2.6 DESIGN OF COLUMN BASE AND GUSSETED BASE

The region where the (smaller) column section gradually gets expanded so as to be adaptable for the larger foundation structures is known as the column base. There are various types of column bases depending upon the column and foundation type.

Column bases are important joints, not only from the structural safety point of Bases view but from other considerations also. For example, it must

i) provide proper alignment of columns in plan;

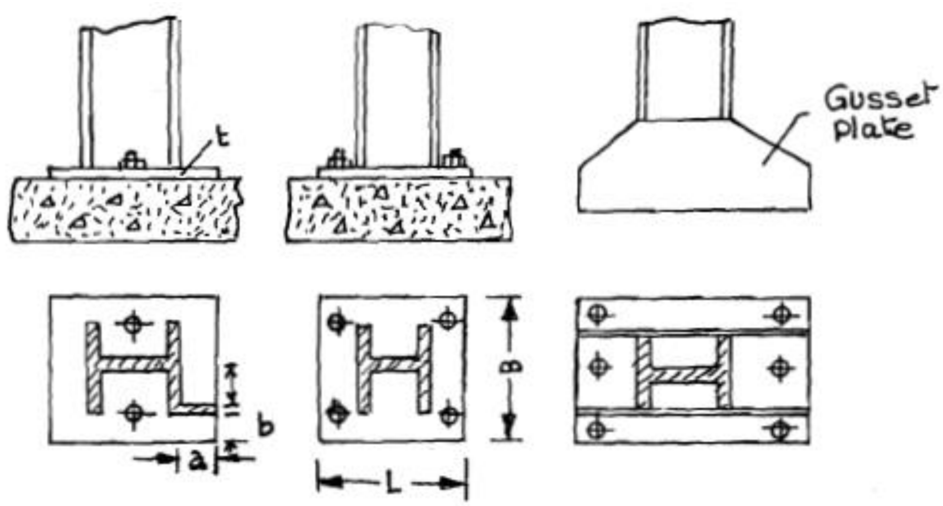
ii) ii) ensure verticality of the columns;

iii) iii) limit the deflections of the columns;

iv) iv) protect the base from floorlground corrosion; v) provide proper and firm anchorage to the column end.

Common Types of Column Bases

Some of the common types of column bases are shown in Figure



(a) Hinged Joint (b) Rigid Joint (c) Gussetted Base

Slab Base: Figure (a) shows a slab base which is usually a rienforced concrete slab. The steel column is connected (either by rivet or welded joints) to a flat steel base plate which is laid down on that horizontal surface of the RC slab. The base plate is fixed to'the slab by means of suitable hold fast (or anchor) bolts.

b) Gussetted Base: Sometimes the base-plate in the above type of foundation becomes very thick as per the design requirements. In such a case the plate size can be reduced by using a combination of stiffeners, gusset plates or wing plates as shown in Figure (b). Such a base is known as gussetted base.

Design of Simple Slab Bases

The base plates are designed to withstand the axial load, horizontal shear or external moments transmitted through the column and must be able to safely transfer the same to the foundation. The pressure distribution of reaction from concrete on the underside of the base-plate is assumed to be uniform.

The following are the major design considerations:

i) Size of the Base Plate The size of the plate must be large enough to ensure the pressure on the base concrete (w) to be within limits. For columns carrying both axial load and moment the bearing stress (w) on the concrete is

$$w = \frac{P}{A_b} \pm \frac{M}{Z_b} \qquad ...(9.1)$$

where,

P = axial load on the column,

M = bending moment transmitted at the column bases,

A_b = area of base (= $B.D.$ for rectangular bases), and

Z_b = section (= $\frac{BD^2}{6}$ for rectangular bases).

Thus, if we denote load eccentricity $e = \frac{M}{P}$, the equation (9.1) above can be written as follows for rectangular plates

$$w = \frac{P}{BD} + \frac{6M}{BD^2} = \frac{P}{BD}\left[1 + \frac{6e}{D}\right] \qquad ...(9.2)$$

The allowable bearing stress (σ_{cbe}) in concrete is given by

$$\sigma_{cbc} = \sigma_{cc}\sqrt{\frac{A_c}{A_b}} \qquad ...(9.3)$$

where,

σ_{cc} = allowable compressive stress in concrete = 0.25 f_{ck} (where f_{ck} is the characteristic strength of concrete),

A_b = area of bearing plate, and

A_c = area of cross-section of pedestal or area of the largest frustum of a cone contained in the footing at a slope of 1 (vert.) in 2 (horiz.) in case of sloping/stepped pedestal. (Figure 9.2(c))

[**Note**: The factor $\sqrt{\frac{A_c}{A_b}}$ cannot be greater than 2.0]

ii) Thickness of the Base Plate

When the slab alone distributes the load uniformly the minimum thickness (t) of a rectangular slab shall be given by the following formula

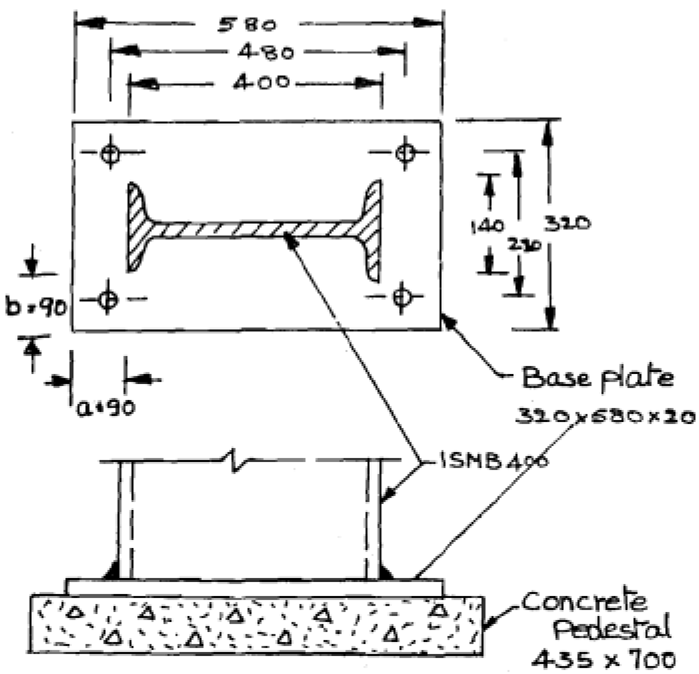
$$t = \sqrt{\frac{3w}{\sigma_{bs}}\left(a^2 - \frac{b^2}{4}\right)} \qquad ...(9.4)$$

where, σ_{bs} = the permissible bending stress in slab bases (for all steels, shall be assumed as (85 MPa),

a = the greater projection of the plate beyond column, and

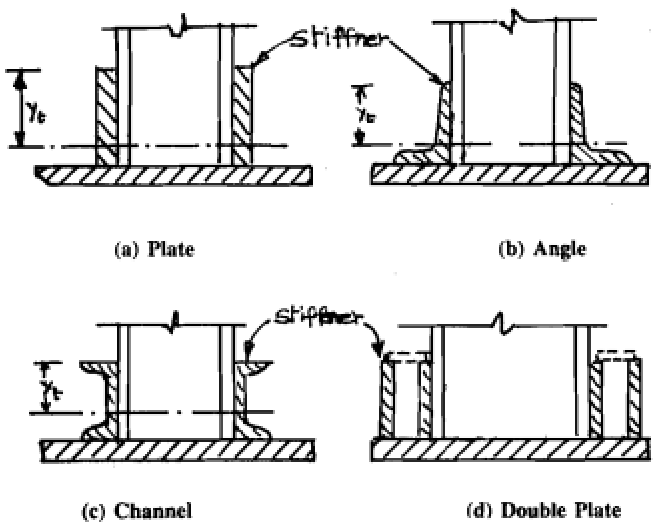
b = the lesser projection of the plate beyond column.
(t, a and b are in mm; w should be given in MPa)

When the slab does not distribute the loading uniformly (or where the plate is not rectangular), special calculations shall be made to show that the stresses are within the specified limits.



DESIGN OF GUSSETTED BASES

When the load is very large apd the base plate size is to be increased the thickness of the plate from Eq. (9.3) becomes excessive. Hence to reduce the projection lengths a and b, fastners like gusset plates, angle cleats and stiffeners etc. are used to (see Figure 9.l(c)). If the column ends are machined for complete bearing on the base plate, half of the axial load is assumed to be transferred to the plate by direct bearing and remaining half through the fasteners. In the case of unfaced column end and gusset plates, the entire design load is assumed to be transmitted through the fasteners.



(a) Plate (b) Angle

(c) Channel (d) Double Plate

MOMENT RESISTANT COLUMN BASES

In bases for column carrying axial loads (P) only were discussed. In this case the bearing pressure between the base plate and footing is assumed uniform

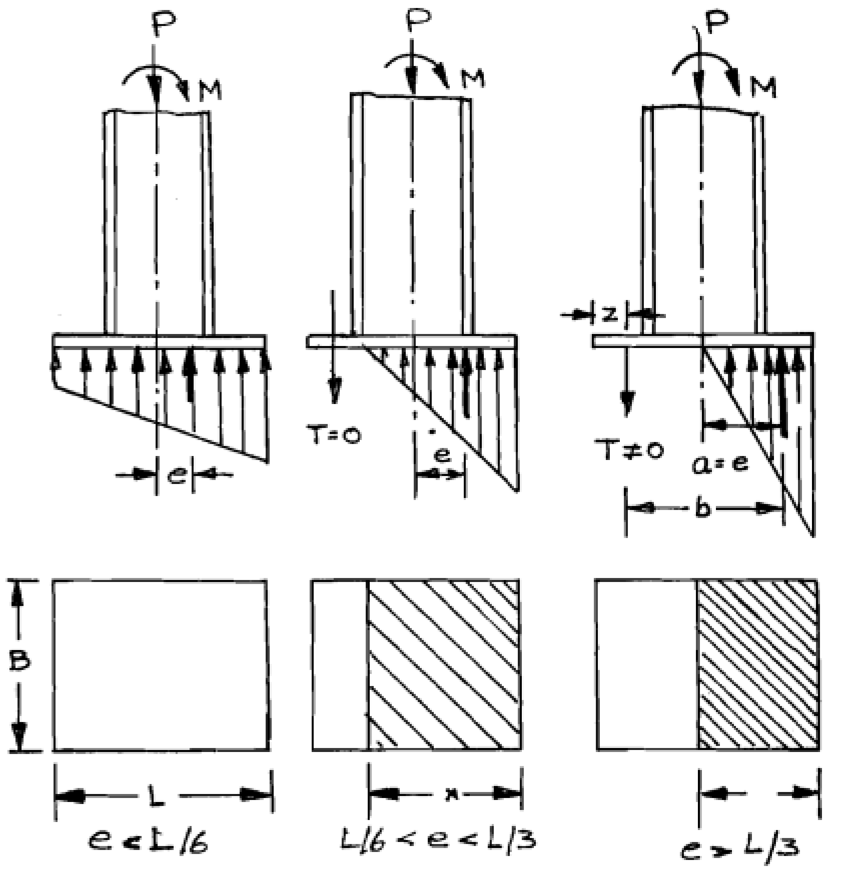
$$\left(w = \frac{P}{A_b} \right)$$

Anchor bolts only hold the column in position and do not take up any loads. If the columns carry bending moments (M) at its ends the bearing pressure follows the linear law

$$w = \frac{P}{A_b} \pm \frac{M}{Z_b}$$

and the anchor bolts are sometimes required to take up tensions.

Eccentrically Loaded Base Plates Three cases of eccentrically loaded base plates may arise (Figure) depending upon the value of eccentricity (e).



(i) Case I (ii) Case II (iii) Case III

a) **Case I:** *Compression over entire area (Figure 9.6(a)(i))*

Here, $e < L/6$

Anchor bolts are theoretically not required but 16 to 20 mm diameter bolts are provided for keeping the column in position.

b) **Case II:** *Tension over an area of less than $\frac{1}{3}$ of the base area (Figure 9.6(a)(ii))*

Here, $L/6 < e < L/3$

From dimension of column the width of base plate (B) may be assumed. The length of the base plate (L) is then given by the formula

$$L = \frac{4P}{3B\sigma_{cbc}} + 2e \qquad ...(9.6)$$

The tension in the bolt, for $e < \frac{L}{3}$, may be neglected.

c) **Case III:** *Tension over more than $\frac{1}{3}$ of the base area (Figure 9.6(a)(iii))*

In this case L can be found out by adopting the positive sign in Eq. (9.2)

$$L = \frac{P}{2B\sigma_{cbc}} \sqrt{\left[\left(\frac{p}{2B\sigma_{cbc}}\right)^2 + \left(\frac{6P.e}{B\sigma_{cbc}}\right)\right]} \qquad ...(9.7)$$

The area (A_s) and number (n) of the anchor bolts in tension can be determined by taking moments of all forces about the centre of the compressive zone in foundation block and increasing it by 40% for consideration of stability. Here,

$$A_{s(net)} = \frac{1.4T}{n\sigma_{tf}} \qquad ...(9.8(a))$$

$$A_{s(gross)} = A_{s(net)}/0.75 \qquad ...(9.8(b))$$

The gross area of the bolt is obtained by dividing it with a factor 0.75

Here, σ_{tf} = permissible tensile stress in bolt

and $$T = \frac{M - Pa}{b} \qquad ...(9.9)$$

where, $$a = \frac{1}{2} - \frac{x}{3}, \text{ and } b = L - e - \frac{x}{3} \qquad ...(9.10)$$

where, e = edge distance of the bolt holes

and $$x = \frac{\sigma_{con(max)}}{\sigma_{conc(max)} + \sigma_{con(min)}} \cdot L \qquad ...(9.11)$$

The maximum and minimum concrete stresses are obtained from formula (9.2).

The base plates may be either (a) **unattached** to the column, or (b) **attacked** to it firmly by welding or riveting.

The latter may have either (i) **initially tensioned** bolts, or (ii) the bolts are **untensioned**.