Structural steel design project

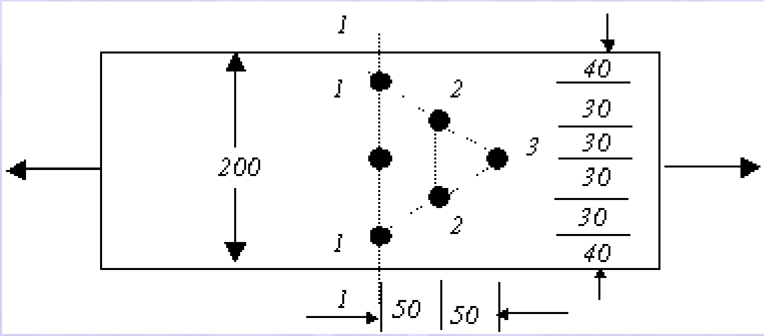
Worked example 1

Problem 1:

Determine the desig tensile strength of the plate (200 X 10 mm) with the holes as shown below, if the yield strength and the ultimate strength of the steel used are 250 MPa and 420 MPa and 20 mm diameter bolts are used.

f_y = 250 MPa

f_u = 420 MPa



Calculation of net area, A_{net}:

A_n Results you need, click here

P_t is lesser of

$$(i)\ A_g f_y / \gamma M_0 = \frac{200*10*250/1.15}{1000} = 434.8\,kN$$

$$(ii)\ 0.9\, A_n f_u / \gamma M_1 = \frac{0.9*1342*420/1.25}{1000} = 405.8\,kN$$

$$P_t = 405.8\ kN$$

Efficiency of the plate with holes = $\dfrac{P_t}{A_g f_y / yM_0} = \dfrac{409.8}{434.8} = 0.93$

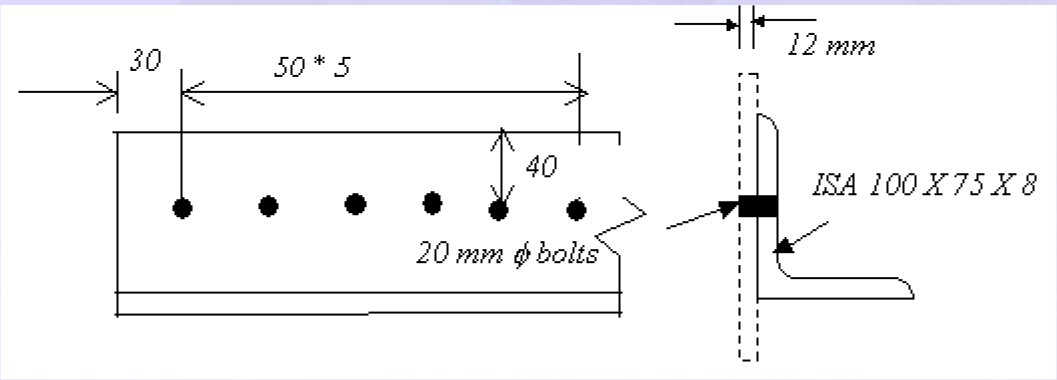
Structural steel design project

Worked example 2

Problem 2:

Analysis of single angle tension members

A single unequal angle 100 X 75 X 8 mm is connected to a 12 mm thick gusset plate at the ends with 6 nos. 20 mm diameter bolts to transfer tension. Determine the design tensile strength of the angle. (a) if the gusset is connected to the 100 mm leg, (b) if the gusset is connected to the 75 mm leg, (c) if two such angles are connected to the same side of the gusset through the 100 mm leg. (d) if two such angles are connected to the opposite sides of the gusset through 100 mm leg.



a) The 100mm leg bolted to the gusset :

A_{nc} = (100 - 8/2 - 21.5) *8 = 596 mm^2.

A_o = (75 - 8/2) * 8 = 568.mm^2

A_g = ((100-8/2) + (75 – 8/2)) * 8 =1336 mm^2

Strength as governed by tearing of net section:

Since the number of bolts = 4; $\beta = 1.0$

$$P_t = A_{nc} f_u / \gamma_{m1} + \beta A_0 f_y / \gamma_{m0}$$

= 596 * 420/1.25 + 1.0 * 568 * 250 / 1.15

= 323734 N (or) 323.7 kN

Strength as governed by yielding of gross section:

$$P_t = A_g f_y / \gamma_{m0}$$

$$= 1336 * 250 / 1.15 = 290435 \text{ N (or) } 290.4 \text{ kN}$$

Block shear strength

V_g – Grass "shearing"

t_n – Tearing net

$$P_v = \left(0.62\, A_{vg}\, f_y / \gamma_{m0} + A_{tn}\, f_u / \gamma_{m1}\right)$$ (Shear yield + tensile fracture)

= 0.62 * (5 *50 +30)* 8 * 250/1.15 + (40-21.5/2) * 8 * 420/1.25

= 380537 N = 380.5 kN

or

$$P_v = \left(0.62\, A_{vn}\, f_u / \gamma_{m1} + A_{tg}\, f_y / \gamma_{m0}\right)$$ (Shear fracture + tensile yield)

= (0.62 (5 * 50 + 30 –5.5 * 21.5) * 8 * 420 / 1.25 + 40 * 8 * 250/ 1.15)

= 339131 N = 339.1

The design tensile strength of the member = 290.4 kN

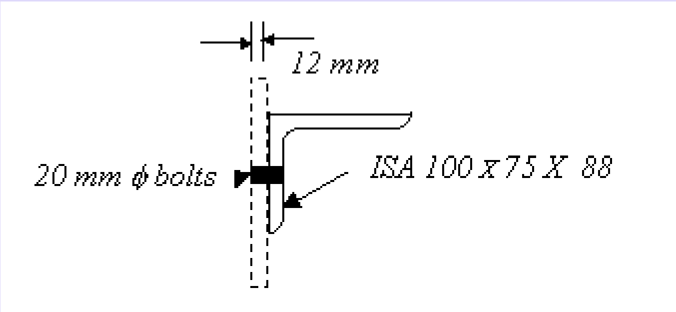
The efficiency of the tension member, is given by

$$\eta = \frac{P_t}{A_g f_y} = \frac{290.4 * 1000}{(100 + 75 - 8) * 8 * 250/1.15} = 1.0$$

b) The 75 mm leg is bolted to the gusset:

A_{nc} = (75 - 8/2 - 21.5) * 8 = 396 mm^2

A_o = (100 - 8/2) * 8 = 768 mm^2



Strength as governed by tearing of net section:

Since the number of bolts = 6, $\beta = 1.0$

$$P_t = A_{nc} f_u / \gamma_{m1} + \beta A_0 f_y / \gamma_{m0}$$

= 396 * 420/1.25 + 1.0 * 768 *250 / 1.15

= 300123 N (or) 300.1 kN

Strength as governed by yielding of gross section:

$$P_t = A_g f_y / \gamma_{m0}$$

= 1336 * 250 / 1.15 = **290435 N (or) 290.4 kN**

Block shear strength:

$$P_v \leq \left(0.62 A_{vg} f_y / \gamma_{m0} + A_{tn} f_u / \gamma_{m1}\right)$$

= 0.62 * (5 *50 +30)* 8 * 250/1.15 + (35-21.5/2) * 8 * 420/1.25

= 367097 N = **367.1 kN**

$$P_v \leq \left(0.62 A_{vn} f_u / \gamma_{m1} + A_{tg} f_y / \gamma_{m0}\right)$$

= (0.62 (5 * 50 + 30 –5.5 *x 21.5) * 8 * 420 / 1.25 + 35 *8 * 250/ 1.15

= 330435 N = **330.4 kN**

The design tensile strength of the member = **290.4 kN**

Even though the tearing strength of the net section is reduced, the yielding of the gross section still governs the design strength.

The efficiency of the tension member is as before 1.0

Note: The design tension strength is more some times if the longer leg of an unequal angle is connected to the gusset (when the tearing strength of the net section governs the design strength).

An understanding about the range of values for the section efficiency, η, is useful to arrive at the trial size of angle members in design problems.

(c & d)The double angle strength would be twice single angle strength as obtained above in case (a)

P_t = 2 * 290.4 = 580.8 kN