INTERNATIONAL UNIVERSITY OF AFRICA
CIVIL ENGINEERING DEPARTMENT

ANALYSIS AND DESIGN OF STEEL WORKS

Connections part 2

8^{TH} SEMESTER

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ECCENTRIC CONNECTIONS

There are two principal types of eccentrically loaded connections:

(1) Bolt group in direct shear and torsion; and

(2) Bolt group in direct shear and tension.

These connections are shown in Figure 10.6.

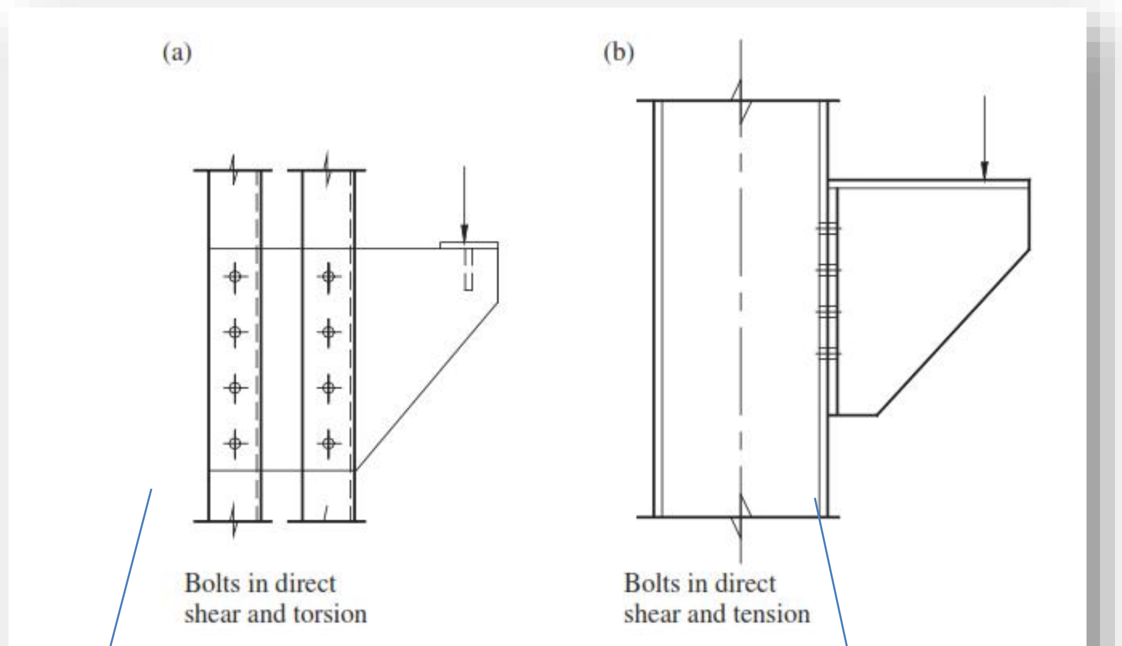
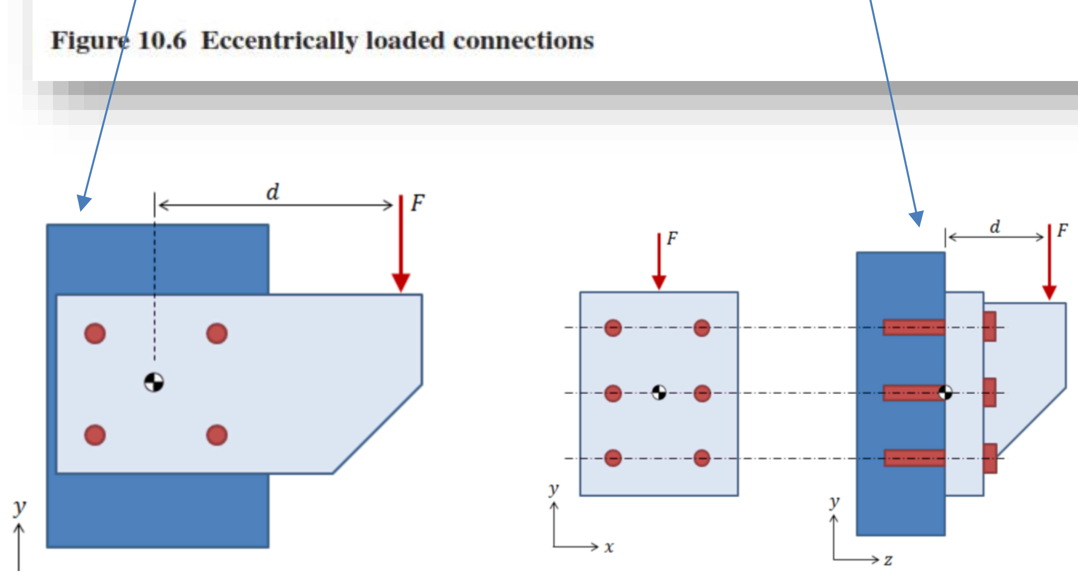
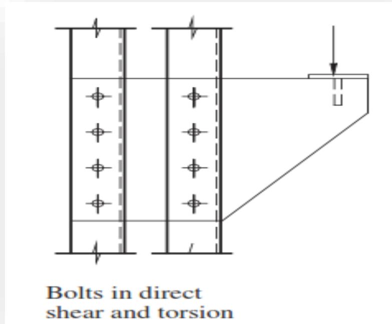


Figure 10.6 Eccentrically loaded connections



➢ Bolts in direct shear and torsion

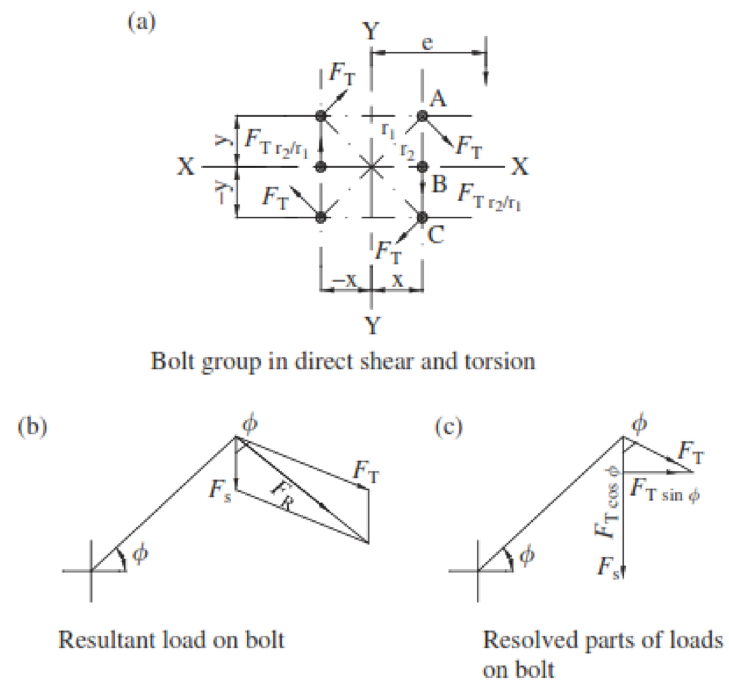
In the connection shown in Figure 10.6(a)



The moment is applied in the plane of the connection and the bolt group rotates about its center of gravity.

A linear variation of loading due to moment is assumed, with the bolt furthest from the center of gravity of the group carrying the greatest load. The direct shear is divided equally between the bolts and the side plates are assumed to be rigid.

Consider the group of bolts shown in Figure 10.7(a), where the load P is applied at an eccentricity e. The bolts A, B, etc. are at distances r_1, r_2, etc. from the centroid of the group. The coordinates of each bolt are (x_1, y_1), (x_2, y_2), etc. Let the force due to the moment on bolt A be F_T. This is the force on the bolt farthest from the centre of rotation. Then the force on a bolt r_2 from the



Bolt group in direct shear and torsion

Figure 10.7 Bolt group in direct shear and torsion

centre of rotation is $F_T r_2/r_1$ and so on for all the other bolts in the group. The moment of resistance of the bolt group is given by Figure 10.7:

The load F_T due to moment on the maximum loaded bolt A is given by

$$F_T = \frac{P \cdot e \cdot r_1}{\sum x^2 + \sum y^2}$$

The load F_S due to direct shear is given by

$$F_S = \frac{P}{\text{No. of bolts}}$$

The resultant load F_R on bolt A can be found graphically, as shown in Figure 10.7(b). The algebraic formula can be derived by referring to Figure 10.7(c).

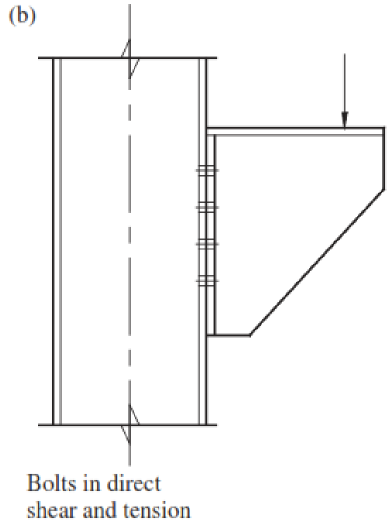
Resolve the load F_T vertically and horizontally to give

Vertical load on bolt $A = F_s + F_T \cos\phi$
Horizontal load on bolt $A = F_T \sin\phi$
Resultant load on bolt A

$$\begin{aligned} F_R &= [(F_T \sin\phi)^2 + (F_S + F_T \cos\phi)^2]^{0.5}, \\ &= [F_S^2 + F_T^2 + 2F_S F_T \cos\phi)]^{0.5}. \end{aligned}$$

The size of bolt required can then be determined from the maximum load on the bolt.

➢ Bolts in direct shear and tension



In the bracket-type connection shown in Figure 10.6(b) the bolts are in combined shear and tension. BS 5950: Part I gives the design procedure for these bolts in Clause 6.3.4.4. This is:

The factored applied shear F_S must not exceed the shear capacity P_s, where $P_s = p_s A_s$. The bearing capacity checks must also be satisfactory. The factored applied tension F_T must not exceed the tension capacity P_T, where $P_T = 0.8 p_t A_t$.

In addition to the above the following relationship must be satisfied:

$$\frac{F_S}{P_S} + \frac{F_T}{P_T} \leq 1.4.$$

An approximate method of analysis that gives conservative results is described first. A bracket subjected to a factored load P at an eccentricity e is shown in Figure 10.9(a). The center of rotation is assumed to be at the bottom bolt in the group. The loads vary linearly as shown on the figure, with the maximum load F_T in the top bolt.

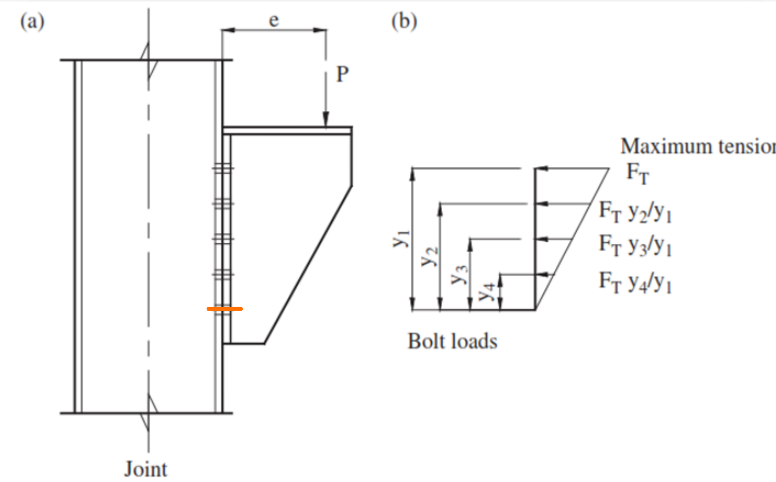


Figure 10.9 Bolts in direct shear and tension: approximate analysis

The moment of resistance of the bolt group is:

$$\begin{aligned} M_R &= 2[F_T \cdot y_1 + F_T \cdot y_2^2/y_1 + \cdots] \\ &= 2F_T/y_1 \cdot [y_1^2 + y_2^2 + \cdots] \\ &= \frac{2\,F_T}{y_1}.\sum y^2 \\ &= P \cdot e \end{aligned}$$

The maximum bolt tension is:

$$F_T = P \cdot e \cdot y_1/2\sum y^2$$

The vertical shear per bolt:

$$F_s = P/\text{No. of bolts}$$

A bolt size is assumed and checked for combined shear and tension as described above.