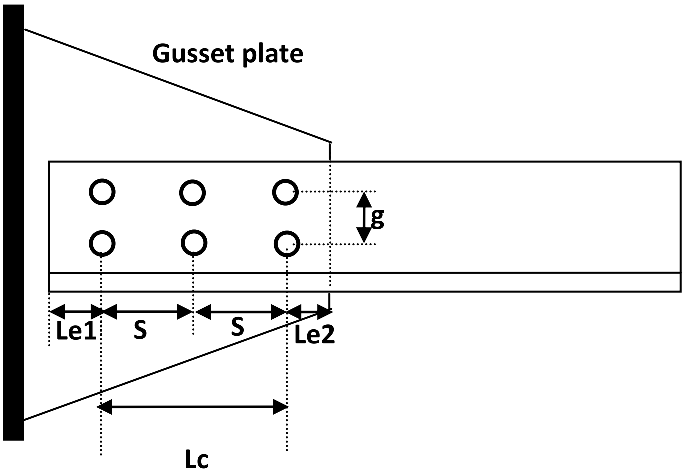
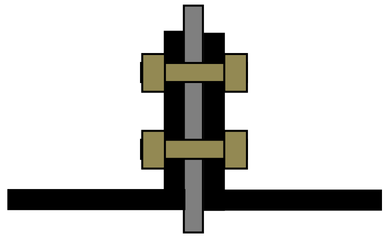
Tension members





$1 - \boldsymbol{Gross\ \ yielding :-}$

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

$2 - \boldsymbol{net\ fractures :-}$

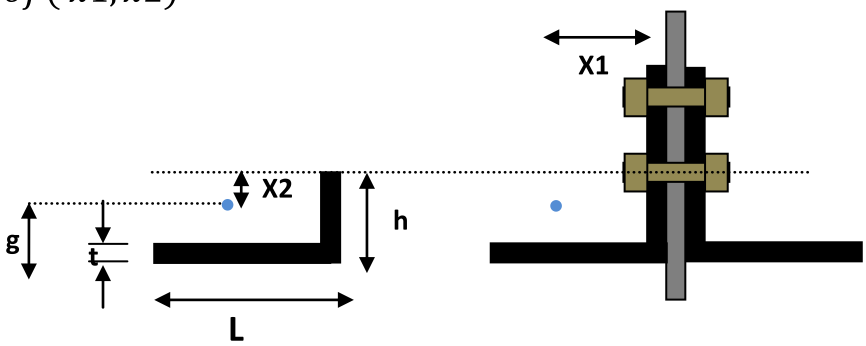
$$\emptyset R_n = 0.75 * F_u * A_e$$

$$A_e = U * A_{net}$$

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

$$U = 1 - \frac{\bar{x}}{Lc}$$

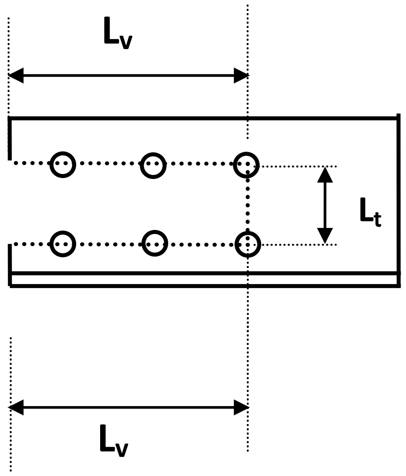
$\bar{x}$ *is the larger of* $(x1, x2)$

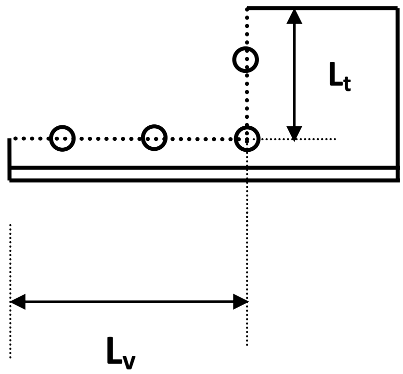


$$x_2 = h - g$$

$$g = \frac{\sum A * d}{\sum A} = \frac{\left((L-t) * t * \frac{t}{2}\right) + (h * t * \frac{h}{2})}{((L-t) * t) + (h * t)}$$

$3 - \boldsymbol{block\ shear} : -$





$$A_{gt} = L_t * t \quad , \quad A_{nt} = (A_{gt} * \sum(d_b + 3)) * t$$

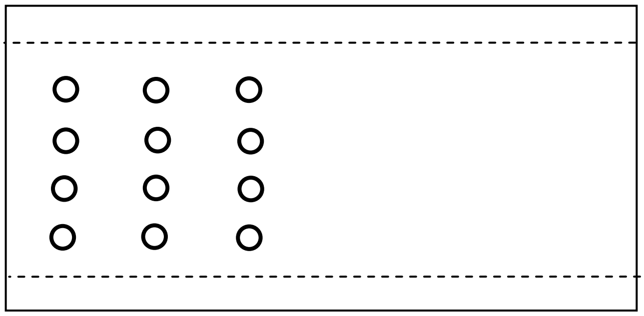
$$A_{gv} = L_v * t \quad , \quad A_{nv} = (A_{gv} * \sum(d_b + 3)) * t$$

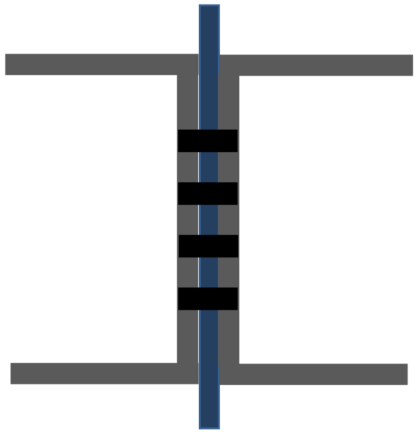
$$if\ 0.6 * Fu * A_{nv} > Fu * A_{nt} \quad ,$$

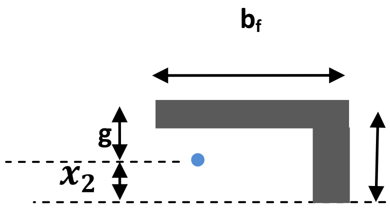
$$\emptyset R_n = 0.75(0.6 * Fu * A_{nv} + Fy * A_{nv})$$

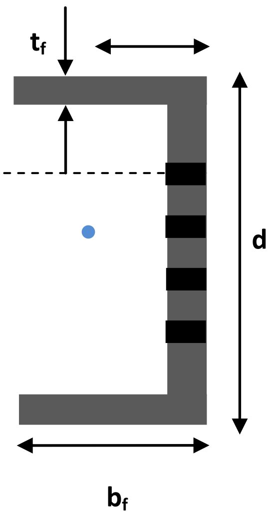
$$if\ 0.6 * Fu * A_{nv} < Fu * A_{nt} \quad ,$$

$$\emptyset R_n = 0.75(Fu * A_{nt} + 0.6 * Fy * A_{gv})$$

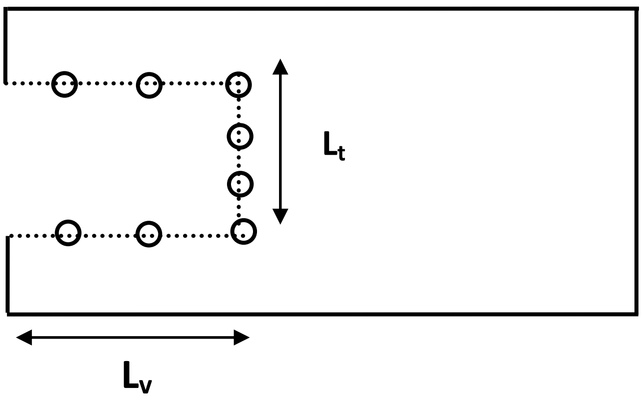






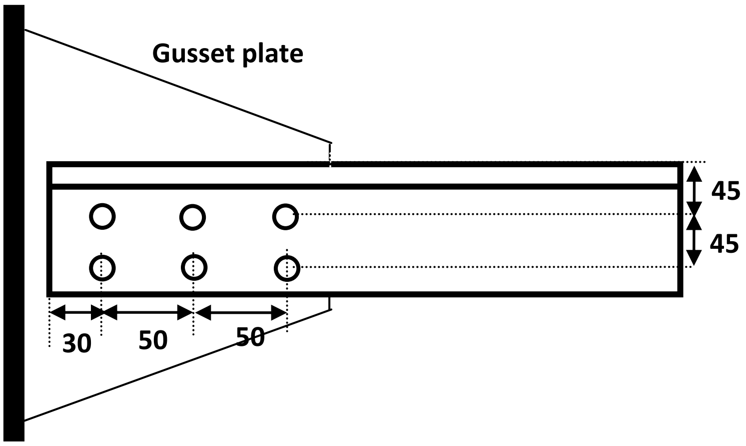


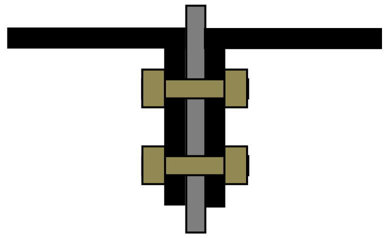
$$g = \frac{\sum A * d}{\sum A} = \frac{\left((b_f -* t_f) * t_f * \frac{t_f}{2}\right) + (h * t_w * \frac{h}{2})}{\left((b_f - t_w) * t_f\right) + (h * t_w)}$$



Question 1:

Compute the design tensile strength of the double angle tension member shown below. Dimensions shown on drawings are in millimeter.





Double L127x127x19
A36M steel

A36M steel: F_y= 250 MPa , F_u= 400MPa
Double L 127x127x19: (Table on page 1-86 of AISC Manual)
A_g= 8940 mm^2, t= 19 mm

$$A_n = A_g - \sum (d_b + 3)t$$

$$A_n = 8940 - 2(2 \times 23 \times 19) = 7192\, mm^2$$

$$x_1 = 38.6\, mm\,, \quad l = 100\, mm$$

$$g = \frac{\sum A * d}{\sum A} = \frac{\left((127-19) * 19 * \frac{19}{2}\right) + (45 * 19 * \frac{45}{2})}{((127-19) * 19) + (45 * 19)} = 13.32\, mm$$

$$x_2 = h - g = 45 - 13.32 = 31.67 mm$$

$$A_e = UA_n \quad , \quad U = 1 - \frac{\bar{x}}{l} \le 0.9 \quad ,U = 1 - \frac{38.6}{100} = 0.614 \le 0.9$$

use **U= 0.614**

$$A_e = 0.614 \times 7192 = 44415.888\, mm^2$$

- **Gross yielding design strength:**
  $\emptyset_t P_n = \emptyset_t A_g F_y = 0.9 \times 8940 \times 250 \times 10^{-3} = \mathbf{2011.5\ kN}$

- **Net section fracture strength:**
  $\emptyset_t P_n = \emptyset_t A_e F_u = 0.75 \times 44415.888 \times 400 \times 10^{-3} = \mathbf{1324.77\ kN}$

- **Block shear strength:**

  - **Section 1:**

    $l_v = 2 \times (2 \times 130) = 520\ mm$
    $l_t = 2 \times 45 = 90\ mm$
    $A_{gt} = 90 \times 19 = 1710\ mm^2$
    $A_{nt} = 1710 - 2 \times 23 \times 19 = 7836 mm^2$
    $A_{gv} = 520 \times 19 = 9880\ mm^2$
    $A_{nv} = 9880 - 10 \times 23 \times 19 = 5510\ mm^2$

    $0.6 F_u A_{nv} = 0.6 \times 400 \times 5510 \times 10^{-3} = 1322.4\ mm^2$
    $F_u A_{nt} = 400 \times 836 \times 10^{-3} = 334.4\ mm^2$
    $0.6 F_u A_{nv} > F_u A_{nt}$
    $\therefore \emptyset_t R_n = \emptyset_t [0.6 F_u A_{nv} + F_y A_{gt}] \quad \leq \emptyset_t [0.6 F_u A_{nv} + F_u A_{nt}]$
    $\therefore \emptyset_t R_n = 0.75[0.6 \times 400 \times 5510 + 250 \times 1710] \times 10^{-3} = 1312.425\ kN$
    $\leq \emptyset_t [0.6 F_u A_{nv} + F_u A_{nt}] = 1242.6\ kN$

  - **Section 2:**

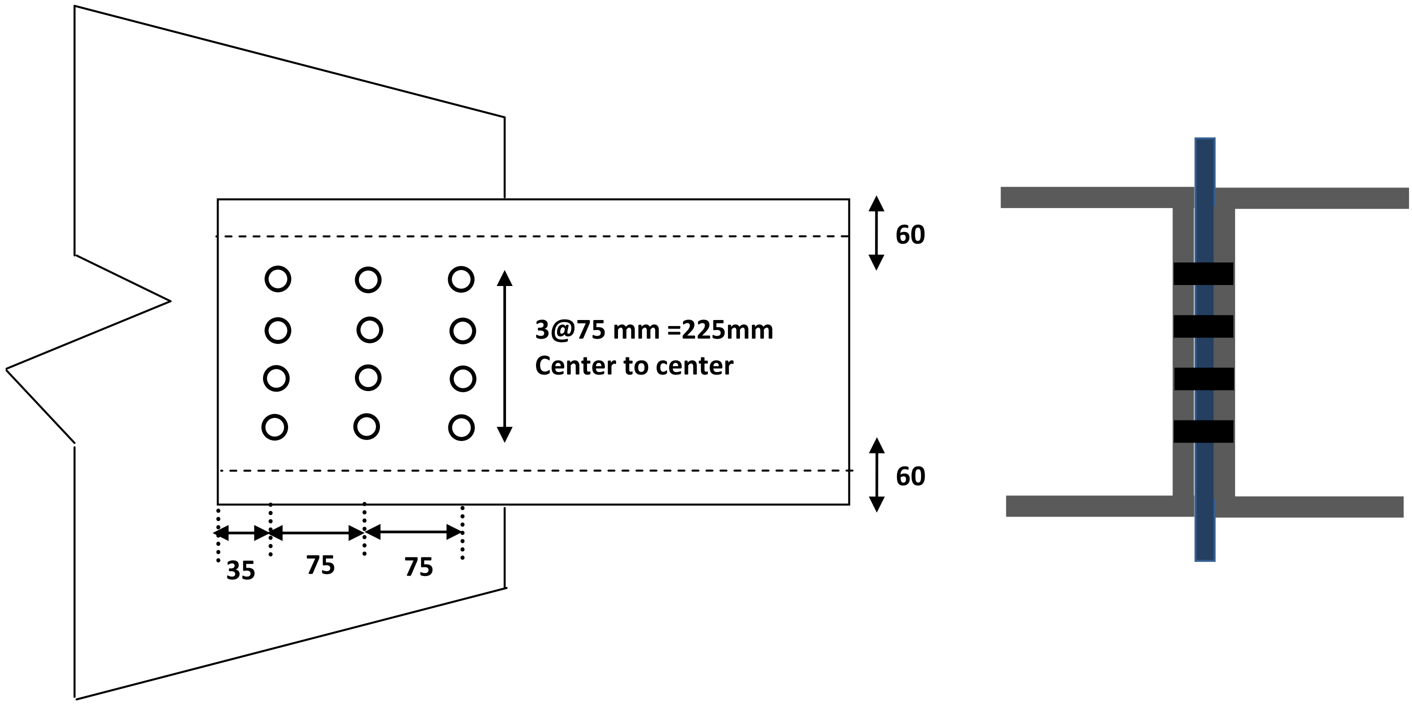
    $l_v = 260\ mm$
    $l_t = 164\ mm$
    $A_{gt} = 3116\ mm^2$
    $A_{nt} = 1805\ mm^2$
    $A_{gv} = 4940\ mm^2$
    $A_{nv} = 2755\ mm^2$

    $0.6 F_u A_{nv} = 661.2\ mm^2$
    $F_u A_{nt} = 722\ mm^2$
    $F_u A_{nt} > 0.6 F_u A_{nv}$
    $\therefore \emptyset_t R_n = \emptyset_t [0.6 F_y A_{gv} + F_u A_{nt}] \quad \leq \emptyset_t [0.6 F_u A_{nv} + F_u A_{nt}]$
    $\therefore \emptyset_t R_n = 1097.25 kN \quad \leq \emptyset_t [0.6 F_u A_{nv} + F_u A_{nt}] = \mathbf{1037.4\ kN}$

∴ **Design tensile strength = 1037.4 kN**

Question 2:

Determine the design tension strength for a double channel C380x74 connected to 14 mm thick guest plate as shown in the figure .assume that the holes are for 20-mm diameter bolts and that the plate is made from structural steel with yield stress fy equal 345 Mpa and ultimate stress equal to 450 Mpa.



F_y= 345 MPa , F_u= 450MPa

Single channel C380 x74: (Table on page 1-44 of AISC Manual)

A_g= 9480 mm^2 , t_w= 18.2 mm , d= 381 mm b_f= 94 mm , t_f= 16.5 mm

$$A_n = A_g - \sum (d_b + 3)t$$

$$A_n = 9480 - (4 \times 23 \times 18.2) = 7805.6\,mm^2$$

$$x_1 = 20.2\,mm\,, \quad l = 150\,mm$$

$$g = \frac{\sum A * d}{\sum A} = \frac{\left((94-18.2)*16.5*\frac{16.5}{2}\right) + (60*18.2*\frac{60}{2})}{\left((94-18.2)*16.5\right) + (60*18.2)} = 18.39\,mm$$

$$x_2 = h - g = 60 - 18.39 = 41.61mm$$

$$A_e = UA_n \quad , \quad U = 1 - \frac{\bar{x}}{l} \leq 0.9 \quad ,U = 1 - \frac{41.61}{150} = 0.7226 \leq 0.9$$

Use **U= 0.7226**

$A_e = 0.7226 \times 7805.6 = 5640.33mm^2$

- **Gross yielding design strength:**
  $\emptyset_t P_n = \emptyset_t A_g F_y = 0.9 \times 9480 \times 345 \times 10^{-3} = \mathbf{2943.54\ kN}$
  $\boldsymbol{for\ double\ channel} \rightarrow\ \ \emptyset_t P_n = 2 * 2943.54 = \mathbf{5887.08\ KN}$

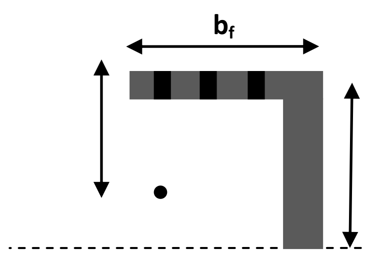
- **Net section fracture strength:**
  $\emptyset_t P_n = \emptyset_t A_e F_u = 0.75 \times 5640.33 \times 450 \times 10^{-3} = \mathbf{1903.61\ kN}$
  $\boldsymbol{for\ double\ channel} \rightarrow\ \ \emptyset_t P_n = 2 * 1903.61 = \mathbf{3807.22KN}$

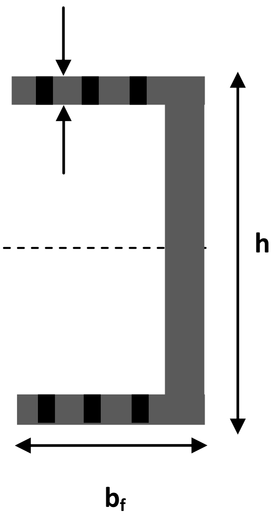
- **Block shear strength:**

  $l_v = (2 \times 185) = 370\ mm$
  $l_t = 225\ mm$
  $A_{gt} = 225 \times 18.2 = 4095\ mm^2$
  $A_{nt} = 4095 - 3 \times 23 \times 18.2 = 2839.2\ mm^2$
  $A_{gv} = 370 \times 18.2 = 6734\ mm^2$
  $A_{nv} = 6734 - 5 \times 23 \times 18.2 = 4641\ mm^2$

  $0.6F_u A_{nv} = 0.6 \times 450 \times 4732 \times 10^{-3} = 1253.07\ mm^2$
  $F_u A_{nt} = 450 \times 2839.2 \times 10^{-3} = 1277.64\ mm^2$
  $0.6F_u A_{nv} < F_u A_{nt}$
  $\therefore \emptyset_t R_n = \emptyset_t [0.6F_y A_{gv} + F_u A_{nt}] \quad \leq \emptyset_t [0.6F_u A_{nv} + F_u A_{nt}]$
  $\therefore \emptyset_t R_n = 2003.68\ kN \quad \leq 1898.0325\ kN$
  $\therefore \boldsymbol{\emptyset_t R_n} = \mathbf{1898.0325\ \ kN}$
  $\boldsymbol{for\ double\ channel} \rightarrow\ \ \emptyset_t P_n = 2 * 1898.0325\ = \mathbf{3796.065KN}$

∴ **Design tensile strength = 3796.065 kN**





$$\bar{x} = \frac{\sum A * d}{\sum A} = \frac{\left((b_f - * \, t_w) * t_f * \frac{t_f}{2}\right) + (\frac{h}{2} * t_w * \frac{h}{4})}{\left((b_f - * \, t_w) * t_f\right) + (\frac{h}{2} * t_w)}$$