Govt. of Bihar
MUZAFFARPUR INSTITUTE OF TECHNOLOGY, MUZAFFARPUR, BIHAR – 842003

(Under the department of Science & Technology, Bihar, Patna)

B.Tech 6th Semester Mid-Term Examination, 2019

DESIGN OF STEEL STRUCTURE, CIVIL ENGINEERING

Time: 2 hours **Full Marks: 20**

Subject Code: 011620

Attempt any four questions.

Question Number (1) is compulsory

1) Choose the correct option from the following. (Only one option is correct)

(i) Poisson ratio of steel in elastic range

(a) 0.25 (b) 0.3 (c) 0.4 (d) 0.5

Ans-b

(ii) Load on which connection is not eccentric

(a) Lap joint (b) single cover butt joint (c) double cover butt joint (d) any of the above.

Ans-c

(iii) For fillet weld subjected to a combination of normal and shear stresses, the equivalent stress f_e should satisfy

(a) $\sqrt{f_a^2 + q^2}) \leq \frac{f_y}{\sqrt{3} \times \gamma_{mw}}$ (b) $\sqrt{f_a^2 + 3q^2}) \leq \frac{f_y}{\sqrt{3} \times \gamma_{mw}}$ (c) $\sqrt{3f_a^2 + q^2}) \leq \frac{f_y}{\sqrt{3} \times \gamma_{mw}}$

(d) $\sqrt{3f_a^2 + 3q^2}) \leq \frac{f_y}{\sqrt{3} \times \gamma_{mw}}$.

Ans-b

(iv) The minimum pitch of the bolt

(a) 2.5 times diameter of the bolt (b) 2.5 times diameter of the hole (c) 12t or 200 mm whichever is less (d)) 16t or 200 mm whichever is less

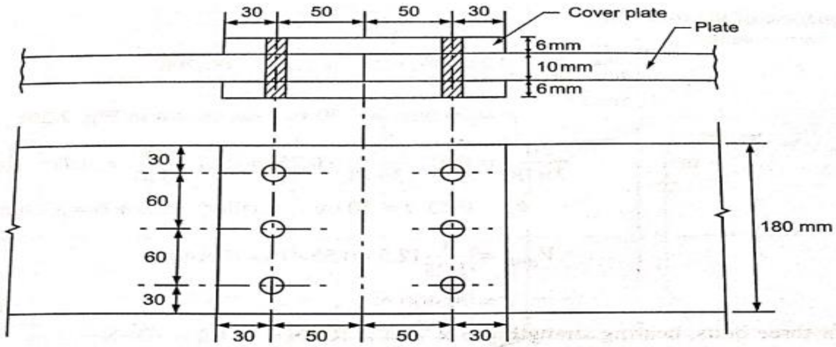
Ans-a

(v) A steel plate is 25cm wide and 12cm thick. If the diameter of the bolt hole is 20mm, the net section area of the plate is

(a) 27 cm^2 (b) 27.6 cm^2 (c) 276 cm^2 (d) 25cm^2

Ans-b

2) Two plates 180×10 mm each are connected by double cover butt joint with 16mm bolts as shown in figure. The covers are 6 mm thick . Determine the strength of the plate.


30
50
50
30
Cover plate
Plate
6 mm
10 mm
6 mm
30
60
60
30
180 mm
30
50
50
30

(2)

Solution: Given data

Dia of bolt $d = 16\,mm$

Dia of hole $d_o = 16 + 2 = 18\,mm$

(Table - 19, Page 73 from IS 800 - 2007)

Strength of bolt material $f_u = 400\,N/mm^2$

Strength of plate material $= 410\,N/mm^2$

Yield strength of steel $= 250\,N/mm^2$

Strength Calculation

(a) Strength of bolt in shear

$$V_{dsb} = \left\{ \frac{f_u}{\sqrt{3}} \left(n_n A_{nb} + n_s A_{sb} \right) \right\} \times \frac{1}{\gamma_{mb}}$$

[Page - 75, IS 800 - 2007]

Let $n_n = 2$, $n_s = 0$

$A_{nb} = 0.78 \times \frac{\pi}{4} \times 16^2 = 156.82\,mm^2$

$\gamma_{mb} = 1.25$ [Page 30, Table 5, from IS 800 - 2007)

$$V_{dsb} = \frac{1}{1.25} \left[\frac{400}{\sqrt{3}} \times 2 \times 156.82 \right]$$

$= 57.94\,kN$

(2)

For 3 bolts = 3 × 57.94 = 173.82 kN

(b) Design strength of bolt in bearing

$$V_{dpb} = \frac{1}{\gamma_{mb}} \left[2.5\, k_b\, d\, t\, f_u \right]$$

$$k_b = \text{Least of} \left\{ \frac{e}{3d_0}, \frac{p}{3d_0} - .25, \frac{f_{ub}}{f_u}, 1.0 \right\}$$

$p = 50\,mm$

$e = 30\,mm$

$$k_b = \text{least of} \left\{ \frac{30}{3 \times 18}, \frac{50}{3 \times 18} - .25, \frac{400}{410}, 1.0 \right\}$$

$$= \{0.55, 0.67, .975, 1.0\}$$

$\therefore k_b = 0.55, \quad t = 10\,mm$

$$\therefore V_{dpb} = \frac{1}{1.25} \left[2.5 \times 0.55 \times 16 \times 10 \times 400 \right]$$

$$= 70.40\ kN$$

$\therefore$ For Three bolts = 3 × 70.4 = 211.2 kN

(c) Design strength of plate from yielding Consideration

$$T_{dg} = \frac{A_g f_y}{\gamma_{m0}}$$ [Clause 6.2 Page - 33 IS 800-2007]

$A_g = 160 \times 10 = 1600\ mm^2$

$\therefore T_{dg} = \frac{1600 \times 250}{1.1} = 409.09\ kN$

(d) Design strength of plate from rupture Consideration

$$T_{dn} = \frac{0.9 A_n f_u}{\gamma_{m1}}$$ [Clause 6.3 Page - 32 IS 800-2007]

$\therefore A_n = (180 - 3 \times 18) \times 10 = 1260\ mm^2$

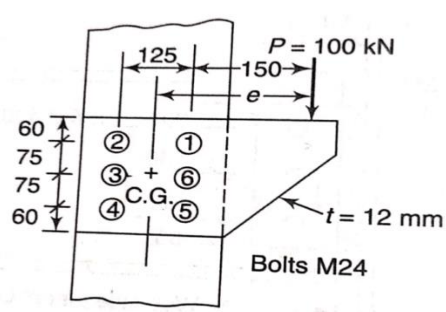
$\therefore T_{dn} = \frac{1}{1.25}[0.9 \times 1260 \times 410]$

$= 371.952\ kN$

$\therefore$ Design strength of Joint $= 173.62\ kN$

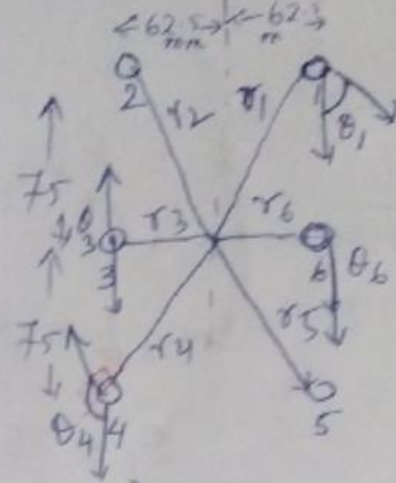
= least of Values Calculated above

3) Find the force carried by the bolt 1,3,4,6, as shown in figure, If P=100KN.



③ Solution

$$\therefore \quad e = 150 + \frac{125}{2}$$
$$= 212.5\,mm$$



$$r_1 = r_3 = r_2 = r_4$$
$$= \sqrt{75^2 + 62.5^2}$$
$$= 97.62\,mm$$

$$r_3 = r_6 = 62.5\,m$$

$$\Sigma r^2 = 4 \times 97.62^2 + 2 \times 62.5^2$$
$$= 45931.16\,mm^2$$

Direct Shear Stress in each bolt $= \frac{100}{6}$

$$F = 16.67\,kN$$

~~Bending~~

Force in bolt due to moment in 1 and 4 $= \frac{P e r_1}{\Sigma r^2}$

$$= \frac{100 \times 212.5 \times 97.62}{45931.16}$$

$$F_1 = F_4 = 45.16\,kN$$

Force in bolt 3 and 6 due to moment $= \frac{P e r_3}{\Sigma r^2}$

$= \frac{100 \times 212.5 \times 62.5}{45931.16}$

$F_3 = F_6 = 28.91\,kN$

For bolt (1)

$\cos\theta_1 = \frac{62.5}{97.62} = 0.64$

$\theta_1 = 55.77°$

Resultant force in bolt 1 $= \sqrt{F^2 + F_1^2 + 2FF_1 \cos\theta_1}$

$= \sqrt{16.67^2 + 45.16^2 + 2 \times 16.67 \times 45.16 \times 0.64}$

$= 57.28\,kN$

For bolt (4)

$\theta_4 = 180 - \theta_1 = 180 - 55.77° = 124.23°$

$\cos\theta_4 = -0.37$

Resultant force in bolt (4) $= \sqrt{F^2 + F_4^2 + 2FF_4 \cos\theta_4}$

$= \sqrt{16.67^2 + 45.16^2 + 2 \times 16.67 \times 45.16 \times (-.37)}$

$= 41.95\,kN$

For bolt (3)

$\theta_3 = 180°$

$\cos\theta_3 = -1$

Resultant force on bolt (3) $= \sqrt{F^2 + F_3^2 + 2FF_3 \cos\theta_3}$

$= \sqrt{16.67^2 + 28.91^2 + 2 \times 16.67 \times 28.91 \times (-1)}$

$= 12.24 \text{ kN}$

For bolt (6)

$\theta_6 = 0$

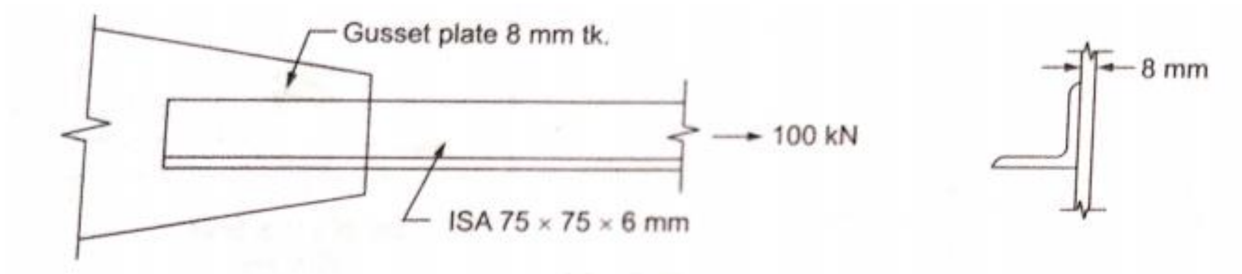
$\cos\theta_6 = 1$

Resultant force $= \sqrt{F^2 + F_6^2 + 2FF_6 \cos\theta_6}$

$= \sqrt{16.67^2 + 28.91^2 + 2 \times 16.67 \times 28.91 \times 1}$

$= 45.58 \text{ kN}$

4) The tie member of a truss made of ISA 75×75×6 mm and is subjected to factor tensile force of 100KN. Design a welded joint.



Soln (4) Given data

Force on Section = 100 kN

From Steel Handbook properties of ISA 75×75×6 mm

$A = 866 mm^2$

and $C_{xx} = C_{yy} = 20.6 mm$

Minimum Size of weld = 3 mm
(Table 21, Page 78, IS 800 2007)

Maximum Size of weld $= \frac{3}{4} t$

$= \frac{3}{4} \times 6$

$= 4.5 mm$

t = Thickness of angle member

∴ Adopt Size of welding = 4 mm = S

Let total Length of weld = L_w

Length of weld at toe end = L_{w_1}

& Length of weld at other end = L_{w_2}

Effective throat thickness of weld $t_t = 0.7s$

$= 0.7 \times 4$

$= 2.8\,mm$

(Table 22, Page 76, IS 800-2007)

Strength of weld of length L_w = Force acting on angle section

$$L_w \times t_t \times \frac{f_u}{\sqrt{3} \times \gamma_{mw}} = 100 \times 10^3$$

$$L_w \times 2.8 \times \frac{410}{\sqrt{3} \times 1.25} = 100 \times 10^3$$

$= 188.59\,mm$

$\simeq 190\,mm$

Taking moment about centroidal axis of angle section

$$L_{w_1} \times t_t \times \frac{f_u}{\sqrt{3} \times \gamma_{mw}} (75 - 20.6) = L_{w_2} \times t_t \times \frac{f_u}{\sqrt{3} \times \gamma_{mw}} \times 20.6$$

$$L_{w_2} = 2.64 L_{w_1}$$

Also $L_{w_1} + L_{w_2} = L_w$

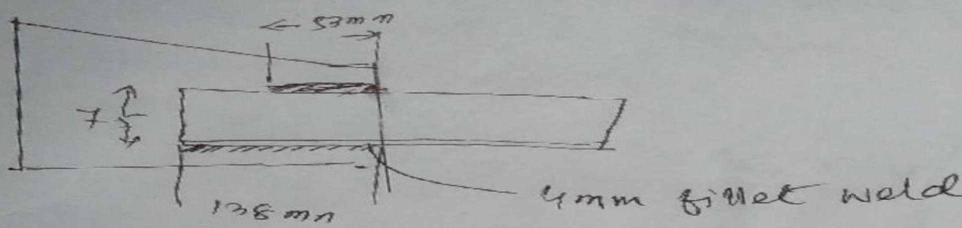
$L_{w_1} + 2.64 L_{w_1} = 190$

$L_{w_1} = 52.19\,mm = 53\,mm$

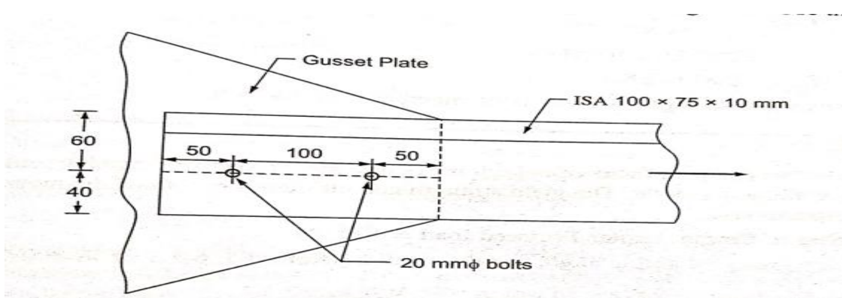
9

$L_{w2} = 190 - 52.19$

$= 137.8\ mm \simeq 138\ mm$



5) Determine the net rupture and block shear strength of the tension member shown in figure.. The yield and ultimate tensile strength of the section is 250 and 410 respectively.



Solution (5)

Design strength due to block Shear T_{db} shall be taken as Smaller of

$$T_{db_1} = \left[\frac{A_{vg} f_y}{\sqrt{3} \times \gamma_{m0}} + \frac{0.9 \times A_{tn} \times f_u}{\gamma_{m1}}\right] \text{ or}$$

$$T_{db_2} = \left[\frac{0.9 \times A_{vn} \times f_u}{\sqrt{3} \times \gamma_{m1}} + \frac{A_{tg} \times f_u}{\gamma_{m0}}\right]$$

Here $f_u = 410$ MPa,

$f_y = 250$ MPa

$\gamma_{m0} = 1.10$, $\gamma_{m1} = 1.25$ [Page 30 Table 5, IS 800-2007]

$d = 20$ mm, $d_0 = 20+2 = 22$ m

$A_{vg} = (150 \times 10) = 1500$ mm²

$A_{vn} = (150 - 1.5 \times 22) \times 10 = 1170$ mm²

$A_{tg} = 40 \times 10 = 400$ mm²

$A_{tn} = (40 - 0.5 \times 22) = 290$ mm²

$$T_{db_1} = \left(\frac{1500 \times 250}{\sqrt{3} \times 1.1} + \frac{0.9 \times 290 \times 410}{1.25}\right)$$

$$= 282.43\ kN$$

$$T_{db_2} = \left(\frac{0.9 \times 1170 \times 410}{\sqrt{3} \times 1.25} + \frac{418 \times 250}{1.10}\right)$$

$$= 290.31\ kN$$

$$\therefore T_{db} = 282.43\ kN$$

Strength of single angle in net section rupture

$$T_{dn} = \frac{0.9 \times A_{nc} \times f_u}{\gamma_{m1}} + \frac{\beta \times A_{go} \times f_y}{\gamma_{m0}}$$

→ Page 33, IS 800-2007

$$A_{nc} = (100 - 10/2 - 22) \times 10$$

$$= 730 \text{ mm}^2$$

$$A_{go} = (75 - 10/2) \times 10$$

$$= 700 \text{ mm}^2$$

$$\beta = 1.4 - 0.076 \left(\frac{w}{t}\right) \times \left(\frac{f_y}{f_u}\right) \times \left(\frac{b_s}{L_c}\right) \leq \left(\frac{f_u \times \gamma_{m0}}{f_y \times \gamma_{m1}}\right) \geq 0.7$$

$$w = 75 \text{ mm}$$

$$b_s = (75 + 60 - 10) = 125 \text{ mm}$$

$$L_c = 100 \text{ mm}$$

$$\beta = 1.4 - 0.076 \times \left(\frac{75}{10}\right) \times \left(\frac{250}{410}\right) \times \left(\frac{125}{100}\right)$$

$$= 0.97$$

$$\frac{f_u \times \gamma_{m0}}{f_y \times \gamma_{m1}} = \frac{410 \times 1.1}{250 \times 1.25} = 1.44$$

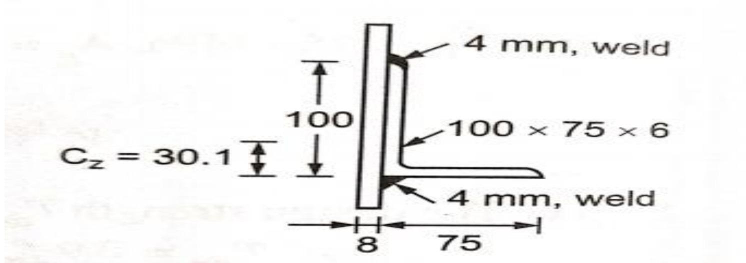
$\therefore$ $\beta \leq 1.44$ and $\beta \geq 0.7$

$$\therefore \beta = 0.97$$

$$T_{dn} = \frac{0.9 \times 730 \times 410}{1.25} + \frac{0.97 \times 700 \times 250}{1.1}$$

$$= 369.61\ kN$$

6) A single unequal angle 100×75×6 mm is connected to a 8mm thick gusset plate at the ends with 4mm welds as shown in figure . Average length of weld is 225mm. Determine the tensile strength of the angle if the gusset is connected to the 100mm leg. The yield and ultimate tensile strength of the section is 250 and 410 respectively.



Solution (6)

(i) Gross section yielding

$$T_{dg} = \frac{A_g \times f_y}{\gamma_{m0}}$$

$A_g = 1010\ mm^2$ (From Steel Table)

$$T_{dg} = \frac{1010 \times 250}{1.1} = 229.55\,kN$$

(ii) Net Section rupture

$T_{dn} = 0.9 \times f_u \times A_{nc} / \gamma_{m1} + \beta_2 A_{go} \times f_y / \gamma_{m0}$

$A_{nc} = (100 - 6/2) \times 6 = 582\ mm^2$

$A_{go} = (75 - 6/2) \times 6 = 432\ mm^2$

$w = 75\,mm$, $b_s = 75\,mm$, $L_c = 225\,mm$

$\beta = 1.4 - 0.076\,(w/t)\left(\frac{f_y}{f_u}\right)\left(\frac{b_s}{L_c}\right)$

$= 1.4 - 0.076 \times \left(\frac{75}{6}\right)\left(\frac{250}{410}\right)\left(\frac{75}{225}\right)$

$= 1.20$

$$\frac{f_u \times \gamma_{m0}}{f_y \times \gamma_{m1}} = \frac{410 \times 1.1}{250 \times 1.25}$$

$$= 1.41$$

$$\therefore 0.7 \le \beta \le 1.41$$

~~$\therefore \beta = 1$.~~

$$\beta = 1.20$$

$$\therefore T_{dn} = \frac{0.9 \times 410 \times 582}{1.25} + \frac{1.20 \times 432 \times 250}{1.1}$$

$$= 306.39\ kN$$

(iii) Block Shear Strength

$$A_{vn} = A_{vg} = (225 \times 8) \times 2$$

$$= 3600\ mm^2$$

~~A_{tn}~~

$$A_{tg} = A_{tn} = 100 \times 8 = 800\ mm^2$$

~~$\therefore T_{db1} = \frac{A_{vg} \times f_y}{\sqrt{3} \times \gamma_{m0}} + 0.9 \times 800 \times 410$~~

$$T_{db1} = \frac{A_{vg}\ f_y}{\sqrt{3} \times \gamma_{m0}} + \frac{0.9 \times A_{tn} \times f_u}{\gamma_{m1}}$$

$$= \frac{3600 \times 250}{\sqrt{3} \times 1.1} + \frac{0.9 \times 800 \times 410}{1.25}$$

$T_{db1} = 702.78$ kN

$$T_{db2} = \frac{0.9 \times A_{vn} \times f_u}{\sqrt{3} \times \gamma_{m1}} + \frac{A_{tg} \times f_y}{\gamma_{m0}}$$

$$= \frac{0.9 \times 3600 \times 410}{\sqrt{3} \times 1.25} + \frac{800 \times 250}{1.1}$$

$= 780.41$ kN

$\therefore T_{db}$ = min of T_{db1} and T_{db2}

$\therefore T_{db} = 702.78$ kN

$\therefore$ Tensile strength T_d is least of T_{dg}, T_{dn} and T_{db}

$\therefore T_d = T_{dg} = $ <u>229.55 kN</u>

<u>BEST OF LUCK</u>