11 CHAPTER Eccentric and Moment Connections

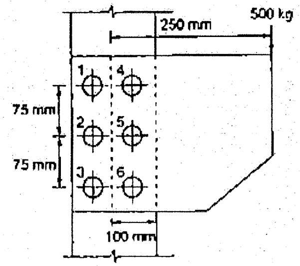
Q.1 To make the connections subjected to shear, to have minimum moment of resistance, the angles used for making connections should be
(a) Rigid (b) Light and flexible
(c) Thick (d) None of these

Q.2 In the design of bolted framed connection, the thickness of the angle is arrived at by equaling end reaction to the shear strength of the angle leg. The strength of angle leg, V_d is given by

$$V_d = \frac{f_y}{\sqrt{3}\gamma_{m0}} h \times (kt)$$

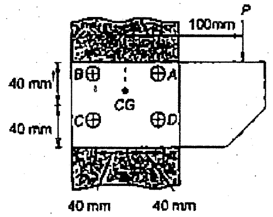
Here, the value of k is taken as
(a) 1 (b) 2
(c) 3 (d) 4

Q.3 The rivets in an eccentrically loaded riveted joint are shown in figure below.



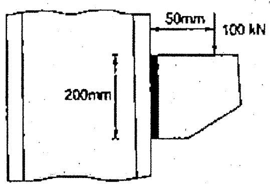
Which rivets will be stressed to the maximum?
(a) 1 and 4 (b) 1 and 3
(c) 3 and 6 (d) 4 and 6

Q.4 A moment of magnitude of 100 kN-m is transmitted from a column flange to a bracket connection as shown in figure. The shear force induced in the bolt A will be



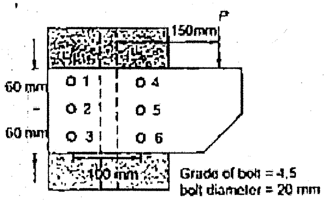
(a) 250 kN (b) 221 kN
(c) 442 kN (d) 494 kN

Q.5 A bracket plate 12 mm thick is used to transmit a factory load of 100 kN at an eccentricity as shown in figure. (Take γ_{mw} = 1.25 and f_u = 410 MPa). The size of fillet weld will be



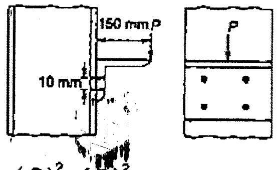
(a) 3.39 mm (b) 5.00 mm
(c) 7.53 mm (d) 9.50 mm

Q.6 For the bracket connection as shown in the figure, which bolt will have maximum resultant force?



(a) 1 (b) 4
(c) 5 (d) 6

Q.7 Each bolt shown in the given figure is capable of resisting a shear force of 40 kN and a tension of 25 kN. The interaction equation between the force is



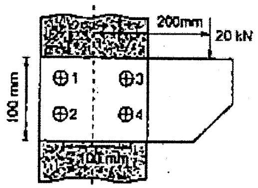
(a) $\left(\frac{P}{40}\right)^2 + \left(\frac{P}{30}\right)^2 = 1.0$

(b) $\left(\frac{P}{80}\right)^2 + \left(\frac{P}{50}\right)^2 = 1.0$

(c) $\left(\frac{P}{160}\right)^2 + \left(\frac{P}{100}\right)^2 = 1.0$

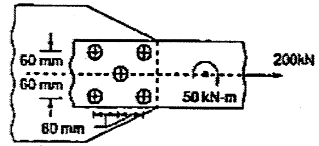
(d) $\left(\frac{P}{80}\right)^2 + \left(\frac{P}{100}\right)^2 = 1.0$

Q.8 A vertical load of 20 kN is applied to a bracket plate at an eccentricity of 200 mm, as shown in figure. The minimum resistance offered by any bolt will be



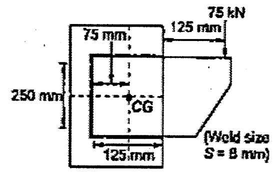
(a) 4.95 kN (b) 14.14 kN
(c) 14.98 kN (d) 11.18 kN

Q.9 A structural member is connected to a gusset plate by a lap joint by the five bolts of grade 4.6 and of diameter 20 mm. The member has to transmit a pull of 200 kN and a clockwise moment of 50 kN-m. The greatest shear produced in any bolt due to moment will be



(a) 50 kN (b) 150 kN
(c) 125 kN (d) 175 kN

Q.10 A bracket is fillet welded to a column as shown in figure. The maximum resistance offered by weld per mm length would be (Use $I = 4 \times 10^6$ mm^4).



(a) 150.0 N/mm (b) 441.6 N/mm
(c) 516.5 N/mm (d) 541.6 N/mm

Q.11 The moment of resistance of clip angle is:
(a) $0.2lt^2 \frac{f_y}{\gamma_{m0}}$ (b) $0.6lt^2 \frac{f_y}{\gamma_{m0}}$
(c) $0.8lt^2 \frac{f_y}{\gamma_{m0}}$ (d) $1.0lt^2 \frac{f_y}{\gamma_{m0}}$

Q.12 The beam-column flexible connection resist and transfer
(a) Only moment
(b) Both shear and moment
(c) Shear only
(d) 10% shear and 50% moment

Q.13 In framed connections, the bolts connecting the web of beam to connecting angles are subjected to:
(a) Double shear with no bearing at all
(b) Single shear and bearing
(c) Double shear with no bearing at all
(d) Double shear and bearing

Q.14 Given below are some of the statements regarding end plate connections.

(i) End plate is welded to the beam end

(ii) End plates extend above and below the beam section.

(iii) End plate is bolted to the column flange.

This connection is classified as:

(a) Rigid and unstiffened
(b) Rigid and stiffened
(c) Flexible and stiffened
(d) Flexible and unstiffened

Q.15 The major difficulty in analyzing the bracket connection type-*I* by ultimate analysis method is:

(i) Determination on non-linear bolt deformation relationship for each and every bolt.

(ii) Locating the instantaneous center of rotation.

(iii) A cumbersome trial and error method is required.

Of the above statements, the correct one(s) is (are):

(a) (i) and (iii)   (b) (i) and (ii)
(c) (ii) and (iii)   (d) (i), (ii) and (iii)

Q.16 The bearing length of seat angle in beam-column connection is given by,

(a) $\frac{R_1\gamma_{m0}}{t_w f_{yw}}$ (b) $1.5\frac{R_1\gamma_{m0}}{t_w f_{yw}}$

(c) $1.5\frac{R\gamma_{m0}}{t_w f_{yw}}$ (d) $1.1\frac{R\gamma_{m0}}{t_w f_{yw}}$

Q.17 In practice, all of the connections fall in the category of

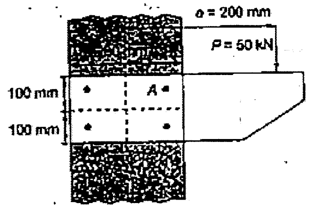
(a) Rigid connection
(b) Semi-rigid connection
(c) Flexible connection
(d) Data insufficient

Q.18 Which of the following statement(s) is(are) true w.r.t. design of moment and eccentric connections?

1. Moment resistant connections are assumed to develop 90% or more of the fixed end moment.
2. Flexible connections are assumed to develop not more 25% of the moment.

(a) 1 only   (b) 2 only
(c) Both 1 and 2   (d) Neither 1 and nor 2

Q.19 In the given figure below, the total force on the rivet *A* due to eccentric loading 50 kN having an eccentricity of 200 mm is



(a) 18.24 kN   (b) 30.17 kN
(c) 34.25 kN   (d) 38.15 kN

■■■■

Answers Eccentric and Moment Connections

1. (b)	2. (b)	3. (d)	4. (c)	5. (b)	6. (b)	7. (c)	8. (d)	9. (c)	10. (c)
11. (a)	12. (c)	13. (d)	14. (b)	15. (d)	16. (a)	17. (b)	18. (c)	19. (b)	

Explanations Eccentric and Moment Connections

1. (b)
To make these connections to have minimum moment of resistance, the angles used for making the connections should be light and flexible as far as possible.

2. (b)
The thickness, t_w, has been multiplied by a factor 2 because of pair of angles on each side of the beam web.

4. (c)
Force (F_2) due to twisting moment ($P\cdot e_0$) = M in each bolt is given as

$$F_2 = \frac{Pe_0\cdot r}{\sum r^2} = \frac{Mr}{\sum r^2}$$

For bolt A, $r_A = 40\sqrt{2}$

Similarly, $r_B = 40\sqrt{2}$

$r_C = 40\sqrt{2}$

$r_D = 40\sqrt{2}$

Thus, $\sum r^2 = r_A^2 + r_B^2 + r_C^2 + r_D^2$

$= 12800\ mm^2$

Force in bolt A

$$F_{2A} = \frac{100\times10^6\times40\sqrt{2}}{12800}N$$

$= 442$ kN

5. (b)
Direct shear due to load P(= 100 kN)

$$q = \frac{100\times10^3}{\text{Effective area}}$$

$$= \frac{100\times10^3}{L_{eff}\times t_{eff}} = \frac{100\times10^3}{(200\times2)\times(0.7S)}$$

$$= \frac{357.14}{S}$$

Bending stress,

$$f_b = \frac{M}{I}\cdot y = \frac{(P.e)\left(\frac{200}{2}\right)}{2\times t_{eff}\times\frac{200^3}{12}}$$

$$= \frac{100\times10^3\times50\times100}{2\times\frac{200^3}{12}\times0.7S} = \frac{535.71}{S}$$

Now, for safe transfer of load, the resultant stress must be less than that of the design stress of weld.

i.e., $q_n \le f_{wd}$

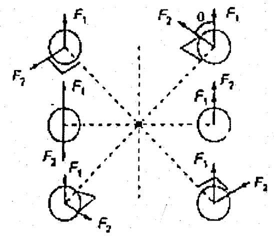
$\Rightarrow$ $\sqrt{f_b^2+q^2} \le \frac{f_u}{\sqrt{3}\times\gamma_{mw}}$

$\Rightarrow \sqrt{\frac{357.14^2+535.71^2}{S^2}} \le \frac{410}{\sqrt{3}\times1.25}$

or $S \ge 3.39$ mm.

Since connecting plate is 12 mm thick, thus minimum weld size = 5 mm

6. (b)



F_1 is force generated in each bolt due to direct shear = $\frac{P}{n}$

or $F_1 = \frac{100}{6}$kN

F_2 is force generated in each bolt due to twisting moment

$$= \frac{Mr}{\sum r^2}$$

Now, resultant force on any bolt

$$F = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$$

which depends upon magnitude of F_1, F_2, θ. Since F_1 is same for all bolts. Therefore, F depends upon F_2 and θ. F_2 will be maximum for farthest bolts (1), (3), (4) and (6) and $\cos\theta$ will be maximum for minimum θ i.e., bolt (4) and bolt (6).

Since, bolt (4) is nearer to applied load therefore it will bear maximum load.

7. (c)

Interaction equation in combined shear and tension.

$$\left(\frac{V_b}{V_{db}}\right)^2 + \left(\frac{T_b}{T_{db}}\right)^2 = 1.0$$

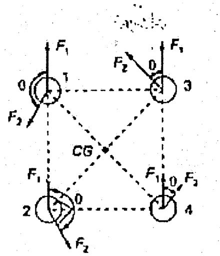
Shear resisted by four bolts = 4 × 40 = 160 kN

Tension resisted by four bolts = 4 × 25 = 100 kN

Thus, interaction equation

$$\left(\frac{P}{160}\right)^2 + \left(\frac{P}{100}\right)^2 = 1.0$$

8. (d)



Distance of all the bolts is same from CG of bolt group

$$r = \sqrt{50^2 + 50^2} = 50\sqrt{2}\text{ mm}$$

• Direct shear force

$$F_1 = \frac{\text{Load}}{\text{Number of bolts}}$$

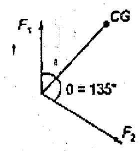
$$= \frac{20}{4} = 5\text{ kN}$$

• Force due to moment

$$F_2 = \frac{Per}{\Sigma r^2}$$

$$= \frac{20 \times 200 \times 50\sqrt{2}}{4 \times (50\sqrt{2})^2} = 14.14\text{ kN}$$

Minimum resistance will be offered by bolt(2) as $\cos\theta$ is minimum for it since θ is largest for bolt (2)



Therefore, minimum resistance

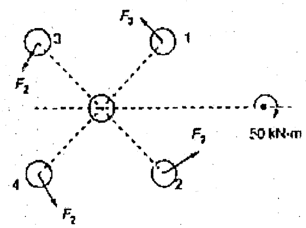
$$= \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$$

$$= \sqrt{5^2 + 14.14^2 + 2 \times 5 \times 14.14\cos 135°}$$

= 11.18 kN

Note: Bolt(1) has also same value of θ = 135°, but it is closer to applied load, thus it will not have minimum resistance.

9. (c)



Greatest shear will be produced in bolts (1) and (2) due to moment which is given by.

$$F_2 = \frac{Mr}{\sum r^2}$$

where, $r = \sqrt{80^2 + 60^2}$ = 100 mm

Thus, $\Sigma r^2 = 100^2 + 100^2 + 100^2 + 100^2$ = 4 × 10⁴ mm²

Therefore, $F_2 = \dfrac{50 \times 10^3 \times 100}{4 \times 10^4}$ kN = 125 kN

10. (c)

Resistance offered by weld per mm length against translation i.e., direct shear load

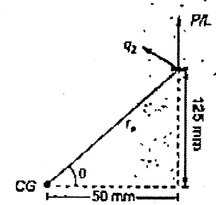
$$q_1 = \frac{P}{\text{Length of weld}}$$

$$= \frac{75 \times 10^3}{(125 \times 2 + 250)}$$

= 150 N/mm

At any point of the weld at a distance r from CG of weld group, the resistance of weld per mm length against twisting moment is,

$$q_2 = \frac{M \cdot r_n}{I} = \frac{Pe \cdot r_n}{I}$$



Eccentricity, e = (125 + 125 − 75)

= 175 mm

$$r_n = \sqrt{50^2 + 125^2} = 134.6\text{ mm}$$

$$\cos\theta = \frac{50}{134.6}$$

Thus, $q_2 = \dfrac{75 \times 10^3 \times 175 \times 134.6}{4 \times 10^6}$

= 441.6 N/mm

Thus, resultant resistance per mm length

$$= \sqrt{q_1^2 + q_2^2 + 2q_1q_2\cos\theta}$$

$$= \sqrt{(150)^2 + (441.6)^2 + 2 \times 150 \times 441.6 \times \frac{50}{134.6}}$$

= 516.5 N/mm

19. (b)

Force due to axial load,

$$F_a = \frac{P}{n} = \frac{50}{4} = 12.5\text{ kN}$$

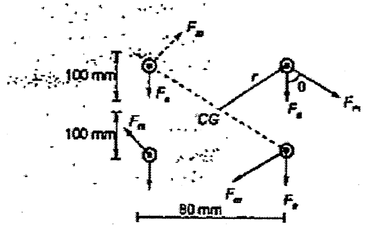
Force due to moment,

$$F_m = \frac{M \times r}{\sum r^2}$$

$$= \frac{50 \times 200 \times \sqrt{100^2 + 40^2}}{4 \times (100^2 + 40^2)}$$

= 23.21 kN

Force on rivets are shown below:



So, $\theta = \tan^{-1}\left(\frac{100}{40}\right) = 68.2°$

∴ Resultant Force,

$$F_r = \sqrt{F_a^2 + F_m^2 + 2F_aF_m\cos\theta}$$

= 30.17 kN