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Sample Calculations – Connection 2

Connection Description

Connection number two consists of a W-section that is welded to an angle on each side of the web, and then bolted to the web of another W-section. There is only one bolt in each angle connection, and the welds runs the full length of all three sides of the angle that are in contact with the W-section. For this connection, we have A992 steel for our two 6 x 12 W-sections and A36 steel for our L 4 x 3 x ¼ angle. A ¾" A325N Hex bolt was used, along with an E-70 electrode weld that was applied using the Shield Metal Arc Welding (SMAW) technique.

Limit States

The limit states that will be looked at for this connection are as follows:

1.) Bolt Bearing
2.) Bolt Shear Rupture
3.) Block Shear
4.) Weld Strength

Analysis

The following equations were used to evaluate each limit state

Bolt Bearing:

$øR_n$ = min {$ø(1.2L_ctF_u)$; $ø(2.4dtF_u)$}

ø = Resistance factor = 0.75

F_u = Ultimate tensile strength of the connected material, in ksi

L_c = Clear distance, in the direction of the force, between the edge of the hole and the edge of the material, in inches

Le' = effective length from center of bolt hole to rolled edge

Le = effective length from center of bolt hole to cut edge

t = Thickness of the connected material, in inches

d = Nominal bolt diameter, in inches

R_n = min{[1.2 * (2"-0.5 * (0.375")) * (0.25") * (58ksi)]

[2.4 * (0.875") * (0.25") * (58ksi)]}

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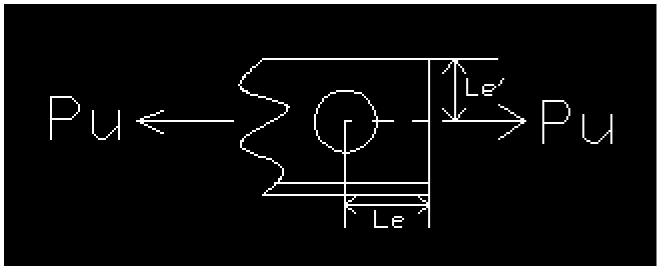
=min{64.16 k, 30.45 k}

Therefore, $øR_n$= (0.75)*(30.45 k) = <u>22.84 k</u>



<u>Bolt Shear Rupture:</u>

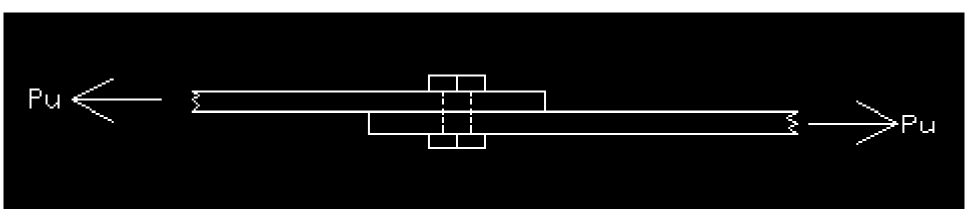
$øR_n = øF_nA_b$

ø = Resistance factor = 0.75

F_n = Nominal shear strength F_v tabulated in AISC/LRFD Manual Table J3.2, ksi

A_b = Nominal unthreaded body area of the bolt, in^2

$øR_n = (0.75) * (48ksi) * (3/4")^2 * (\pi/4)$ = <u>15.91k</u>



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Block Shear on Angle:

Block shear on W-section will not control because of the two flanges.

$øP_n = \min\{ø[(0.6 * F_u) * A_{nv} + U_{bs} * F_u * A_{nt}]$

$ø[(0.6 * F_y) * A_{gv} + U_{bs} * F_u * A_{nt}]\}$

ø = Resistance factor = 0.75

A_{gv} = Gross area subjected to shear, in^2

A_{nv} = Net area subjected to shear, in^2

A_{gt} = Gross area subjected to tension, in^2

A_{nt} = Net area subjected to tension, in^2

U_{bs} = 1.0 since tension stress is uniform

F_y = Minimum yield stress, ksi

F_u = Tensile stress, ksi

$A_{gv} = 3" * 0.25" = 0.75in^2$

$A_{nv} = 0.75in^2 - 1 * (^1/_4" + ^1/_{16}" + ^1/_{16}") * (^1/_4") = 0.656in^2$

$A_{gt} = 2" * 0.25" = 0.5in^2$

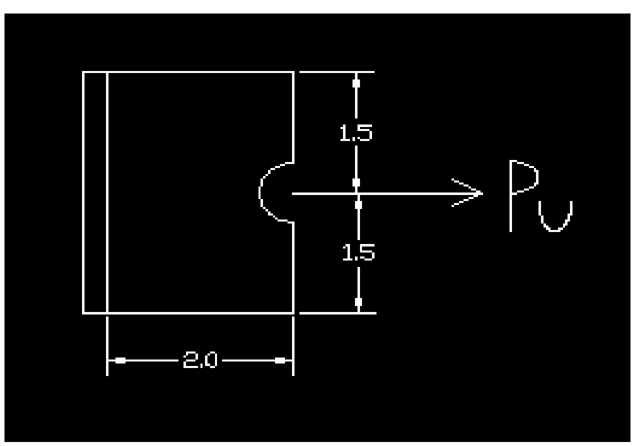
$A_{nt} = 0.5in^2 - 0 = 0.5in^2$

$øP_n = \min\{[0.75 * (0.6 * 36ksi) * (0.5in^2) + (58ksi) * (0.5in^2)]$

$[0.75 * (0.6 * 58ksi) * (0.656in^2) + (58ksi) * (0.5in^2)]\}$

$= \min\{29.85 \text{ k}, 38.87 \text{ k})$

Therefore, $øP_n$ = <u>29.85 k</u>



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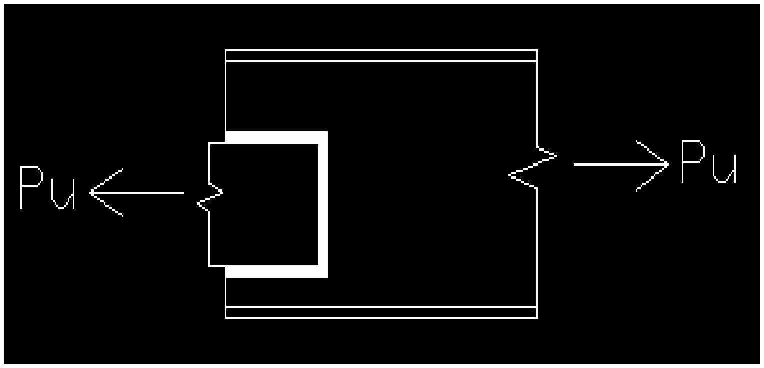
Weld strength:



$øR_n = \min \{øF_wA_w; øF_{bm}A_{bm}\}$

$øF_wA_w = ø(0.6F_{EXX}) * (L_w) * (t_w)$

$t_w = 0.707 * D_w$

$øF_{bm}A_{bm} = \min \{ 0.75 * t_{bm} * L_w * (0.6F_u) ;$

$0.75 * U * A_n * F_u ;$

$1.0 * A_g * (0.6F_y) \}$

ø = Resistance factor = 0.75

R_n = Nominal strength of weld design material, kips

F_{bm} = Nominal strength of the base material, ksi

F_w = Nominal strength of the weld electrodes

F_y = Tensile yield of base material, ksi

F_u = Tensile strength of base material, ksi

F_{EXX} = Tensile strength of electrode material, ksi

A_{bm} = Cross-sectional area of the base material, in^2

A_w = Effective cross-sectional area of the weld, in^2

A_{nv} = Net area subject to shear, in^2

A_g = Gross cross-sectional area of base material, in^2

t_{bm} = Thickness of the base material, in^2

t_w = Effective throat dimension, in

L_w = Length of weld, nominal value, in

$t_w = 0.707 * {}^1/_4" = 0.177"$

$øF_wA_w = 0.75 * (0.6 * 70 \text{ ksi}) * 9" * 0.177" = \underline{50.18 \text{ k}}$

<u>Angle Section</u>

$øF_{bm}A_{bm} = \min \{ 0.75 * 0.25" * 9" * (0.6 * 58 \text{ ksi});$

$0.75 * 1.0 * 1.69 \text{ in}^2 * 58 \text{ ksi};$

$1.0 * 1.69 \text{ in}^2 * (0.6 * 36 \text{ ksi}) \} \quad = \min\{ 58.73 \text{ k}, 73.52 \text{ k}, 36.50 \text{ k} \}$

Therefore, $øF_{bm}A_{bm}$ (Angle) = <u>36.50 k</u>

$øF_{bm}A_{bm} = \min \{ 0.75 * 0.230" * 9" * (0.6 * 65 \text{ ksi});$

$0.75 * 1.0 * 3.55 \text{ in}^2 * 65 \text{ ksi};$

$1.0 * 3.55 \text{ in}^2 * (0.6 * 50 \text{ ksi}) \} \quad = \min\{ 60.55 \text{ k}, 173.06 \text{ k}, 106.50 \text{ k} \}$

Therefore, $øF_{bm}A_{bm}$ (W-section) = <u>60.55 k</u>

$øR_n = \min \{ 50.18 \text{ k}, 36.50 \text{ k}, 60.55 \text{ k} \}$ Therefore, $øR_n$ = <u>36.50 k</u>

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CONTROLLING $ØP_N$

Once we have all of our values calculated, we need to compare them all to find out which value is the controlling value for our connection.

The final values are:

$øP_n$ = min {22.84 k, 15.91 k, 29.85 k, 36.50 k}

$øP_n$ = 15.91 k

Therefore, our controlling value for this connection comes from the block shear rupture on the angle bracket.