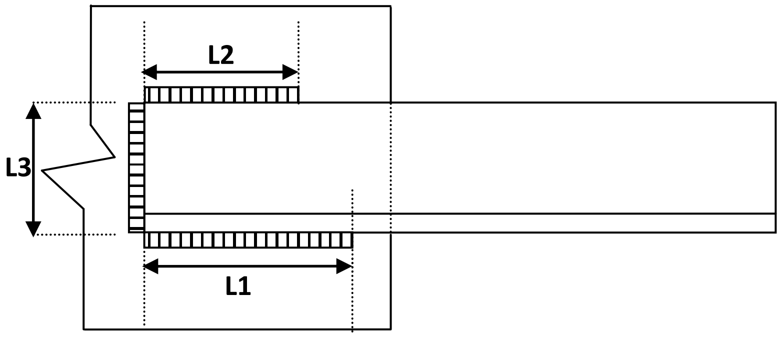
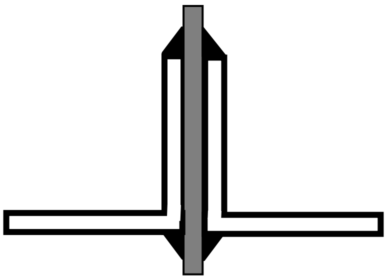
Strength of Welded connections





1-Strength of fillet welds:-

$$\emptyset R_n = 0.75 * 0.6 * F_{EX} * 0.707 * S_w * L_w * (1 + 0.5\, Sin^{1.5}\theta)$$

1) For longitudinal weld:- ($\theta = 0$)

a) Weld fracture:

$$\emptyset R_n = 0.75 * 0.6 * F_{EX} * 0.707 * S_w * L_w * 2$$

b) Shear rupture of angle:

$$\emptyset R_n = 0.75 * 0.6 * F_u * t_{angle} * (L_1 + L_2) * 2$$

b) Shear rupture of guest plate:

$$\emptyset R_n = 0.75 * 0.6 * F_u * t_{guest} * (L_1 + L_1)$$

2) For Transversal weld:- ($\theta = 90$)

a) Weld fracture:

$$\emptyset R_n = 0.75 * 0.6 * F_{EX} * 0.707 * S_w * L_w * 1.5 * 2$$

b) Tensile fracture of angle:

$$\emptyset R_n = 0.75 * F_u * h_{angle} * t_{angle} * 2$$

b Tensile fracture of guest plate:

$$\emptyset R_n = 0.75 * F_u * h_{angle} * t_{guest}$$

2-Strength of members:-

$\boldsymbol{a - Gross\ \ yielding} : -$

$$\emptyset R_n = 0.9 * F_y * A_g$$

$\boldsymbol{b - net\ fractures} : -$

$$\emptyset R_n = 0.75 * F_u * A_e$$

$\boldsymbol{C - block\ shear: -}$

$L_t = h - t \quad , \quad L_v = L_1$

$A_t = L_t * t \quad , \quad A_v = L_v * t$

$if\ 0.6 * Fu * A_v > Fu * A_t \quad , \emptyset R_n = 0.75(0.6 * Fu * A_v + Fy * A_t)$

$if\ 0.6 * Fu * A_v < Fu * A_t \quad , \ \emptyset R_n = 0.75(Fu * A_t + 0.6 * Fy * A_v)$

3-Strength of guest plate:-

$\boldsymbol{a - Gross\ \ yielding: -}$

$\emptyset R_n = 0.9 * \ F_y * A_g$

$\boldsymbol{b - net\ fractures: -}$

$\emptyset R_n = 0.75 * \ F_u * A_e$

$\boldsymbol{C - block\ shear: -}$

$L_t = \frac{(L_{plate} \ \ - h_{angle}\ )}{2} + h_{angle} \quad , \quad L_V = L_1$

$A_t = L_t * t \quad , \quad A_v = L_v * t$

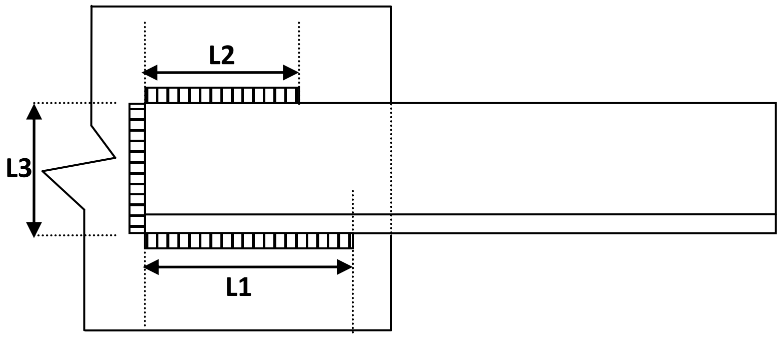
$f\ 0.6 * Fu * A_v > Fu * A_t \quad , \emptyset R_n = 0.75(0.6 * Fu * A_v + Fy * A_t)$

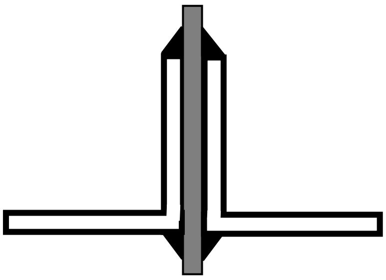
$if\ 0.6 * Fu * A_v < Fu * A_t \quad , \emptyset R_n = 0.75(Fu * A_t + 0.6 * Fy * A_v)$

Question 1

Determine the factor resistance of the given welded connection and guest plate.

PL130*16





2L 102x76x15.9

Given:

$F_{EX} = 500\ Mpa$, $F_y = 250\ Mpa$, $F_u = 400\ Mpa$, $weld\ size = 6\ mm$

$L_1 = 120mm$, $L_2 = 48mm$, $L_3 = 102mm$

For one angle L 102x76x19.5: (Table on page 1-57 of AISC Manual)

A_g= 2580 mm^2 , x'= 22 mm

Plate 300x16

1-Strength of fillet welds:-

$$\emptyset R_n = 0.75 * 0.6 * F_{EX} * 0.707 * S_w * L_w * (1 + 0.5\ Sin^{1.5}\theta)$$

2) For longitudinal weld:- ($\theta = 0$)

a) Weld fracture:

$\emptyset R_n = 0.75 * 0.6 * 500 * 0.707 * 6 * (120 + 40) * 2\ X10^{-3} = 305.424\ KN$

b) Shear rupture of angle:

$\emptyset R_n = 0.75 * 0.6 * 400 * 15.9 * (120 + 40) * 2X10^{-3} = 915.84\ KN$

b) Shear rupture of guest plate:

$\emptyset R_n = 0.75 * 0.6 * 400 * 20 * (120 + 120) * 2X10^{-3} = 864\ KN$

Governing strength of longitudinal weld= 305.424 KN

2) For Transversal weld:- ($\theta = 90$)

a) Weld fracture:

$\emptyset R_n = 0.75 * 0.6 * 500 * 0.707 * 6 * 102 * 1.5 * 2X10^{-3} = 292.1\ KN$

b) Tensile fracture of angle:

$\emptyset R_n = 0.75 * 400 * 102 * 15.9 * 2X10^{-3} = 973.08\ KN$

b Tensile fracture of guest plate:

$\emptyset R_n = 0.75 * 400 * 102 * 20 = 612\ KN$

Governing strength of transversal weld= 292.1 KN

Design of group weld=305.424+292.1=597.524 KN

2-Strength of members:-

$\boldsymbol{a - Gross\ \ yielding : -}$

$\emptyset R_n = 0.9 * \ 250 * 2580 * 2X10^{-3} = 1161\ KN$

$\boldsymbol{b - net\ fractures : -}$

$U = 1 - \frac{22}{120} = 0.817 < 0.9$

$\emptyset R_n = 0.75 * \ 400 * 0.817 * 2580 * 2X10^{-3} = 1264.716\ KN$

$\boldsymbol{C - block\ shear : -}$

$L_t = 86.1\ mm \quad , \quad L_V = 120 * 2 = 240\ mm$

$A_t = 1368.99\ mm^2 \quad , \quad A_v = 1908\ mm^2$

$i\ 0.6 * Fu * A_v < Fu * A_t \quad , \emptyset R_n = 625.347\ KN$

3-Strength of guest plate:-

$\boldsymbol{a - Gross\ \ yielding : -}$

$\emptyset R_n = 0.9 * \ 250 * (130 * 20)X10^{-3} = 585\ KN$

$\boldsymbol{b - net\ fractures : -}$

$\emptyset R_n = 0.75 * \ 400 * (130 * 20) * 0.85\ X10^{-3} = 663\ KN$

$\boldsymbol{C - block\ shear : -}$

$L_t = 116\ mm \quad , \quad A_{gv} = 120\ mm$

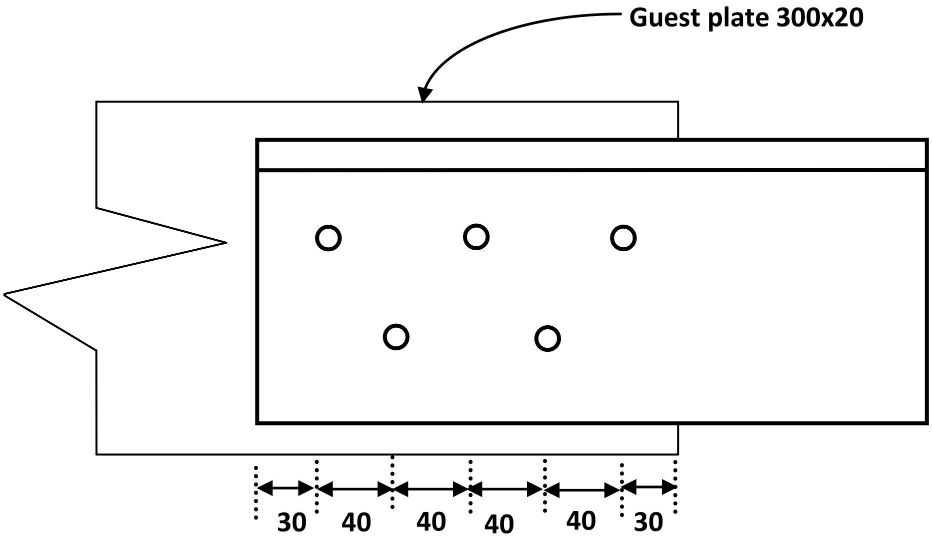
$A_t = 2320\ mm^2 \quad , \quad A_v = 2400\ mm^2$

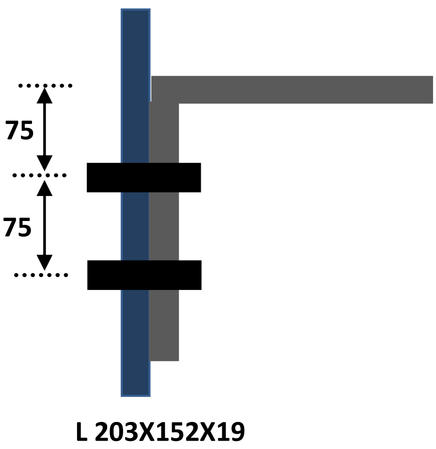
$0.6 * Fu * A_v < Fu * A_t \quad , \quad \emptyset R_n = 966\ KN$

The governing design strength =585 KN that is governed by yielding of guest plate

Question 2

Compute the design tensile strength of the tension member and guest plate and bolted connection shown in figure below. Steel is A36 for guest plate and member. Bolts is A940M 24-mm diameter Fu=620 Mpa and Fv=400 Mpa.





L 203x152x19: (Table on page 1-50 of AISC Manual)
A_g= 6380 mm^2 , t= 19 mm
Plate 300x20
A_g= 6000 mm^2 , t= 20 mm
A36M steel: F_y= 250 MPa , F_u= 400 MPa

Bolts: 24 mm, A_b= 452.16 mm^2

For Angle:

- **Gross yielding design strength:**

$$\emptyset_t P_n = \emptyset_t A_g F_y = 0.9 \times 6380 \times 250 \times 10^{-3} = \mathbf{1435.5\ kN}$$

- **Net section fracture strength:**

$$A_n = A_g - \sum(d_b + 3)t + \frac{s^2}{4g}t$$

$$A_n = 6380 - (2 \times 27 \times 19) + \frac{40^2}{4 \times 75} \times 19 = 5455.33 mm^2$$

$$A_e = UA_n\ , \qquad U = 1 - \frac{\bar{x}}{l} \leq 0.9 \qquad , \qquad \bar{x} = 39.6\ mm\ , \quad l = 160\ mm$$

$$U = 1 - \frac{39.6}{160} = 0.7525 \leq 0.9$$

$$A_e = 0.7525 \times 5455.33 = 4105.14\ mm^2$$

$$\emptyset_t P_n = \emptyset_t A_e F_u = 0.75 \times 4105.14 \times 400 \times 10^{-3} = \mathbf{1231.54\ kN}$$

- **Block shear strength:**

$l_v = 340\ mm$
$l_t = 75 + \frac{40^2}{4\times75} = 80.33\ mm$
$A_{gt} = 80.33 \times 19 = 1526.33\ mm^2$
$A_{nt} = 1526.33 - 1 \times 27 \times 19 = 1013.33\ mm^2$
$A_{gv} = 340 \times 19 = 6460\ mm^2$
$A_{nv} = 6460 - 4 \times 27 \times 19 = 4408\ mm^2$

$0.6F_uA_{nv} = 0.6 \times 400 \times 4408 \times 10^{-3} = 1057.92\ kN$
$F_uA_{nt} = 400 \times 1013.33 \times 10^{-3} = 405.332\ kN$
$0.6F_uA_{nv} > F_uA_{nt}$
$\therefore \emptyset_tR_n = \emptyset_t[0.6F_uA_{nv} + F_yA_{gt}] \qquad \le \emptyset_t[0.6F_uA_{nv} + F_uA_{nt}]$
$\therefore \emptyset_tR_n = 0.75[0.6 \times 400 \times 4408 + 250 \times 1526.33] \times 10^{-3}\mathbf{1079.628\ kN}$
$\le \emptyset_t[0.6F_uA_{nv} + F_uA_{nt}] = 1097.439\ kN$

For Plate:

- **Gross yielding design strength:**
$\emptyset_tP_n = \emptyset_tA_gF_y = 0.9 \times 6000 \times 250 \times 10^{-3} = \mathbf{1350\ kN}$

- **Net section fracture strength:**
$A_n = A_g - \sum(d_b + 3)t + \frac{s^2}{4g}t$
$A_n = A_e = 6000 - (2 \times 27 \times 20) + \frac{40^2}{4\times75} \times 20 = 5026.67\ mm^2$

$\emptyset_tP_n = \emptyset_tA_eF_u = 0.75 \times 5026.67 \times 400 \times 10^{-3} = \mathbf{1508\ kN}$

- **Block shear strength:**
$l_v = 340\ mm$
$l_t = 75 + \frac{40^2}{4\times75} = 80.33\ mm$
$A_{gt} = 80.33 \times 20 = 1606.67\ mm^2$
$A_{nt} = 1606.67 - 1 \times 27 \times 20 = 1066.67\ mm^2$
$A_{gv} = 340 \times 20 = 6800\ mm^2$
$A_{nv} = 6800 - 4 \times 27 \times 20 = 4640\ mm^2$

$0.6F_uA_{nv} = 0.6 \times 400 \times 4640 \times 10^{-3} = 1113.6\ kN$
$F_uA_{nt} = 400 \times 1066.67 \times 10^{-3} = 426.668\ kN$
$0.6F_uA_{nv} > F_uA_{nt}$
$\therefore \emptyset_tR_n = \emptyset_t[0.6F_uA_{nv} + F_yA_{gt}] \qquad \le \emptyset_t[0.6F_uA_{nv} + F_uA_{nt}]$
$\therefore \emptyset_tR_n = 0.75[0.6 \times 400 \times 4640 + 250 \times 1606.67] \times 10^{-3} =$
$\mathbf{1136.45\ kN}$
$\le \emptyset_t[0.6F_uA_{nv} + F_uA_{nt}] = 1155.201\ kN$

For Bolts:

- **Slip critical connection**

$$\emptyset R_n = \emptyset * 1.13 * \mu * 0.7 * (\pi * \frac{d^2{}_b}{4}) * F_{ub} * N_b * N_s$$

$$\emptyset R_n = 1 * 1.13 * 0.33 * 0.7 * \left(\pi * \frac{24^2}{4}\right) * 620 * 5 * 1 \times 10^{-3} = 365.88\ KN$$

- **Bearing strength of bolts:**

$$\emptyset R_n = 0.75 * 2.4 * F_u * d_b * t_{min} * N_b$$

$$\emptyset R_n = 0.75 * 2.4 * 620 * 24 * 19 * 5 \times 10^{-3} = 2544.48\ KN$$

- **Shearing strength of bolts:**
  Bolts are in single shear

$$\emptyset R_n = 0.75 * F_{vb} * (\pi * \frac{d^2{}_b}{4}) * N_b * N_s$$

$$\emptyset R_n = 0.75 * 400 * \left(\pi * \frac{24^2}{4}\right) * 5 * 1 \times 10^{-3} = 678.24\ KN$$

∴ **Design tensile strength = 365.88 kN**