shear yielding of element	
[P1/Ra]	0.279
Shear tab shear rupture check:	
Connecting element net area in shear	3.781 in^2
Nominal shear strength of connecting element in rupture (Rn)	131.587 kip
LRFD factor in shear rupture (phi)	0.750
Allowable shear strength of connecting element in rupture	
[Ra=phi*Rn]	98.691 kip
Interaction ratio in shear rupture of connecting element	
[P1/Ra]	0.374
Shear tab block shear check:	
Gross area in shear for block shear rupture	5.562 in^2
Net area in shear for block shear rupture	3.453 in^2
Net area in tension for block shear rupture	0.641 in^2
Nominal strength in block shear at shear tab (Rn)	157.306 kip
LRFD factor in block shear (phi)	0.750
Allowable strength in block shear at connecting element	
[Ra=phi*Rn]	117.980 kip
Interaction ratio in block shear at connecting element	
[P1/Ra]	0.312
Shear tab flexure yeilding check:	
Nominal flexure yeilding strength of connecting element (Mn)	675.281 kip in
LRFD factor in flexure (phi)	0.900
Allowable strength of connecting element in flexure	
[Ma=phi*Mn]	607.753 kip in
Interaction ratio in flexure yielding of connecting element	
[P1*gs/Ma]	0.106
Weld check:	
Maximum stress in weld (f)	1.982 kip/in
Nominal weld strength (fn)	7.423 kip/in
LRFD factor for weld strength(phi)	0.750
Allowable weld strength	
[fa=phi*fn]	5.568 kip/in
Interaction ratio for weld strength	
[f/fa]	0.356
Shear tab rupture at weld check:	
Nominal strength of shear tab rupture at weld (Rn)	17.400 kip/in
LRFD factor for rupture at weld (phi)	0.750
Allowable strength of shear tab rupture at weld	
[Ra=phi*Rn]	13.050 kip/in

Interaction ratio for shear tab rupture at weld [P1/Ra]	0.304
Beam web rupture at weld check:	
Nominal strength of beam web at weld (Rn)	10.440 kip/in
LRFD factor for rupture at weld (phi)	0.750
Allowable strength of beam web rupture at weld [Ra=phi*Rn]	7.830 kip/in
Interaction ratio for beam web rupture at weld [P1/Ra]	0.253
Connection 2 Checks	

Component of brace force along connection 2 [P2=P*sin(theta)]	25.811 kip
Force per bolt in connection 2 [Pb2=P2/n2]	6.453 kip
Bolt shear check:	
Nominal strength in bolt shear (Rn)	32.476 kip
LRFD factor in bolt shear (phi)	0.750
Allowable strength in bolt shear [Ra=phi*Rn]	24.357 kip
Interaction ratio in bolt shear [Pb2/Ra]	0.265
Bolt bearing at shear tab check:	
Nominal strength in bolt bearing at shear tab (Rn)	22.837 kip
LRFD factor in bolt bearing (phi)	0.750
Allowable strength in bolt bearing at shear tab [Ra=phi*Rn]	17.128 kip
Interaction ratio in bolt bearing at shear tab [Pb2/Ra]	0.377
Bolt bearing at gusset check:	
Nominal strength in bolt bearing at gusset (Rn)	54.375 kip
LRFD factor in bolt bearing (phi)	0.750
Allowable strength in bolt bearing at gusset [Ra=phi*Rn]	40.781 kip
Interaction ratio in bolt bearing at gusset [Pb2/Ra]	0.158
Gusset shear yielding check:	
Gusset plate shear area	8.000 in^2
Nominal shear strength of gusset in yielding (Rn)	172.800 kip
LRFD factor in shear yielding (phi)	1.000
Allowable shear strength of gusset in yielding [Ra=phi*Rn]	172.800 kip
Interaction ratio in shear yielding at gusset [P2/Ra]	0.149
Gusset shear rupture check:	
Gusset gross area in shear	8.000 in^2

Gusset net area in shear	6.125 in^2
Nominal shear strength of gusset in rupture (Rn)	213.150 kip
LRFD factor in shear rupture (phi)	0.750
Allowable shear strength of gusset in rupture	
[phi*Rn]	159.862 kip
Interaction ratio in shear rupture of gusset	
[P2/Ra]	0.161
Gusset block shear check:	
Gross area in shear for block shear rupture	5.612 in^2
Net area in shear for block shear rupture	3.972 in^2
Net area in tension for block shear rupture	0.391 in^2
Nominal strength in block shear at gusset (Rn)	143.886 in^2
LRFD factor in BLOCK shear (phi)	0.750
Allowable strength in block shear at gusset plate	
[Ra=phi*Rn]	107.915 kip
Interaction ratio in block shear at gusset plate	
[P2/Ra]	0.239
Gusset flexure yielding check:	
Eccentricity of force at connection (e)	4.625 in
Nominal flexure strength of gusset in yielding (Mn)	1800.000 kip in
LRFD factor in flexure yielding (phi)	0.900
Allowable flexure strength of gusset in yielding	
[Ma=phi*Mn]	1620.000 kip in
Interaction ratio in flexure yielding at gusset	
[P1*e/Ma]	0.074
Shear tab shear yielding check:	
Gross area in shear	4.875 in^2
Nominal shear yielding strength of connecting element (Rn)	105.300 kip
LRFD factor in shear yielding (phi)	1.000
Allowable shear yielding strength of connecting element	
[Ra=phi*Rn]	105.300 kip
Interaction ratio in shear yielding of element	
[P2/Ra]	0.245
Shear tab shear rupture check:	
Connecting element net area in shear	3.000 in^2
Nominal shear strength of connecting element in rupture (Rn)	104.400 kip
LRFD factor in shear rupture (phi)	0.750
Allowable shear strength of connecting element in rupture	
[Ra=phi*Rn]	78.300 kip
Interaction ratio in shear rupture of connecting element	
[P2/Ra]	0.330
Shear tab block shear check:	
Gross area in shear for block shear rupture	4.312 in^2
Net area in shear for block shear rupture	2.672 in^2
Net area in tension for block shear rupture	0.641 in^2
Nominal strength in block shear at shear tab (Rn)	130.137 kip
LRFD factor in block shear (phi)	0.750
Allowable strength in block shear at connecting element	

[Ra=phi*Rn]	97.603 kip
Interaction ratio in block shear at connecting element	
[P2/Ra]	0.264
Shear tab flexure yeilding check:	
Nominal flexure yeilding strength of connecting element (Mn)	427.781 kip in
LRFD factor in flexure (phi)	0.900
Allowable strength of connecting element in flexure	
[Ma=phi*Mn]	385.003 kip in
Interaction ratio in flexure yielding of connecting element	
[P2*gs/Ma]	0.117
Weld check:	
Maximum stress in weld (f)	1.945 kip/in
Nominal weld strength (fn)	7.423 kip/in
LRFD factor for weld strength(phi)	0.750
Allowable weld strength	
[fa=phi*fn]	5.568 kip/in
Interaction ratio for weld strength	
[f/fa]	0.349
Shear tab rupture at weld check:	
Nominal strength of shear tab rupture at weld (Rn)	17.400 kip
LRFD factor for rupture at weld (phi)	0.750
Allowable strength of shear tab rupture at weld	
[Ra=phi*Rn]	13.050 kip
Interaction ratio for shear tab rupture at weld	
[P2/Ra]	0.298
Beam web rupture at weld check:	
Nominal strength of beam web at weld (Rn)	8.700 kip
LRFD factor for rupture at weld (phi)	0.750
Allowable strength of beam web rupture at weld	
[Ra=phi*Rn]	6.525 kip
Interaction ratio for beam web rupture at weld	
[P2/Ra]	0.298

3.3 Validation problem 3

Osoconn v1.1
Connection code : HB001AM10
Connection ID : HB001_3

Design Summary	
Connection is OK	
Maximum interaction ratio	0.818
Design Input	
Design method	LRFD
Brace axial force (P)	65.000 kip

Beam steel grade	ASTM A992
Beam yield strength	50.000 ksi
Beam tensile strength	65.000 ksi
Angle steel grade	ASTM A36
Angle yield strength	36.000 ksi
Angle tensile strength	58.000 ksi
Plate steel grade	ASTM A36
Plate yield strength	36.000 ksi
Plate tensile strength	58.000 ksi
Number of bolts in gusset to brace connection	3
Number of bolt rows in gusset to brace connection	2
Number of bolts in connection 1 (n1)	3
Number of bolts in connection 2 (n2)	3
Bolt grade	ASTM A490
Bolt nominal tensile strength	113.000 ksi
Bolt type	Friction
Bolt thread in shear plane	Yes
Bolt diameter	1.000 in
Bolt gage on brace angle	2.000 in
Bolt spacing	3.000 in
Bolt distance to edge on brace in the direction of force	1.500 in
Weld electrode	E70
Weld tensile strength	70.000 ksi
Brace section	2 X L6X4X5/16
Brace angle from beam at connection 1 (theta)	55.000 deg
Orientation of back to back legs	Horizontal
Outstanding leg type	Short Leg
Gusset plate thickness	0.500 in
Gusset dimension along connection 1	15.000 in
Gusset dimension along connection 2	15.000 in
Gusset cutout along connection 1	0.000 in
Gusset cutout along connection 2	0.000 in
Connection type at connection 1	Bolted to Flange
Connection type at connection 2	Bolted to Flange
Section property of beam at connection 1	W12X58
Thickness of web	0.360 in
Thickness of flange	0.640 in
Width of fange	10.000 in
Section property of beam at connection 2	W12X58
Thickness of web	0.360 in
Thickness of flange	0.640 in
Width of fange	10.000 in

Design Calculation	
Bolt shear at brace check:	
Nominal strength of bolts in shear (Rn)	260.352 kip
LRFD factor in bolt shear (phi)	1.000
Allowable strength in bolt shear	
[Ra=phi*Rn]	260.352 kip
Interaction ratio in bolt shear	
[P/Ra]	0.250
Bolt bearing at brace check:	
Shear force per bolt in brace connection (Pb)	10.833 kip
Nominal strength in bolt bearing at brace (Rn)	21.104 kip
LRFD factor in bolt bearing (phi)	0.750
Allowable strength in bolt bearing at brace	
[Ra=phi*Rn]	15.828 kip
Interaction ratio in bolt bearing at brace	
[Pb/(2*Ra)]	0.342
Bolt bearing at gusset check:	
Nominal strength in bolt bearing at gusset plate	33.712 kip
LRFD factor in bolt bearing (phi)	0.750
Allowable strength in bolt bearing at gusset	
[Ra=phi*Rn]	25.284 kip
Interaction ratio in bolt bearing at gusset plate	
[Pb/Ra]	0.428
Brace tension rupture check:	
Gross area of brace	6.060 in^2
Shear Lag Factor (U)	0.849
Net area of brace (An)	4.730 in^2
Effective area for tensile rupture	
[Ae=An*U]	4.014 in^2
Nominal strength in brace rupture (Pn)	232.811 kip
LRFD factor in tension rupture (phi)	0.750
Allowable strength in brace rupture	
[Pa=phi*Pn]	174.608 kip
Interaction ratio in brace rupture	
[P/Pa]	0.372
Brace block shear check:	
Gross area in shear	4.695 in^2
Net area in shear	3.032 in^2
Net area in tension	1.506 in^2
Nominal block shear strength at brace (Rn)	188.778 kip
LRFD factor in block shear (phi)	0.750
Alloable block shear strength at brace	
[Ra=phi*Rn]	141.584 kip
Interaction ratio in block shear at brace	
[P/Ra]	0.459
Gusset tension yielding check:	

Lenght of Whitmore section	8.678 in
Gusset plate area in tension yielding	6.060 in^2
Nominal strength in gusset yielding (Pn)	156.208 kip
LRFD factor in tension yielding	
[phi]	0.900
Allowable strength of gusset tension yielding	
[Pa=phi*Pn]	140.587 kip
Interaction ratio in gusset plate tension yielding	
[P/Pa]	0.462
Gusset tension rupture check:	
Gusset plate net area in tension	3.277 in^2
Nominal strength in gusset rupture (Pn)	190.043 kip
LRFD factor in tension rupture	
[phi]	0.750
Allowable strength of gusset tension rupture	
[Pa=phi*Pn]	142.532 kip
Interaction ratio in gusset plate tension rupture	
[P/Pa]	0.456
Gusset block shear check:	
Gross area in shear	7.500 in^2
Net area in shear	4.844 in^2
Net area in tension	0.344 in^2
Nominal strength of gusset in block shear (Rn)	181.937 kip
LRFD factor in block shear (phi)	0.750
Allowable strength og gusset in block shear	
[Ra=phi*Rn]	136.453 kip
Interaction ratio in block shear at gusset plate	
[P/Ra]	0.476
Connection 1 Checks	

Component of brace force along connection 1	
[P1=P*cos(theta)]	37.282 kip
Force per bolt in connection 1	
[Pb1=P1/n1]	12.427 kip
Bolt shear check:	
Nominal strength in bolt shear (Rn)	21.696 kip
LRFD factor in bolt shear (phi)	1.000
Allowable strength in bolt shear	
[Ra=phi*Rn]	21.696 kip
Interaction ratio in bolt shear	
[Pb1/Ra]	0.573
Bolt bearing at gusset check:	
Nominal strength in bolt bearing at gusset (Rn)	67.425 kip
LRFD factor in bolt bearing (phi)	0.750
Allowable strength in bolt bearing at gusset	
[Ra=phi*Rn]	50.569 kip
Interaction ratio in bolt bearing at gusset	
[Pb1/Ra]	0.246

Bolt bearing at beam flange check:	
Nominal strength in bolt bearing at beam flange (Rn)	39.374 kip
LRFD factor in bolt bearing (phi)	0.750
Allowable strength in bolt bearing at beam flange [Ra=phi*Rn]	29.531 kip
Interaction ratio in bolt bearing at beam flange [Pb1/Ra]	0.421
Gusset shear yielding check:	
Gusset plate shear area	7.500 in^2
Nominal shear strength of gusset in yielding (Rn)	162.000 kip
LRFD factor in shear yielding (phi)	1.000
Allowable shear strength of gusset in yielding [Ra=phi*Rn]	162.000 kip
Interaction ratio in shear yielding at gusset [P1/Ra]	0.230
Gusset shear rupture check:	
Gusset gross area in shear	7.500 in^2
Gusset net area in shear	5.906 in^2
Nominal shear strength of gusset in rupture (Rn)	205.537 kip
LRFD factor in shear rupture (phi)	0.750
Allowable shear strength of gusset in rupture [phi*Rn]	154.153 kip
Interaction ratio in shear rupture of gusset [P1/Ra]	0.242
Gusset plate block shear check:	
Gross area in shear for block shear rupture	4.250 in^2
Net area in shear for block shear rupture	2.922 in^2
Net area in tension for block shear rupture	1.484 in^2
Nominal strength in block shear at gusset (Rn)	177.894 in^2
LRFD factor in BLOCK shear (phi)	0.750
Allowable strength in block shear at gusset plate [Ra=phi*Rn]	133.420 kip
Interaction ratio in block shear at gusset plate [P1/Ra]	0.279
Gusset flexure yielding check:	
Eccentricity of force at connection (e)	0.000 in
Nominal flexure strength of gusset in yielding (Mn)	1012.500 kip in
LRFD factor in flexure yielding (phi)	0.900
Allowable flexure strength of gusset in yielding [Ma=phi*Mn]	911.250 kip in
Interaction ratio in flexure yielding at gusset [P1*e/Ma]	0.000
Connection 2 Checks	

Component of brace force along connection 2 [P2=P*sin(theta)]	53.245 kip
Force per bolt in connection 2	

[Pb2=P2/n2]	17.748 kip
Bolt shear check:	
Nominal strength in bolt shear (Rn)	21.696 kip
LRFD factor in bolt shear (phi)	1.000
Allowable strength in bolt shear	
[Ra=phi*Rn]	21.696 kip
Interaction ratio in bolt shear	
[Pb2/Ra]	0.818
Bolt bearing at gusset check:	
Nominal strength in bolt bearing at gusset (Rn)	67.425 kip
LRFD factor in bolt bearing (phi)	0.750
Allowable strength in bolt bearing at gusset	
[Ra=phi*Rn]	50.569 kip
Interaction ratio in bolt bearing at gusset	
[Pb2/Ra]	0.351
Bolt bearing at beam flange check:	
Nominal strength in bolt bearing at beam flange (Rn)	96.720 kip
LRFD factor in bolt bearing (phi)	0.750
Allowable strength in bolt bearing at beam flange	
[Ra=phi*Rn]	72.540 kip
Interaction ratio in bolt bearing at beam flange	
[Pb2/Ra]	0.245
Gusset shear yielding check:	
Gusset plate shear area	7.500 in^2
Nominal shear strength of gusset in yielding (Rn)	162.000 kip
LRFD factor in shear yielding (phi)	1.000
Allowable shear strength of gusset in yielding	
[Ra=phi*Rn]	162.000 kip
Interaction ratio in shear yielding at gusset	
[P2/Ra]	0.329
Gusset shear rupture check:	
Gusset gross area in shear	7.500 in^2
Gusset net area in shear	5.906 in^2
Nominal shear strength of gusset in rupture (Rn)	205.537 kip
LRFD factor in shear rupture (phi)	0.750
Allowable shear strength of gusset in rupture	
[phi*Rn]	154.153 kip
Interaction ratio in shear rupture of gusset	
[P2/Ra]	0.345
Gusset block shear check:	
Gross area in shear for block shear rupture	4.250 in^2
Net area in shear for block shear rupture	2.922 in^2
Net area in tension for block shear rupture	1.484 in^2
Nominal strength in block shear at gusset (Rn)	177.894 in^2
LRFD factor in BLOCK shear (phi)	0.750
Allowable strength in block shear at gusset plate	
[Ra=phi*Rn]	133.420 kip

Interaction ratio in block shear at gusset plate [P2/Ra]	0.399
Gusset flexure yielding check:	
Eccentricity of force at connection (e)	0.000 in
Nominal flexure strength of gusset in yielding (Mn)	1012.500 kip in
LRFD factor in flexure yielding (phi)	0.900
Allowable flexure strength of gusset in yielding [Ma=phi*Mn]	911.250 kip in
Interaction ratio in flexure yielding at gusset [P1*e/Ma]	0.000

3.4 Validation problem 4

Osoconn v1.1
Connection code : HB001AM10
Connection ID : HB001_4

Design Summary	
Connection is OK	
Maximum interaction ratio	0.514
Design Input	
Design method	ASD
Brace axial force (P)	105000.000 N
Beam steel grade	ASTM A992
Beam yield strength	345.000 MPa
Beam tensile strength	450.000 MPa
Angle steel grade	ASTM A36
Angle yield strength	250.000 MPa
Angle tensile strength	400.000 MPa
Plate steel grade	ASTM A36
Plate yield strength	250.000 MPa
Plate tensile strength	400.000 MPa
Number of bolts in gusset to brace connection	4
Number of bolt rows in gusset to brace connection	1
Number of bolts in connection 1 (n1)	4
Number of bolts in connection 2 (n2)	4
Bolt grade	ASTM A325
Bolt nominal tensile strength	620.000 MPa
Bolt type	Friction
Bolt thread in shear plane	Yes
Bolt diameter	24.000 mm
Bolt gage on brace angle	55.000 mm
Bolt spacing	70.000 mm
Bolt distance to edge on brace in the direction of force	35.000 mm

Weld electrode	E70
Weld tensile strength	482.000 MPa
Brace section	2 X L102X89X12.7
Brace angle from beam at connection 1 (theta)	65.000 deg
Orientation of back to back legs	Horizontal
Outstanding leg type	Short Leg
Gusset plate thickness	12.000 mm
Gusset dimension along connection 1	500.000 mm
Gusset dimension along connection 2	500.000 mm
Gusset cutout along connection 1	125.000 mm
Gusset cutout along connection 2	125.000 mm
Connection type at connection 1	Clip Angle
Connection type at connection 2	Shear Tab
Thickness of shear tab	12.000 mm
Thickness of shear tab to beam weld	6.000 mm
Bolt gage on shear tab (gs)	50.000 mm
Clip angles at connection to beam	2 X L89X89X9.5
Thickness of clip to gusset weld	6.000 mm
Bolt gage on clip angle	45.000 mm
Section property of beam at connection 1	W360X64
Thickness of web	7.750 mm
Thickness of flange	13.500 mm
Width of fange	203.000 mm
Section property of beam at connection 2	W310X38.7
Thickness of web	5.840 mm
Thickness of flange	9.650 mm
Width of fange	165.000 mm

Design Calculation	
Bolt shear at brace check:	
Nominal strength of bolts in shear (Rn)	555960.000 N
ASD factor in bolt shear (omega)	1.500
Allowable strength in bolt shear	
[Ra=Rn/omega]	370640.000 N
Interaction ratio in bolt shear	
[P/Ra]	0.283
Bolt bearing at brace check:	
Shear force per bolt in brace connection (Pb)	26250.000 N
Nominal strength in bolt bearing at brace (Rn)	131064.000 N
ASD factor in bolt bearing (omega)	2.000
Allowable strength in bolt bearing	
[Ra=Rn/omega]	65532.000 N
Interaction ratio in bolt bearing at brace	
[Pb/(2*Ra)]	0.200

Bolt bearing at gusset check:	
Nominal strength in bolt bearing at gusset plate	123840.000 N
ASD factor in bolt bearing (omega)	2.000
Allowable strength in bolt bearing at gusset [Ra=Rn/omega]	61920.000 N
Interaction ratio in bolt bearing at gusset plate [Pb/Ra]	0.424
Brace tension rupture check:	
Gross area of brace	4520.000 mm^2
Shear Lag Factor (U)	0.880
Net area of brace (An)	3834.200 mm^2
Effective area for tensile rupture [Ae=An*U]	3374.096 mm^2
Nominal strength in brace rupture (Pn)	1349638.400 N
ASD factor in tension rupture (omega)	2.000
Allowable strength in brace rupture [Pa=Pn/omega]	674819.200 N
Interaction ratio in brace rupture [P/Pa]	0.156
Brace block shear check:	
Gross area in shear	6223.000 mm^2
Net area in shear	3822.700 mm^2
Net area in tension	850.900 mm^2
Nominal block shear strength at brace (Rn)	1257808.000 N
ASD factor in block shear (omega)	2.000
Allowable block shear strength at brace [cap= Rn/omega]	628904.000 N
Interaction ratio in block shear at brace [P/Ra]	0.167
Gusset tension yielding check:	
Lenght of Whitmore section	242.487 mm
Gusset plate area in tension yielding	4520.000 mm^2
Nominal strength in gusset yielding (Pn)	727461.339 N
ASD factor in tension yielding [omega]	1.670
Allowable strength of gusset in tension yielding [Pa=Pn/omega]	435605.592 N
Interaction ratio in gusset plate tension yielding [P/Pa]	0.241
Gusset tension rupture check:	
Gusset plate net area in tension	2585.845 mm^2
Nominal strength in gusset rupture (Pn)	1034338.143 N
ASD factor in tension rupture [omega]	2.000
Allowable strength of gusset in tension rupture [Pa=Pn/omega]	517169.071 N
Interaction ratio in gusset plate tension rupture [P/Pa]	0.203

Connection 1 Checks	

Component of brace force along connection 1	
[P1=P*cos(theta)]	44374.917 N
Force per bolt in connection 1	
[Pb1=P1/n1]	5546.865 N
Bolt shear check:	
Nominal strength in bolt shear (Rn)	69495.000 N
ASD factor in bolt shear (omega)	1.500
Allowable strength in bolt shear	
[Ra=Rn/omega]	46330.000 N
Interaction ratio in bolt shear	
[Pb1/Ra]	0.120
Bolt bearing at clip angle check:	
Nominal strength in bolt bearing at clip angle (Rn)	98349.600 N
ASD factor in bolt shear (omega)	2.000
Allowable strength in bolt bearing at clip angle	
[Ra=Rn/omega]	49174.800 N
Interaction ratio in bolt bearing at clip angle	
[Pb1/Ra]	0.113
Bolt bearing at beam web check:	
Nominal strength in bolt bearing at beam web (Rn)	179955.000 N
ASD factor in bolt shear (omega)	2.000
Allowable strength in bolt bearing at beam web	
[Ra=Rn/omega]	89977.500 N
Interaction ratio in bolt bearing at beam web	
[Pb1/Ra]	0.062
Gusset shear yielding check:	
Gusset plate shear area	4500.000 mm^2
Nominal shear strength of gusset in yielding (Rn)	675000.000 N
ASD factor in shear yielding (omega)	1.500
Allowable shear strength of gusset in yielding	
[Ra=Rn/omega]	450000.000 N
Interaction ratio in shear yielding at gusset	
[P1/Ra]	0.099
Gusset plate block shear check:	
Gross area in shear for block shear rupture	4379.040 mm^2
Net area in shear for block shear rupture	4379.040 mm^2
Net area in tension for block shear rupture	922.800 mm^2
Nominal strength in block shear at gusset (Rn)	1025976.000 mm^2
ASD factor in block shear (omega)	2.000
Allowable strength in block shear at gusset plate	
[Ra=Rn/omega]	512988.000 N
Interaction ratio in block shear at gusset plate	
[P1/Ra]	0.087
Gusset flexure yielding check:	

Eccentricity of force at connection (e)	140.875 mm
Nominal flexure strength of gusset in yielding (Mn)	187500000.000 N mm
ASD factor in flexure yielding (omega)	1.670
Allowable flexure strength of gusset in yielding	
[Ma=Mn/omega]	112275449.102 N mm
Interaction ratio in flexure yielding at gusset	
[P1*e/Ma]	0.056
Clip angle shear yielding check:	
Gross area in shear	5336.800 mm^2
Nominal shear yielding strength of connecting element (Rn)	800520.000 N
ASD factor in shear yielding (omega)	1.500
Allowable shear yielding strength of connecting element	
[Ra=Rn/omega]	533680.000 N
Interaction ratio in shear yielding of element	
[P1/Ra]	0.083
Clip angle shear rupture check:	
Connecting element net area in shear	3278.320 mm^2
Nominal shear strength of connecting element in rupture (Rn)	786796.800 N
ASD factor in shear rupture (omega)	2.000
Allowable shear strength of connecting element in rupture	
[Ra=Rn/omega]	393398.400 N
Interaction ratio in shear rupture of connecting element	
[P1/Ra]	0.113
Clip angle block shear check:	
Gross area in shear for block shear rupture	4669.700 mm^2
Net area in shear for block shear rupture	2868.530 mm^2
Net area in tension for block shear rupture	693.784 mm^2
Nominal strength in block shear at shear tab (Rn)	965960.800 N
ASD factor in block shear (omega)	2.000
Allowable strength in block shear at connecting element	
[Ra=Rn/omega]	482980.400 N
Interaction ratio in block shear at connecting element	
[P1/Ra]	0.092
Weld check:	
Maximum stress in weld (f)	85.521 N/mm
Nominal weld strength (fn)	1226.786 N/mm
ASD factor for weld strength (omega)	2.000
Allowable weld strength	
[fa=fn/omega]	613.393 N/mm
Interaction ratio for weld strength	
[f/fa]	0.139
Gusset rupture at weld check:	
Nominal strength of gusset at weld (Rn)	2880.000 N/mm
ASD factor for rupture at weld (omega)	2.000
Allowable strength of gusset rupture at weld	
[Ra=Rn/omega]	1440.000 N/mm
Interaction ratio for gusset rupture at weld	
[P1/Ra]	0.119

Connection 2 Checks	

Component of brace force along connection 2	
[P2=P*sin(theta)]	95162.318 N
Force per bolt in connection 2	
[Pb2=P2/n2]	23790.579 N
Bolt shear check:	
Nominal strength in bolt shear (Rn)	69495.000 N
ASD factor in bolt shear (omega)	1.500
Allowable strength in bolt shear	
[Ra=Rn/omega]	46330.000 N
Interaction ratio in bolt shear	
[Pb2/Ra]	0.514
Bolt bearing at shear tab check:	
Nominal strength in bolt bearing at shear tab (Rn)	123840.000 N
ASD factor in bolt shear (omega)	2.000
Allowable strength in bolt bearing at shear tab	
[Ra=Rn/omega]	61920.000 N
Interaction ratio in bolt bearing at shear tab	
[Pb2/Ra]	0.384
Bolt bearing at gusset check:	
Nominal strength in bolt bearing at gusset (Rn)	247680.000 N
ASD factor in bolt shear (omega)	2.000
Allowable strength in bolt bearing at gusset	
[Ra=Rn/omega]	123840.000 N
Interaction ratio in bolt bearing at gusset	
[Pb2/Ra]	0.192
Gusset shear yielding check:	
Gusset plate shear area	4500.000 mm^2
Nominal shear strength of gusset in yielding (Rn)	675000.000 N
ASD factor in shear yielding (omega)	1.500
Allowable shear strength of gusset in yielding	
[Ra=Rn/omega]	450000.000 N
Interaction ratio in shear yielding at gusset	
[P2/Ra]	0.211
Gusset shear rupture check:	
Gusset gross area in shear	4500.000 mm^2
Gusset net area in shear	3204.000 mm^2
Nominal shear strength of gusset in rupture (Rn)	768960.000 N
ASD factor in shear rupture (omega)	2.000
Allowable shear strength of gusset in rupture	
[Rn/omega]	384480.000 N
Interaction ratio in shear rupture of gusset	
[P2/Ra]	0.248
Gusset block shear check:	
Gross area in shear for block shear rupture	3505.500 mm^2

Net area in shear for block shear rupture	2371.500 mm^2
Net area in tension for block shear rupture	294.000 mm^2
Nominal strength in block shear at gusset (Rn)	643425.000 mm^2
ASD factor in block shear (omega)	2.000
Allowable strength in block shear at gusset plate	
[Ra=Rn/omega]	321712.500 N
Interaction ratio in block shear at gusset plate	
[P2/Ra]	0.296
Gusset flexure yielding check:	
Eccentricity of force at connection (e)	139.920 mm
Nominal flexure strength of gusset in yielding (Mn)	187500000.000 N mm
ASD factor in flexure yielding (omega)	1.670
Allowable flexure strength of gusset in yielding	
[Ma=Mn/omega]	112275449.102 N mm
Interaction ratio in flexure yielding at gusset	
[P1*e/Ma]	0.119
Shear tab shear yielding check:	
Gross area in shear	3360.000 mm^2
Nominal shear yielding strength of connecting element (Rn)	504000.000 N
ASD factor in shear yielding (omega)	1.500
Allowable shear yielding strength of connecting element	
[Ra=Rn/omega]	336000.000 N
Interaction ratio in shear yielding of element	
[P2/Ra]	0.283
Shear tab shear rupture check:	
Connecting element net area in shear	2064.000 mm^2
Nominal shear strength of connecting element in rupture (Rn)	495360.000 N
ASD factor in shear rupture (omega)	2.000
Allowable shear strength of connecting element in rupture	
[Ra=Rn/omega]	247680.000 N
Interaction ratio in shear rupture of connecting element	
[P2/Ra]	0.384
Shear tab block shear check:	
Gross area in shear for block shear rupture	2940.000 mm^2
Net area in shear for block shear rupture	1806.000 mm^2
Net area in tension for block shear rupture	438.000 mm^2
Nominal strength in block shear at shear tab (Rn)	608640.000 N
ASD factor in block shear (omega)	2.000
Allowable strength in block shear at connecting element	
[Ra=Rn/omega]	304320.000 N
Interaction ratio in block shear at connecting element	
[P2/Ra]	0.313
Shear tab flexure yeilding check:	
Nominal flexure yeilding strength of connecting element (Mn)	58800000.000 N mm
ASD factor in flexure (omega)	1.670
Allowable strength of connecting element in flexure	
[Ma=Mn/omega]	35209580.838 N mm
Interaction ratio in flexure yielding of connecting element	

[P2*gs/Ma]	0.135
Weld check:	
Maximum stress in weld (f)	249.052 N/mm
Nominal weld strength (fn)	1226.786 N/mm
ASD factor for weld strength (omega)	2.000
Allowable weld strength	
[fa=fn/omega]	613.393 N/mm
Interaction ratio for weld strength	
[f/fa]	0.406
Shear tab rupture at weld check:	
Nominal strength of shear tab rupture at weld (Rn)	2880.000 N
ASD factor for rupture at weld (omega)	2.000
Allowable strength of shear tab rupture at weld	
[Ra=Rn/omega]	1440.000 N
Interaction ratio for shear tab rupture at weld	
[P2/Ra]	0.346
Beam web rupture at weld check:	
Nominal strength of beam web at weld (Rn)	1576.800 N
ASD factor for rupture at weld (omega)	2.000
Allowable strength of beam web rupture at weld	
[Ra=Rn/omega]	788.400 N
Interaction ratio for beam web rupture at weld	
[P2/Ra]	0.316

3.5 Validation problem 5

Osoconn v1.1
Connection code : HB001AM10
Connection ID : HB001_5

Design Summary	
Connection is OK	
Maximum interaction ratio	0.231
Design Input	
Design method	ASD
Brace axial force (P)	46000.000 N
Beam steel grade	ASTM A36
Beam yield strength	250.000 MPa
Beam tensile strength	400.000 MPa
Angle steel grade	ASTM A36
Angle yield strength	250.000 MPa
Angle tensile strength	400.000 MPa
Plate steel grade	ASTM A36
Plate yield strength	250.000 MPa

Plate tensile strength	400.000 MPa
Number of bolts in gusset to brace connection	3
Number of bolt rows in gusset to brace connection	1
Number of bolts in connection 1 (n1)	4
Number of bolts in connection 2 (n2)	4
Bolt grade	ASTM A490
Bolt nominal tensile strength	780.000 MPa
Bolt type	Bearing
Bolt thread in shear plane	Yes
Bolt diameter	20.000 mm
Bolt gage on brace angle	45.000 mm
Bolt spacing	60.000 mm
Bolt distance to edge on brace in the direction of force	35.000 mm
Weld electrode	E70
Weld tensile strength	482.000 MPa
Brace section	2 X L76X76X6.4
Brace angle from beam at connection 1 (theta)	40.000 deg
Orientation of back to back legs	Vertical
Outstanding leg type	Short Leg
Gusset plate thickness	12.000 mm
Gusset dimension along connection 1	500.000 mm
Gusset dimension along connection 2	500.000 mm
Gusset cutout along connection 1	125.000 mm
Gusset cutout along connection 2	125.000 mm
Connection type at connection 1	Shear Tab
Connection type at connection 2	Bolted to Flange
Thickness of shear tab	10.000 mm
Thickness of shear tab to beam weld	6.000 mm
Bolt gage on shear tab (gs)	50.000 mm
Section property of beam at connection 1	W360X64
Thickness of web	7.750 mm
Thickness of flange	13.500 mm
Width of fange	203.000 mm
Section property of beam at connection 2	W200X100
Thickness of web	14.500 mm
Thickness of flange	23.700 mm
Width of fange	210.000 mm

Design Calculation	
Bolt shear at brace check:	
Nominal strength of bolts in shear (Rn)	884158.800 N
ASD factor in bolt shear (omega)	2.000
Allowable strength in bolt shear	

[Ra=Rn/omega]	442079.400 N
Interaction ratio in bolt shear	
[P/Ra]	0.104
Bolt bearing at brace check:	
Shear force per bolt in brace connection (Pb)	7666.667 N
Nominal strength in bolt bearing at brace (Rn)	73152.000 N
ASD factor in bolt bearing (omega)	2.000
Allowable strength in bolt bearing	
[Ra=Rn/omega]	36576.000 N
Interaction ratio in bolt bearing at brace	
[Pb/Ra]	0.210
Bolt bearing at gusset check:	
Nominal strength in bolt bearing at gusset plate	138240.000 N
ASD factor in bolt bearing (omega)	2.000
Allowable strength in bolt bearing at gusset	
[Ra=Rn/omega]	69120.000 N
Interaction ratio in bolt bearing at gusset plate	
[Pb/Ra]	0.111
Brace tension rupture check:	
Gross area of brace	1858.000 mm^2
Shear Lag Factor (U)	0.823
Net area of brace (An)	1578.600 mm^2
Effective area for tensile rupture	
[Ae=An*U]	1299.714 mm^2
Nominal strength in brace rupture (Pn)	519885.600 N
ASD factor in tension rupture (omega)	2.000
Allowable strength in brace rupture	
[Pa=Pn/omega]	259942.800 N
Interaction ratio in brace rupture	
[P/Pa]	0.177
Brace block shear check:	
Gross area in shear	1968.500 mm^2
Net area in shear	1270.000 mm^2
Net area in tension	256.540 mm^2
Nominal block shear strength at brace (Rn)	397891.000 N
ASD factor in block shear (omega)	2.000
Allowable block shear strength at brace	
[cap= Rn/omega]	198945.500 N
Interaction ratio in block shear at brace	
[P/Ra]	0.231
Gusset tension yielding check:	
Lenght of Whitmore section	234.564 mm
Gusset plate area in tension yielding	1858.000 mm^2
Nominal strength in gusset yielding (Pn)	703692.194 N
ASD factor in tension yielding	
[omega]	1.670
Allowable strength of gusset in tension yielding	
[Pa=Pn/omega]	421372.571 N

Interaction ratio in gusset plate tension yielding [P/Pa]	0.109
Gusset tension rupture check:	
Gusset plate net area in tension	2286.769 mm^2
Nominal strength in gusset rupture (Pn)	914707.510 N
ASD factor in tension rupture [omega]	2.000
Allowable strength of gusset in tension rupture [Pa=Pn/omega]	457353.755 N
Interaction ratio in gusset plate tension rupture [P/Pa]	0.101
Gusset block shear check:	
Gross area in shear	3720.000 mm^2
Net area in shear	2400.000 mm^2
Net area in tension	888.000 mm^2
Nominal strength of gusset in block shear (Rn)	913200.000 N
ASD factor in block shear (omega)	2.000
Allowable strength og gusset in block shear [Ra=Rn/omega]	456600.000 N
Interaction ratio in block shear at gusset plate [P/Ra]	0.101
Connection 1 Checks	

Component of brace force along connection 1 [P1=P*cos(theta)]	35238.044 N
Force per bolt in connection 1 [Pb1=P1/n1]	8809.511 N
Bolt shear check:	
Nominal strength in bolt shear (Rn)	147359.800 N
ASD factor in bolt shear (omega)	2.000
Allowable strength in bolt shear [Ra=Rn/omega]	73679.900 N
Interaction ratio in bolt shear [Pb1/Ra]	0.120
Bolt bearing at shear tab check:	
Nominal strength in bolt bearing at shear tab (Rn)	115200.000 N
ASD factor in bolt shear (omega)	2.000
Allowable strength in bolt bearing at shear tab [Ra=Rn/omega]	57600.000 N
Interaction ratio in bolt bearing at shear tab [Pb1/Ra]	0.153
Bolt bearing at gusset check:	
Nominal strength in bolt bearing at gusset (Rn)	218880.000 N
ASD factor in bolt shear (omega)	2.000
Allowable strength in bolt bearing at gusset [Ra=Rn/omega]	109440.000 N
Interaction ratio in bolt bearing at gusset	

[Pb1/Ra]	0.080
Gusset shear yielding check:	
Gusset plate shear area	4500.000 mm^2
Nominal shear strength of gusset in yielding (Rn)	675000.000 N
ASD factor in shear yielding (omega)	1.500
Allowable shear strength of gusset in yielding	
[Ra=Rn/omega]	450000.000 N
Interaction ratio in shear yielding at gusset	
[P1/Ra]	0.078
Gusset shear rupture check:	
Gusset gross area in shear	4500.000 mm^2
Gusset net area in shear	3444.000 mm^2
Nominal shear strength of gusset in rupture (Rn)	826560.000 N
ASD factor in shear rupture (omega)	2.000
Allowable shear strength of gusset in rupture	
[Rn/omega]	413280.000 N
Interaction ratio in shear rupture of gusset	
[P1/Ra]	0.085
Gusset plate block shear check:	
Gross area in shear for block shear rupture	2880.000 mm^2
Net area in shear for block shear rupture	1956.000 mm^2
Net area in tension for block shear rupture	324.000 mm^2
Nominal strength in block shear at gusset (Rn)	561600.000 mm^2
ASD factor in block shear (omega)	2.000
Allowable strength in block shear at gusset plate	
[Ra=Rn/omega]	280800.000 N
Interaction ratio in block shear at gusset plate	
[P1/Ra]	0.125
Gusset flexure yielding check:	
Eccentricity of force at connection (e)	140.875 mm
Nominal flexure strength of gusset in yielding (Mn)	187500000.000 N mm
ASD factor in flexure yielding (omega)	1.670
Allowable flexure strength of gusset in yielding	
[Ma=Mn/omega]	112275449.102 N mm
Interaction ratio in flexure yielding at gusset	
[P1*e/Ma]	0.044
Shear tab shear yielding check:	
Gross area in shear	2500.000 mm^2
Nominal shear yielding strength of connecting element (Rn)	375000.000 N
ASD factor in shear yielding (omega)	1.500
Allowable shear yielding strength of connecting element	
[Ra=Rn/omega]	250000.000 N
Interaction ratio in shear yielding of element	
[P1/Ra]	0.141
Shear tab shear rupture check:	
Connecting element net area in shear	1620.000 mm^2
Nominal shear strength of connecting element in rupture (Rn)	388800.000 N

ASD factor in shear rupture (omega)	2.000
Allowable shear strength of connecting element in rupture	
[Ra=Rn/omega]	194400.000 N
Interaction ratio in shear rupture of connecting element	
[P1/Ra]	0.181
Shear tab block shear check:	
Gross area in shear for block shear rupture	2150.000 mm^2
Net area in shear for block shear rupture	1380.000 mm^2
Net area in tension for block shear rupture	390.000 mm^2
Nominal strength in block shear at shear tab (Rn)	478500.000 N
ASD factor in block shear (omega)	2.000
Allowable strength in block shear at connecting element	
[Ra=Rn/omega]	239250.000 N
Interaction ratio in block shear at connecting element	
[P1/Ra]	0.147
Shear tab flexure yeilding check:	
Nominal flexure yeilding strength of connecting element (Mn)	39062500.000 N mm
ASD factor in flexure (omega)	1.670
Allowable strength of connecting element in flexure	
[Ma=Mn/omega]	23390718.563 N mm
Interaction ratio in flexure yielding of connecting element	
[P1*gs/Ma]	0.075
Weld check:	
Maximum stress in weld (f)	110.087 N/mm
Nominal weld strength (fn)	1226.786 N/mm
ASD factor for weld strength (omega)	2.000
Allowable weld strength	
[fa=fn/omega]	613.393 N/mm
Interaction ratio for weld strength	
[f/fa]	0.179
Shear tab rupture at weld check:	
Nominal strength of shear tab rupture at weld (Rn)	2400.000 N/mm
ASD factor for rupture at weld (omega)	2.000
Allowable strength of shear tab rupture at weld	
[Ra=Rn/omega]	1200.000 N/mm
Interaction ratio for shear tab rupture at weld	
[P1/Ra]	0.183
Beam web rupture at weld check:	
Nominal strength of beam web at weld (Rn)	1860.000 N/mm
ASD factor for rupture at weld (omega)	2.000
Allowable strength of beam web rupture at weld	
[Ra=Rn/omega]	930.000 N/mm
Interaction ratio for beam web rupture at weld	
[P1/Ra]	0.118
Connection 2 Checks	

Component of brace force along connection 2	

[P2=P*sin(theta)]	29568.230 N
Force per bolt in connection 2	
[Pb2=P2/n2]	7392.058 N
Bolt shear check:	
Nominal strength in bolt shear (Rn)	147359.800 N
ASD factor in bolt shear (omega)	2.000
Allowable strength in bolt shear	
[Ra=Rn/omega]	73679.900 N
Interaction ratio in bolt shear	
[Pb2/Ra]	0.100
Bolt bearing at gusset check:	
Nominal strength in bolt bearing at gusset (Rn)	218880.000 N
ASD factor in bolt shear (omega)	2.000
Allowable strength in bolt bearing at gusset	
[Ra=Rn/omega]	109440.000 N
Interaction ratio in bolt bearing at gusset	
[Pb2/Ra]	0.068
Bolt bearing at beam flange check:	
Nominal strength in bolt bearing at beam flange (Rn)	432288.000 N
ASD factor in bolt shear (omega)	2.000
Allowable strength in bolt bearing at beam flange	
[Ra=Rn/omega]	216144.000 N
Interaction ratio in bolt bearing at beam flange	
[Pb2/Ra]	0.034
Gusset shear yielding check:	
Gusset plate shear area	4500.000 mm^2
Nominal shear strength of gusset in yielding (Rn)	675000.000 N
ASD factor in shear yielding (omega)	1.500
Allowable shear strength of gusset in yielding	
[Ra=Rn/omega]	450000.000 N
Interaction ratio in shear yielding at gusset	
[P2/Ra]	0.066
Gusset shear rupture check:	
Gusset gross area in shear	4500.000 mm^2
Gusset net area in shear	3444.000 mm^2
Nominal shear strength of gusset in rupture (Rn)	826560.000 N
ASD factor in shear rupture (omega)	2.000
Allowable shear strength of gusset in rupture	
[Rn/omega]	413280.000 N
Interaction ratio in shear rupture of gusset	
[P2/Ra]	0.072
Gusset block shear check:	
Gross area in shear for block shear rupture	3769.500 mm^2
Net area in shear for block shear rupture	2845.500 mm^2
Net area in tension for block shear rupture	768.000 mm^2
Nominal strength in block shear at gusset (Rn)	872625.000 mm^2
ASD factor in block shear (omega)	2.000

Allowable strength in block shear at gusset plate [Ra=Rn/omega]	436312.500 N
Interaction ratio in block shear at gusset plate [P2/Ra]	0.068
Gusset flexure yielding check:	
Eccentricity of force at connection (e)	100.000 mm
Nominal flexure strength of gusset in yielding (Mn)	187500000.000 N mm
ASD factor in flexure yielding (omega)	1.670
Allowable flexure strength of gusset in yielding [Ma=Mn/omega]	112275449.102 N mm
Interaction ratio in flexure yielding at gusset [P1*e/Ma]	0.026

3.6 Validation problem 6

Osoconn v1.1
Connection code : HB001AM10
Connection ID : HB001_6

Design Summary	
Connection is OK	
Maximum interaction ratio	0.827
Design Input	
Design method	ASD
Brace axial force (P)	190000.000 N
Beam steel grade	ASTM A992
Beam yield strength	345.000 MPa
Beam tensile strength	450.000 MPa
Angle steel grade	ASTM A36
Angle yield strength	250.000 MPa
Angle tensile strength	400.000 MPa
Plate steel grade	ASTM A36
Plate yield strength	250.000 MPa
Plate tensile strength	400.000 MPa
Number of bolts in gusset to brace connection	3
Number of bolt rows in gusset to brace connection	2
Number of bolts in connection 1 (n1)	3
Number of bolts in connection 2 (n2)	5
Bolt grade	ASTM A325
Bolt nominal tensile strength	620.000 MPa
Bolt type	Friction
Bolt thread in shear plane	Yes
Bolt diameter	22.000 mm
Bolt gage on brace angle	50.000 mm

Bolt spacing	70.000 mm
Bolt distance to edge on brace in the direction of force	30.000 mm
Weld electrode	E70
Weld tensile strength	482.000 MPa
Brace section	2 X L152X89X12.7
Brace angle from beam at connection 1 (theta)	60.000 deg
Orientation of back to back legs	Horizontal
Outstanding leg type	Short Leg
Gusset plate thickness	16.000 mm
Gusset dimension along connection 1	500.000 mm
Gusset dimension along connection 2	500.000 mm
Gusset cutout along connection 1	150.000 mm
Gusset cutout along connection 2	150.000 mm
Connection type at connection 1	Clip Angle
Connection type at connection 2	Bolted to Flange
Clip angles at connection to beam	2 X L89X89X9.5
Thickness of clip to gusset weld	6.000 mm
Bolt gage on clip angle	45.000 mm
Section property of beam at connection 1	W460X74
Thickness of web	9.020 mm
Thickness of flange	14.500 mm
Width of fange	191.000 mm
Section property of beam at connection 2	W250X67
Thickness of web	8.890 mm
Thickness of flange	15.700 mm
Width of fange	204.000 mm

Design Calculation	
Bolt shear at brace check:	
Nominal strength of bolts in shear (Rn)	715968.000 N
ASD factor in bolt shear (omega)	1.500
Allowable strength in bolt shear	
[Ra=Rn/omega]	477312.000 N
Interaction ratio in bolt shear	
[P/Ra]	0.398
Bolt bearing at brace check:	
Shear force per bolt in brace connection (Pb)	31666.667 N
Nominal strength in bolt bearing at brace (Rn)	109728.000 N
ASD factor in bolt bearing (omega)	2.000
Allowable strength in bolt bearing	
[Ra=Rn/omega]	54864.000 N
Interaction ratio in bolt bearing at brace	
[Pb/(2*Ra)]	0.289

Bolt bearing at gusset check:	
Nominal strength in bolt bearing at gusset plate	138240.000 N
ASD factor in bolt bearing (omega)	2.000
Allowable strength in bolt bearing at gusset	
[Ra=Rn/omega]	69120.000 N
Interaction ratio in bolt bearing at gusset plate	
[Pb/Ra]	0.458
Brace tension rupture check:	
Gross area of brace	5800.000 mm^2
Shear Lag Factor (U)	0.849
Net area of brace (An)	4580.800 mm^2
Effective area for tensile rupture	
[Ae=An*U]	3890.408 mm^2
Nominal strength in brace rupture (Pn)	1556163.200 N
ASD factor in tension rupture (omega)	2.000
Allowable strength in brace rupture	
[Pa=Pn/omega]	778081.600 N
Interaction ratio in brace rupture	
[P/Pa]	0.244
Brace block shear check:	
Gross area in shear	4318.000 mm^2
Net area in shear	2794.000 mm^2
Net area in tension	1676.400 mm^2
Nominal block shear strength at brace (Rn)	1318260.000 N
ASD factor in block shear (omega)	2.000
Allowable block shear strength at brace	
[cap= Rn/omega]	659130.000 N
Interaction ratio in block shear at brace	
[P/Ra]	0.288
Gusset tension yielding check:	
Lenght of Whitmore section	231.658 mm
Gusset plate area in tension yielding	5800.000 mm^2
Nominal strength in gusset yielding (Pn)	926632.301 N
ASD factor in tension yielding	
[omega]	1.670
Allowable strength of gusset in tension yielding	
[Pa=Pn/omega]	554869.642 N
Interaction ratio in gusset plate tension yielding	
[P/Pa]	0.342
Gusset tension rupture check:	
Gusset plate net area in tension	2938.529 mm^2
Nominal strength in gusset rupture (Pn)	1175411.682 N
ASD factor in tension rupture	
[omega]	2.000
Allowable strength of gusset in tension rupture	
[Pa=Pn/omega]	587705.841 N
Interaction ratio in gusset plate tension rupture	
[P/Pa]	0.323

Gusset block shear check:	
Gross area in shear	5440.000 mm^2
Net area in shear	3520.000 mm^2
Net area in tension	736.000 mm^2
Nominal strength of gusset in block shear (Rn)	1110400.000 N
ASD factor in block shear (omega)	2.000
Allowable strength og gusset in block shear	
[Ra=Rn/omega]	555200.000 N
Interaction ratio in block shear at gusset plate	
[P/Ra]	0.342
Connection 1 Checks	

Component of brace force along connection 1	
[P1=P*cos(theta)]	95000.000 N
Force per bolt in connection 1	
[Pb1=P1/n1]	15833.333 N
Bolt shear check:	
Nominal strength in bolt shear (Rn)	59664.000 N
ASD factor in bolt shear (omega)	1.500
Allowable strength in bolt shear	
[Ra=Rn/omega]	39776.000 N
Interaction ratio in bolt shear	
[Pb1/Ra]	0.398
Bolt bearing at clip angle check:	
Nominal strength in bolt bearing at clip angle (Rn)	105211.200 N
ASD factor in bolt shear (omega)	2.000
Allowable strength in bolt bearing at clip angle	
[Ra=Rn/omega]	52605.600 N
Interaction ratio in bolt bearing at clip angle	
[Pb1/Ra]	0.301
Bolt bearing at beam web check:	
Nominal strength in bolt bearing at beam web (Rn)	214315.200 N
ASD factor in bolt shear (omega)	2.000
Allowable strength in bolt bearing at beam web	
[Ra=Rn/omega]	107157.600 N
Interaction ratio in bolt bearing at beam web	
[Pb1/Ra]	0.148
Gusset shear yielding check:	
Gusset plate shear area	5600.000 mm^2
Nominal shear strength of gusset in yielding (Rn)	840000.000 N
ASD factor in shear yielding (omega)	1.500
Allowable shear strength of gusset in yielding	
[Ra=Rn/omega]	560000.000 N
Interaction ratio in shear yielding at gusset	
[P1/Ra]	0.170
Gusset plate block shear check:	
Gross area in shear for block shear rupture	4400.000 mm^2

Net area in shear for block shear rupture	4400.000 mm^2
Net area in tension for block shear rupture	1230.400 mm^2
Nominal strength in block shear at gusset (Rn)	1152160.000 mm^2
ASD factor in block shear (omega)	2.000
Allowable strength in block shear at gusset plate	
[Ra=Rn/omega]	576080.000 N
Interaction ratio in block shear at gusset plate	
[P1/Ra]	0.165
Gusset flexure yielding check:	
Eccentricity of force at connection (e)	166.510 mm
Nominal flexure strength of gusset in yielding (Mn)	250000000.000 N mm
ASD factor in flexure yielding (omega)	1.670
Allowable flexure strength of gusset in yielding	
[Ma=Mn/omega]	149700598.802 N mm
Interaction ratio in flexure yielding at gusset	
[P1*e/Ma]	0.106
Clip angle shear yielding check:	
Gross area in shear	4002.600 mm^2
Nominal shear yielding strength of connecting element (Rn)	600390.000 N
ASD factor in shear yielding (omega)	1.500
Allowable shear yielding strength of connecting element	
[Ra=Rn/omega]	400260.000 N
Interaction ratio in shear yielding of element	
[P1/Ra]	0.237
Clip angle shear rupture check:	
Connecting element net area in shear	2630.280 mm^2
Nominal shear strength of connecting element in rupture (Rn)	631267.200 N
ASD factor in shear rupture (omega)	2.000
Allowable shear strength of connecting element in rupture	
[Ra=Rn/omega]	315633.600 N
Interaction ratio in shear rupture of connecting element	
[P1/Ra]	0.301
Clip angle block shear check:	
Gross area in shear for block shear rupture	3335.500 mm^2
Net area in shear for block shear rupture	2191.900 mm^2
Net area in tension for block shear rupture	760.494 mm^2
Nominal strength in block shear at shear tab (Rn)	804522.600 N
ASD factor in block shear (omega)	2.000
Allowable strength in block shear at connecting element	
[Ra=Rn/omega]	402261.300 N
Interaction ratio in block shear at connecting element	
[P1/Ra]	0.236
Weld check:	
Maximum stress in weld (f)	248.909 N/mm
Nominal weld strength (fn)	1226.786 N/mm
ASD factor for weld strength (omega)	2.000
Allowable weld strength	
[fa=fn/omega]	613.393 N/mm

Interaction ratio for weld strength	
[f/fa]	0.406
Gusset rupture at weld check:	
Nominal strength of gusset at weld (Rn)	3840.000 N/mm
ASD factor for rupture at weld (omega)	2.000
Allowable strength of gusset rupture at weld	
[Ra=Rn/omega]	1920.000 N/mm
Interaction ratio for gusset rupture at weld	
[P1/Ra]	0.259
Connection 2 Checks	

Component of brace force along connection 2	
[P2=P*sin(theta)]	164544.827 N
Force per bolt in connection 2	
[Pb2=P2/n2]	32908.965 N
Bolt shear check:	
Nominal strength in bolt shear (Rn)	59664.000 N
ASD factor in bolt shear (omega)	1.500
Allowable strength in bolt shear	
[Ra=Rn/omega]	39776.000 N
Interaction ratio in bolt shear	
[Pb2/Ra]	0.827
Bolt bearing at gusset check:	
Nominal strength in bolt bearing at gusset (Rn)	188236.800 N
ASD factor in bolt shear (omega)	2.000
Allowable strength in bolt bearing at gusset	
[Ra=Rn/omega]	94118.400 N
Interaction ratio in bolt bearing at gusset	
[Pb2/Ra]	0.350
Bolt bearing at beam flange check:	
Nominal strength in bolt bearing at beam flange (Rn)	373032.000 N
ASD factor in bolt shear (omega)	2.000
Allowable strength in bolt bearing at beam flange	
[Ra=Rn/omega]	186516.000 N
Interaction ratio in bolt bearing at beam flange	
[Pb2/Ra]	0.176
Gusset shear yielding check:	
Gusset plate shear area	5600.000 mm^2
Nominal shear strength of gusset in yielding (Rn)	840000.000 N
ASD factor in shear yielding (omega)	1.500
Allowable shear strength of gusset in yielding	
[Ra=Rn/omega]	560000.000 N
Interaction ratio in shear yielding at gusset	
[P2/Ra]	0.294
Gusset shear rupture check:	
Gusset gross area in shear	5600.000 mm^2

Gusset net area in shear	3680.000 mm^2
Nominal shear strength of gusset in rupture (Rn)	883200.000 N
ASD factor in shear rupture (omega)	2.000
Allowable shear strength of gusset in rupture [Rn/omega]	441600.000 N
Interaction ratio in shear rupture of gusset [P2/Ra]	0.373
Gusset block shear check:	
Gross area in shear for block shear rupture	5064.160 mm^2
Net area in shear for block shear rupture	3336.160 mm^2
Net area in tension for block shear rupture	1008.000 mm^2
Nominal strength in block shear at gusset (Rn)	1162824.000 mm^2
ASD factor in block shear (omega)	2.000
Allowable strength in block shear at gusset plate [Ra=Rn/omega]	581412.000 N
Interaction ratio in block shear at gusset plate [P2/Ra]	0.283
Gusset flexure yielding check:	
Eccentricity of force at connection (e)	125.000 mm
Nominal flexure strength of gusset in yielding (Mn)	250000000.000 N mm
ASD factor in flexure yielding (omega)	1.670
Allowable flexure strength of gusset in yielding [Ma=Mn/omega]	149700598.802 N mm
Interaction ratio in flexure yielding at gusset [P1*e/Ma]	0.137