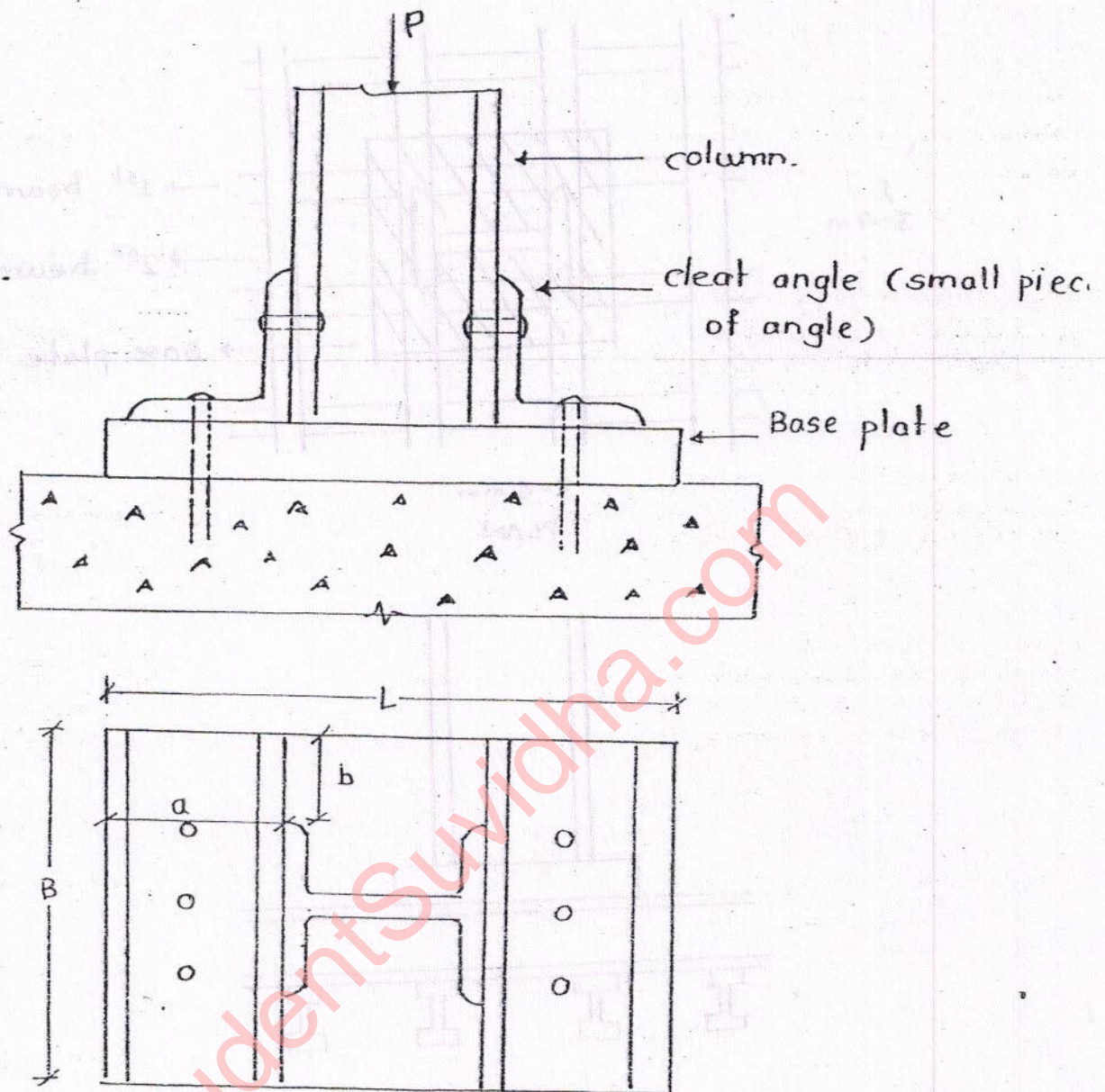
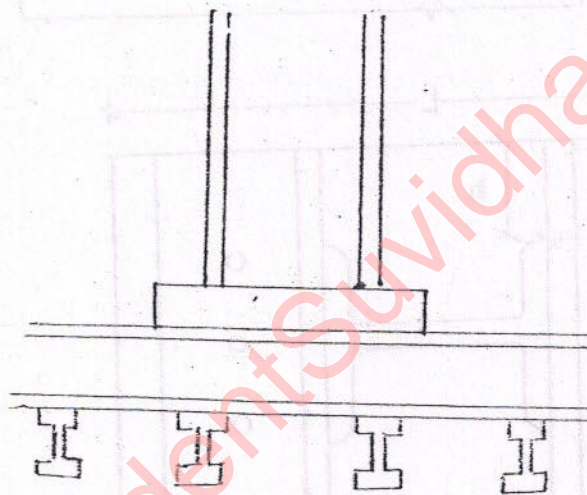
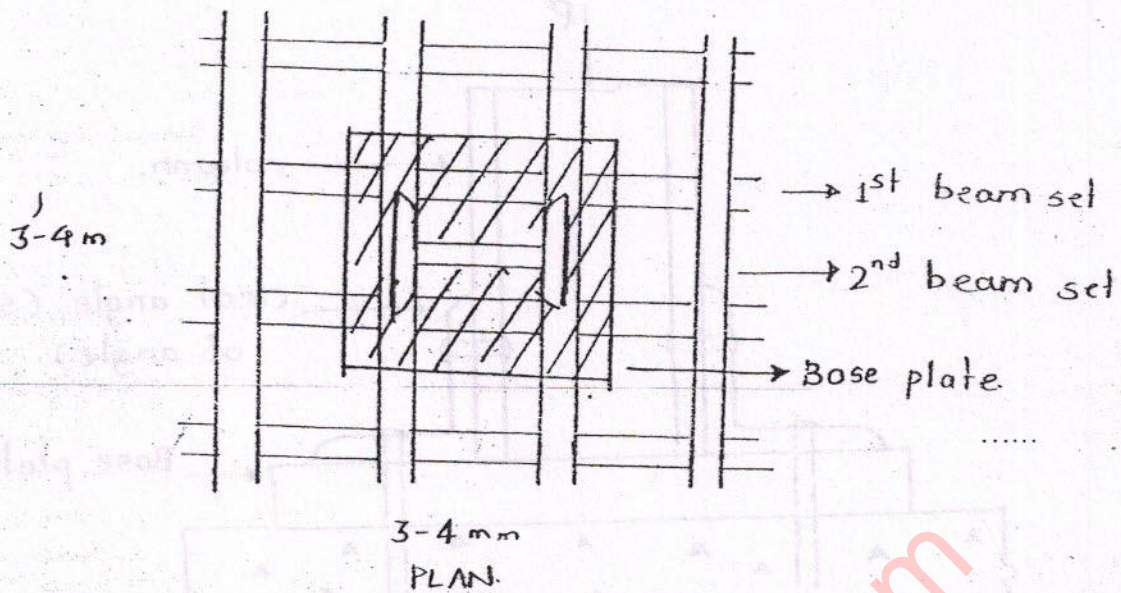


Design of column bases :



- (i) Column base is base plate used to reduce the bearing pressure on the concrete footing. It transfers the load to concrete footing. It prevents punching shear of footing.
- (ii) If the column loads are less then, slab bases are used. and if column loads are more then gusseted slab bases are used.
- (iii) If the soil is weak, grillage foundations are used.



Grillage foundation.

Since grillage foundation consist of series of beams, they are checked for shear force, buckling of beam web due to column loads and bending moment.

In slab base, base plate and cleat angles are used.

Slab base:

- (i) In slab base, base plate and cleat angles are used.
- (ii) If the column bottom and base plate are machined for complete bearing then entire load is transferred to the base plate by direct bearing action only. The purpose of cleat angle is only to hold the column in position. But, it is assumed that 50% of load is transferred by direct bearing action and remaining 50% is transferred through cleat angles and their connections.
- (iii) If the bearing ends are not machined for complete bearing then entire load is assumed to be transfer to base plate through cleat angles and their connections.
- (iv) If column load is axial, then thickness of base plate is given

$$t = \sqrt{\frac{3W}{\sigma_{bs}} \left(a^2 - \frac{b^2}{4} \right)} \quad \text{in WSM}$$

$$t = \sqrt{\frac{2.5W}{\sigma_{bs}} \left(a^2 - 0.3b^2 \right)} \quad \text{in LSM}$$

where

W - upward pressure on base plate.

a, b - greater and smaller projection of Base plate beyond column edge, respectively.

σ_{bs} - permissible bending compressive stress in base plate.

$$\sigma_{bs} \leq 185 \text{ MPa} \quad (\text{in WSM})$$

$$= \frac{F_y}{1.1} \quad (\text{in LSM})$$

- (v) To get minimum thickness of base plate, keep the projections a and b equal and magnitudes of a & b should be also less.

Q. A square steel slab base of area 1 m^2 , is provided for a column made up of 2-rolled channel sections. $300 \times 300\text{ mm}$ column carries an axial compressive load of 2000 kN . If $\sigma_{bs} = 185\text{ MPa}$, thickness of slab base required is.

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

$$W = \frac{P}{\text{Area of plate}} = \frac{2000 \times 10^3}{1000 \times 1000} = 2\text{ N/mm}^2$$

$$a = b = 350\text{ mm}, \quad \sigma_{bs} = 185\text{ MPa}$$

$$t = \sqrt{\frac{3 \times 2}{185} \left(350^2 - \frac{350^2}{4} \right)} = 54.5\text{ mm}$$

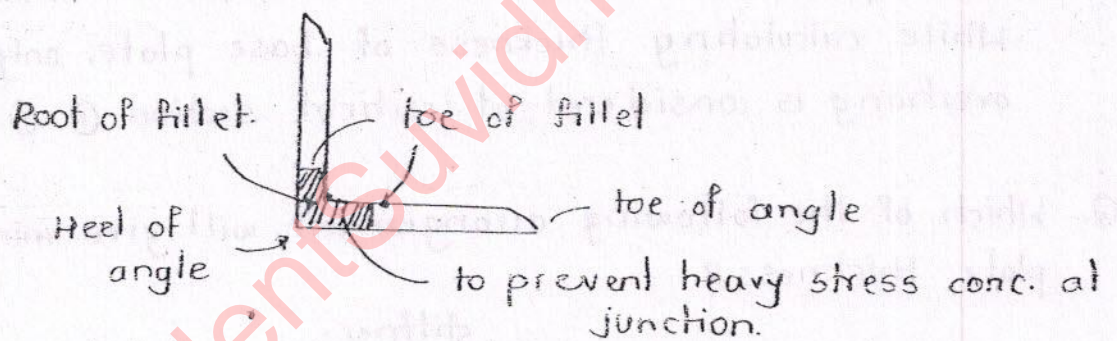
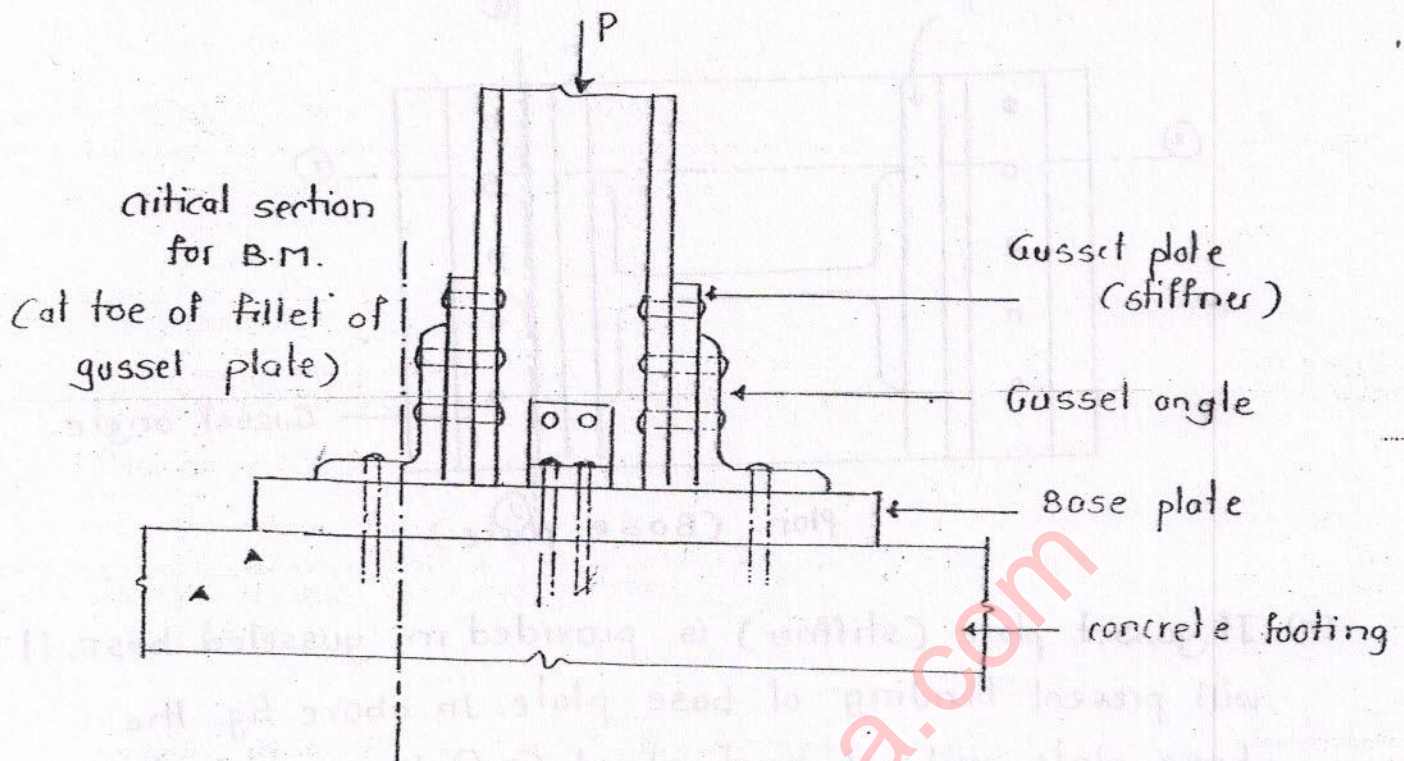
Q. If factored compressive load in above problem is 2000 kN and yield stress for the base plate material is 250 MPa find thickness of base plate

$$t = \sqrt{\frac{2.5W}{\sigma_{bs}} \left(a^2 - 0.3b^2 \right)}$$

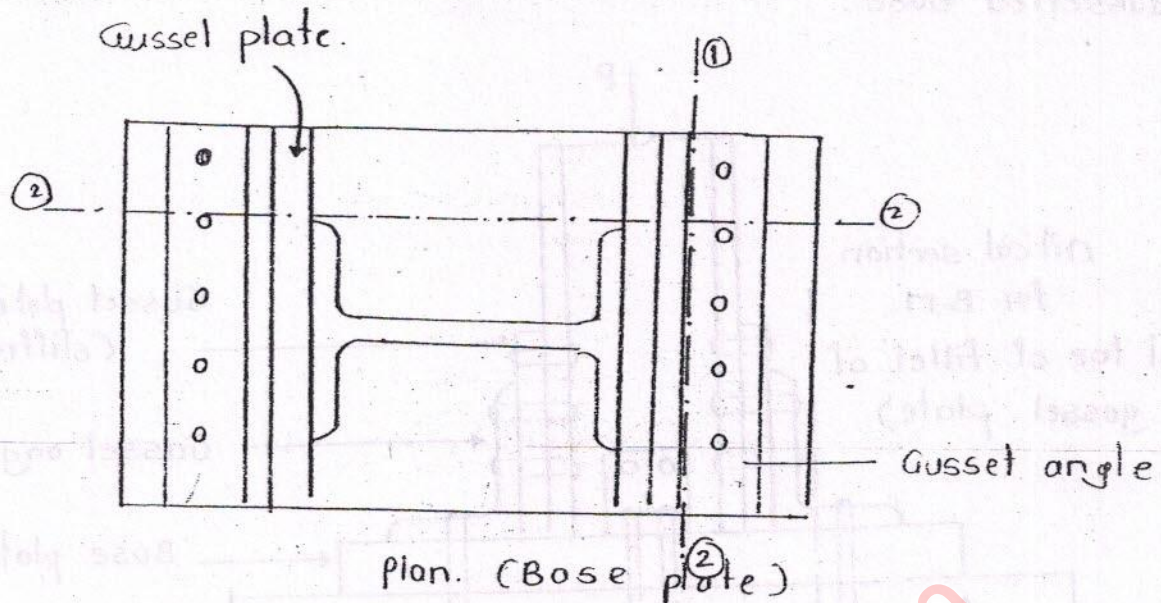
$$= \sqrt{\frac{2.5 \times 2}{\left(\frac{250}{1.1} \right)} \left(350^2 - 0.3 \times 350^2 \right)}$$

$$= 43.43\text{ mm}$$

Gusseted base:

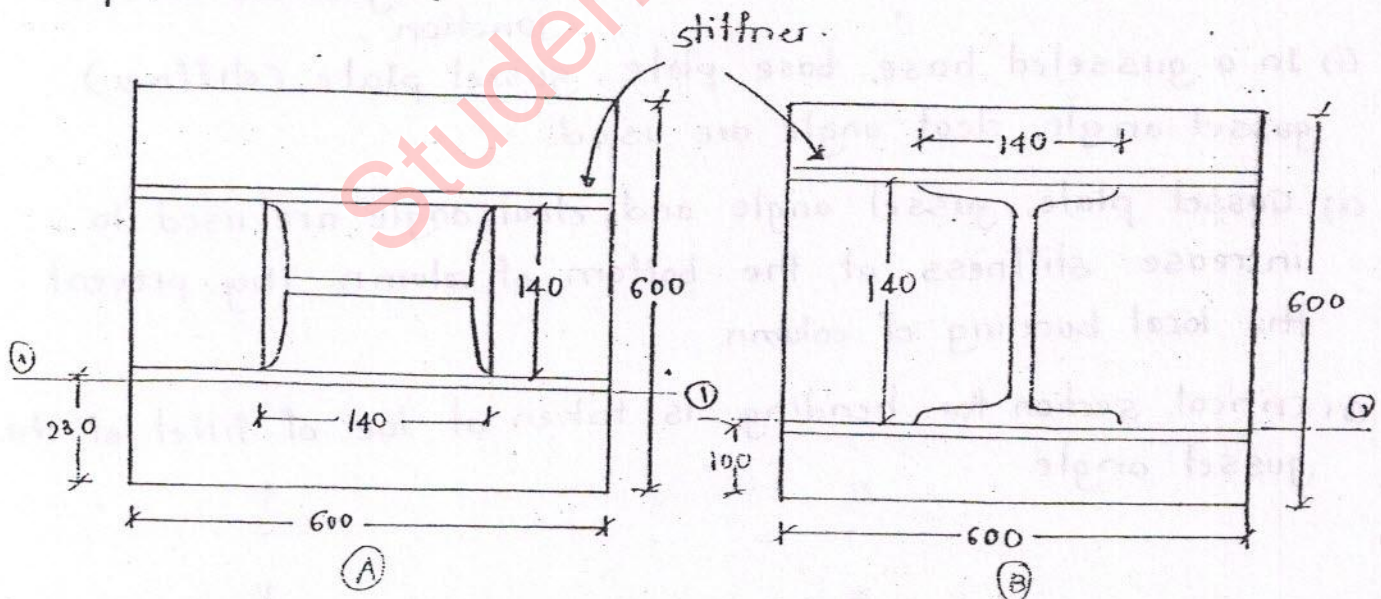


- (i) In a gusseted base, base plate, gusset plate (stiffener), gusset angle, cleat angle are used.
- (ii) Gusset plate, gusset angle and cleat angle are used to increase stiffness at the bottom of column. They prevent the local buckling of column.
- (iii) critical section for bending is taken at toe of fillet of the gusset angle.



(iv) If gusset plate (stiffener) is provided in gusseted base, it will prevent bending of base plate. In above fig. the base plate will not bend about ②-② because of stiffener. While calculating thickness of base plate, only one overhang is considered at critical section ①-① as shown.

Q. Which of the following arrangement will give minimum base plate thickness?

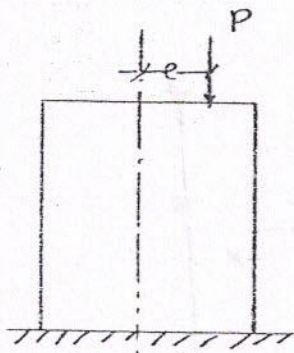


Arrangement (B) gives minimum base plate thickness because it can bend about ①-① only and overhang is less (100 mm)

Note:

- (i) If the applied load is axial, then the pressure distribution below the base plate will be uniform. If the column load is eccentric or if the column is subjected to axial load and moment, then direct and bending stresses are developed below the base plate, and the pressure distribution will not be uniform.
- (ii) The IS code formula for the thickness of base plate is applicable only when the load is axial and pressure distribution is uniform. If the pressure distribution is not uniform we cannot use IS code formula.

Direct and bending stresses below base plate:



Direct compressive stress, $f_c = \frac{P}{A}$

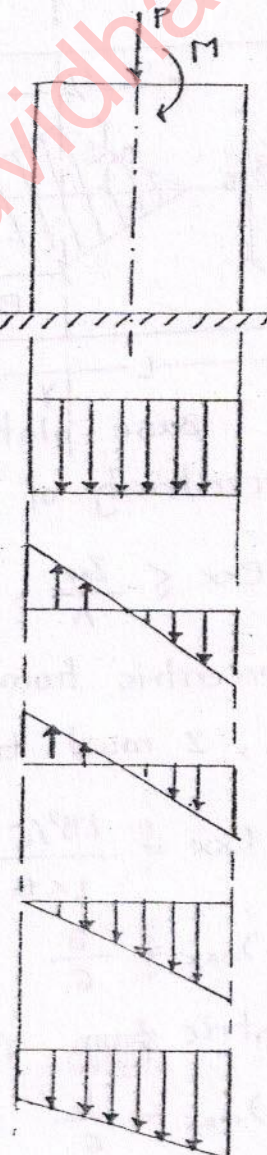
Bending stress, $f_b = \frac{M}{Z}$

compression - +ve
tension - -ve

$(f_c - f_b)$

$(f_c + f_b)$

Final stress
distribution



(i) Depending on the magnitudes of f_o and f_b , there can be three possible final stress distribution diagrams.

(ii) Core or Kernel of c/s :

It is the small portion of the c/s within which if load is applied, tension will not be developed.

so,

$$f_o - f_b \geq 0$$

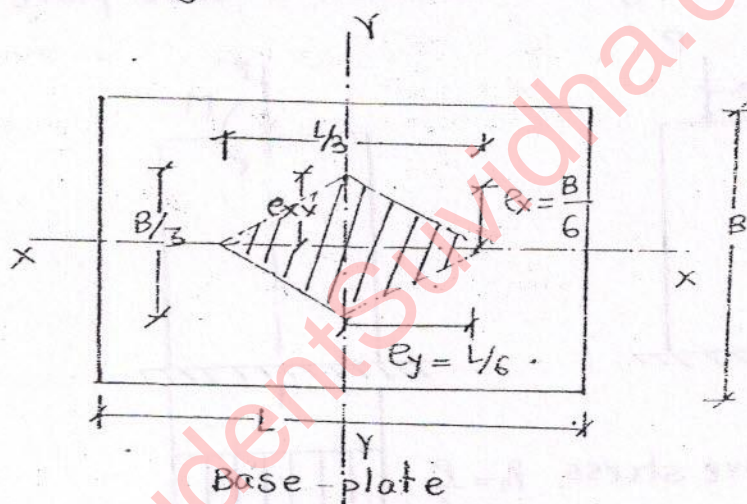
$$\frac{P}{A} - \frac{P \cdot e}{Z} \geq 0$$

$$e \leq \frac{Z}{A}$$

- no tension condition at base.

e.g.

(iii) Core of rectangular section



e_{xx} - eccentricity of load from XX-axis

$$e_{xx} \leq \frac{Z_{xx}}{A}$$

(If load is eccentric from X-axis, B.M. will act about X axis. So M.I., Z must be taken about X-axis)

$$e_{xx} = \frac{LB^2/6}{L \times B}$$

$$(e_x)_{max} = \frac{B}{6}$$

If load is eccentric from Y-axis

$$(e_y)_{max} = \frac{L}{6}$$

So the core of a rectangular section is Rhombus, with diagonals $(L/3 \times B/3)$

(iv) Final stresses below base plate area.

$$f_{\max} = f_o + f_b = \frac{P}{A} + \frac{M}{Z}$$

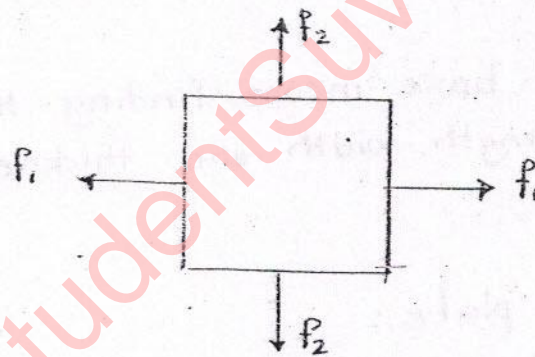
$$= \frac{P}{L \times B} + \frac{P \cdot e}{\left(\frac{B \times L^2}{6}\right)}$$

$$f_{\max} = \frac{P}{L \times B} \left(1 + \frac{6e}{L}\right)$$

$$f_{\min} = f_o - f_b = \frac{P}{A} - \frac{M}{Z}$$

$$f_{\min} = \frac{P}{L \times B} \left(1 - \frac{6e}{L}\right)$$

(v) Effective stress :



strains :
Tensile - +ve
Compressive - -ve

$$e_1 = \frac{P_1}{E} - \mu \frac{P_2}{E} \quad , \text{ strain in } \textcircled{1} \text{ direction.}$$

Effective stress in direction $\textcircled{1}$

$$P_e = e_1 \cdot E$$

$$= \left(\frac{P_1}{E} - \mu \frac{P_2}{E} \right) \cdot E$$

$$f_e = P_1 - \mu P_2$$

- Q. A built up column made up of 2-JSSC, 200 ϕ is to support an axial compressive load of 700 kN and moment of 55 kNm. Design a slab base assuming the bearing ends are machined for complete bearing. Allowable bearing stress in concrete (σ_{cc}) = 3.75 N/mm². (If not given assume $\sigma_{cc} = 0.6 f_{ck}$) $f_y = 250$ MPa. Also design the welded connection between column & base of slab.

$$t_f = 15 \text{ mm}$$

Take strength of 1mm weld = 76 kN.

σ_{bs} - permissible bending tensile stress
 $= 0.7 f_y$

$$M = 0.25$$

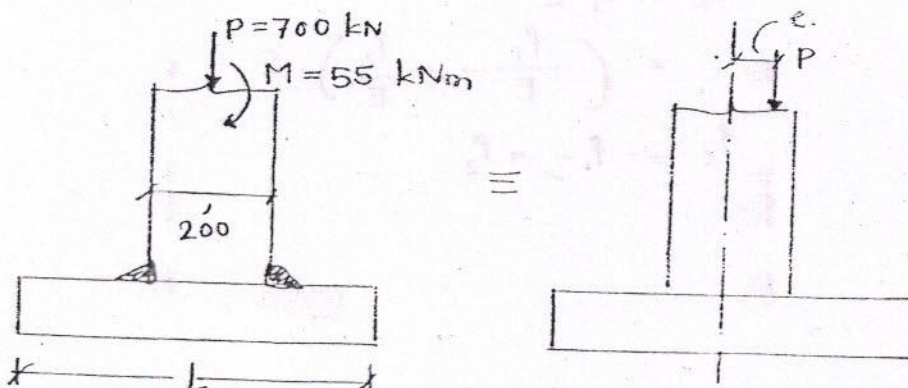
- (i) Since the column is subjected to axial load and moment, pressure distribution below base plate will not be uniform. So IS code formula for thickness of base plate cannot be used.
- (ii) Designing a slab base means finding the dimensions of base plate (length, width and thickness of base plate)

Dimensions of base plate:

@ Length of base plate:

Note:

- (i) Length of base plate is found from no tension condition.



(ii) The effect of direct load and moment can be replaced by equivalent eccentric point load as shown in fig.

$$\begin{aligned}\text{Equivalent eccentricity, } e &= \frac{M}{P} \\ &= \frac{55 \times 10^6 \text{ Nmm}}{700 \times 10^3 \text{ N}} \\ &= 78.5 \text{ mm}\end{aligned}$$

For no tension condition,

$$e \leq \frac{L}{6}$$

$$L \geq 6 \cdot e$$

$$\geq 6 \times 78.5 = 471 \text{ mm}$$

So provide $L = 600 \text{ mm}$. (we can also provide 500 mm)

⑥ Width of base plate (B)

Note:

Width of base plate is fixed based on maximum bearing stress consideration i.e. max. bearing stress in concrete should not exceed 3.75 MPa.

$$f_{\max} = \frac{P}{L \times B} \left[1 + \frac{6e}{L} \right] \nless 3.75 \text{ MPa.}$$

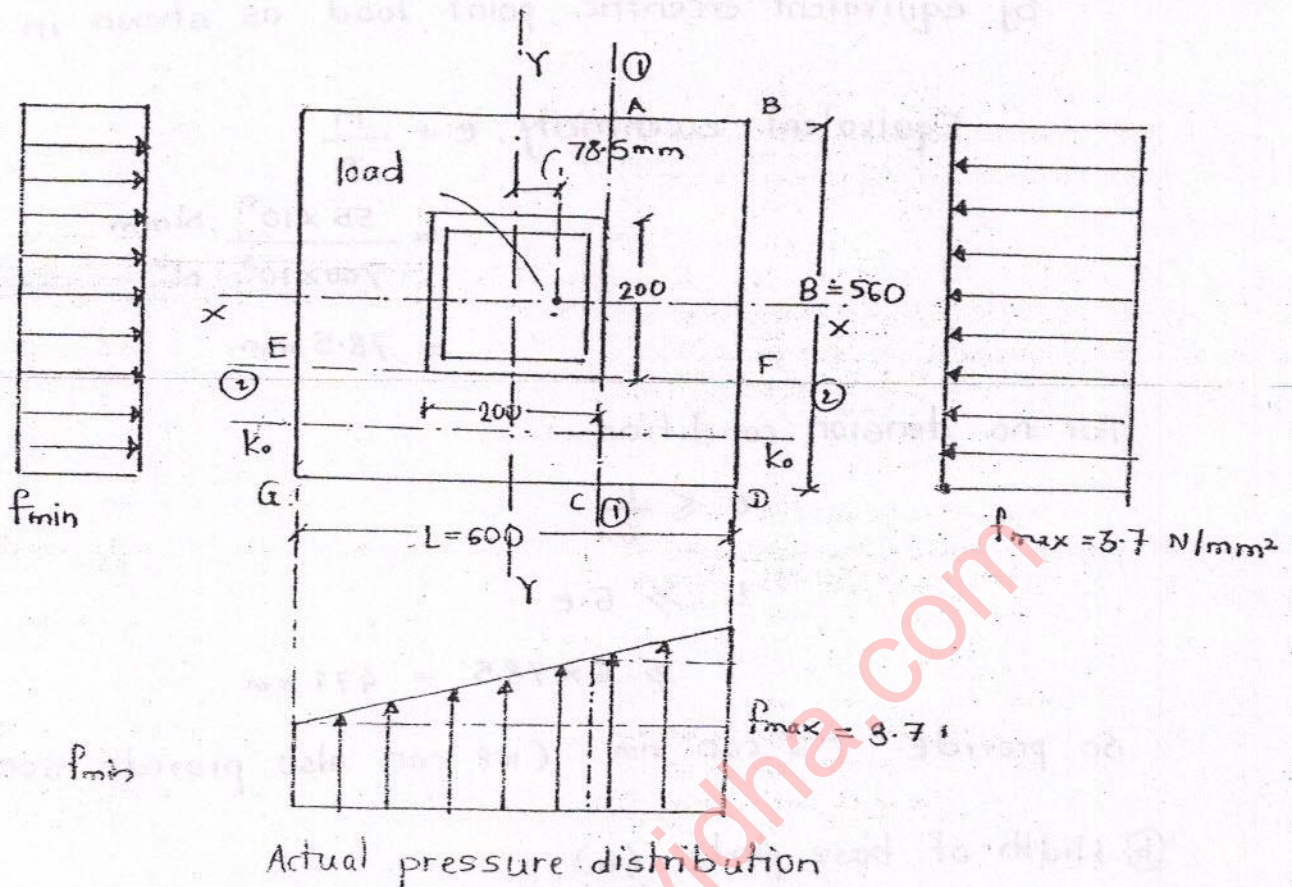
$$\frac{700 \times 10^3}{600 \times B} \left[1 + \frac{6 \times 78.5}{600} \right] \nless 3.75 \text{ N/mm}^2$$

$$B = 555 \text{ mm}$$

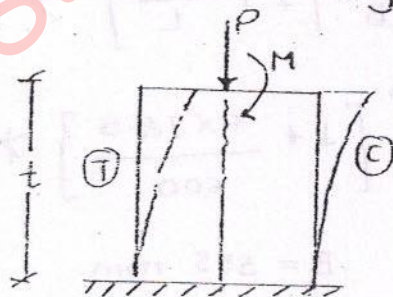
So, provide $B = 560 \text{ mm}$ (We can also provide $B = 600 \text{ mm}$ so that it will become a square base plate).

Tuesday
29th October 2015

© Thickness of base plate:



- i) If base plate is treated as short column of height 't' and subjected to eccentric load P, final stress distribution varies linearly along the length as shown in fig. but across the width of the plate, final stress is constant as shown in fig.



- (ii) Thickness of base plate is found from effective stress consideration.

$$f_c = f_1 - \mu f_2 \quad \& \quad \sigma_{bs} = 0.7 f_y$$

(iii) Actual pressure distribution below base plate.

$$f_{\max} = \frac{P}{L \times B} \left[1 + \frac{6e}{L} \right] = \frac{700 \times 10^3}{600 \times 560} \left[1 + \frac{6 \times 78.5}{600} \right]$$

$$= 3.71 \text{ N/mm}^2$$

$$f_{\min} = \frac{P}{L \times B} \left[1 - \frac{6e}{L} \right] = 0.447 \text{ N/mm}^2$$

(iv) Slab base can be idealised as two way slab because base plate bends about ①① and ②② as shown in fig. i.e. critical section for B.M. is taken at face of column.

B.M. @ ①① = M_{11} = upward force on A (ABCD) \times centroidal distance from ①①

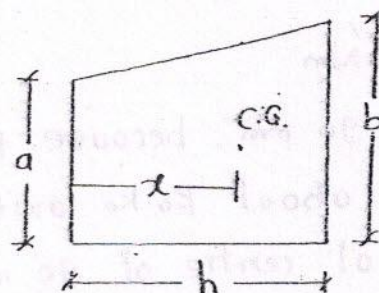
$$\therefore \text{Upward pressure} = 0.447 + \frac{400}{600} \times (3.71 - 0.447)$$

$$= 2.62 \text{ N/mm}^2$$

$$\text{Total upward force} = \text{Avg. pressure on ABCD} \times \text{Area ABCD}$$

$$= \frac{2.62 + 3.71}{2} \times (200 \times 560)$$

$$= 354.48 \text{ kN}$$



$$A = \left(\frac{a+b}{2} \right) \cdot h$$

$$\text{Centroidal distance from 'a'} = \bar{x} = \frac{2a + b}{a+b} \cdot \frac{h}{3}$$

$$\text{Centroidal distance from 'b'} = \frac{b + 2a}{a+b} \cdot \frac{h}{3}$$

centroidal distance \bar{x} from ①①

$$= \left(\frac{a+2b}{a+b} \right) \cdot \frac{h}{3} = \left(\frac{2.62 + 2 \times 3.71}{2.62 + 3.71} \right) \times \frac{200}{3}$$
$$= 105.74 \text{ mm}$$

$$M_{1-1} = 354.48 \times 105.74$$
$$= 37.47 \text{ kNm}$$

..... Bending stress at ①-①. $f_1 = \frac{M_{1-1}}{Z_{1-1}}$

$$Z_{1-1} = \frac{B \cdot t^2}{6}$$

$$f_1 = \frac{37.47 \times 10^6 \text{ Nmm}}{\left(\frac{560 \times t^2}{6} \right)}$$

$$f_1 = \frac{401464.3}{t^2} \text{ N/mm}^2$$

B.M. at ②②

M_{2-2} = total upward force on EFGD $\times 1^{\text{st}}$ distance

= (Avg. pressure \times area of EFGD) $\times 1^{\text{st}}$ dist.

$$= \left[\left(\frac{0.447 + 3.71}{2} \right) \times (600 \times 180) \right] \times 90 \text{ mm}$$

$$= 20.2 \text{ kNm}$$

(centroidal distance is 90 mm, because pressure distribution is symmetrical about K_o-K_o axis. So C.G. lies on symmetric axis. So C.G. is at centre of 90 mm from ②-②)

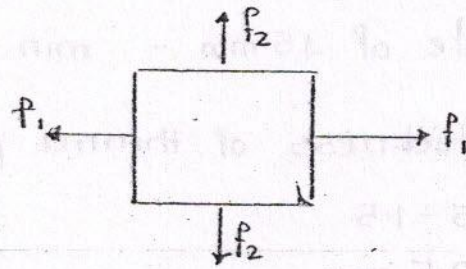
Bending stress at ②-②

$$f_2 = \frac{M_{2-2}}{Z_{2-2}}$$

$$= \frac{20.2 \times 10^6}{\left(\frac{600 \times t^2}{6} \right)}$$

$$f_2 = \frac{0.202 \times 10^6}{t^2}$$

F.B.D. of an element at the bottom of the base plate.



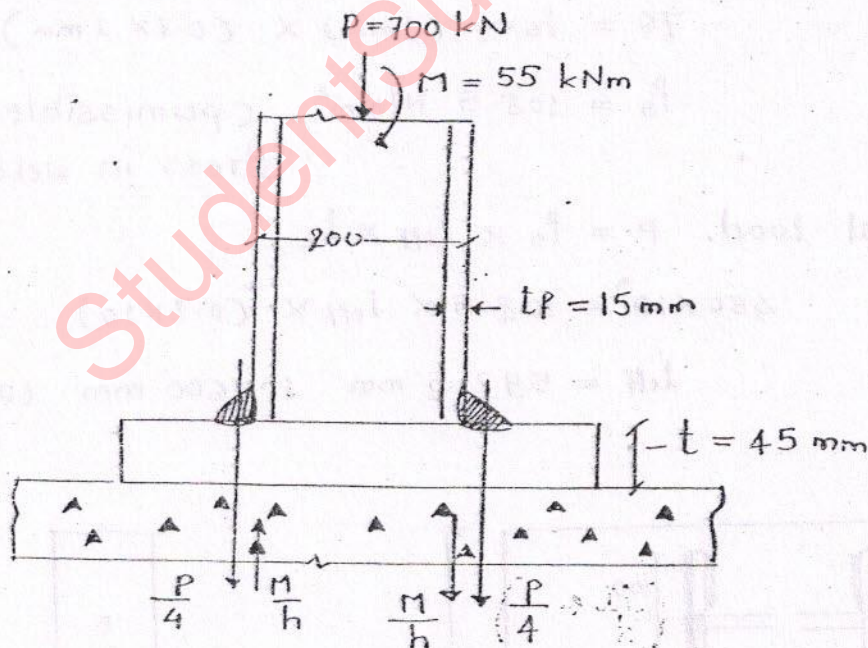
$$f_c = f_1 - f_2 \leq 6_{bs} = 0.7 f_y$$

$$\frac{401464.3}{t^2} - 0.25 \times \frac{0.202 \times 10^6}{t^2} \leq (0.7 \times 250)$$

$$t = 44.75 \text{ mm}$$

So provide thickness of base plate as 45 mm.

Design of fillet weld connection:



Analysis (finding force in fillet weld)

Since bearing ends are machined max force in fillet weld,

$$= \frac{P}{4} + \frac{M}{h}$$

$$= \frac{700}{4} + \frac{55}{0.2} = 250 \text{ kN}$$

Design of weld (fixing size & length of weld)

(a) Size of weld:

Min. size = depends on thickness of thicker plate

For thicker plate of 45 mm - min. size is 8 mm

Max. size = thickness of thinner plate - 1.5 mm

$$= 15 - 1.5$$

$$= 13.5 \text{ mm}$$

So provide size of weld (s) = 10 mm.

(b) Effective length of weld: (l_{eff})

Strength of weld = 76 N - (given)

(It means that load carrying capacity of 1mm size and 1mm length of weld is 76 N)

$$P = f_s \times l_{eff} \times t_t$$

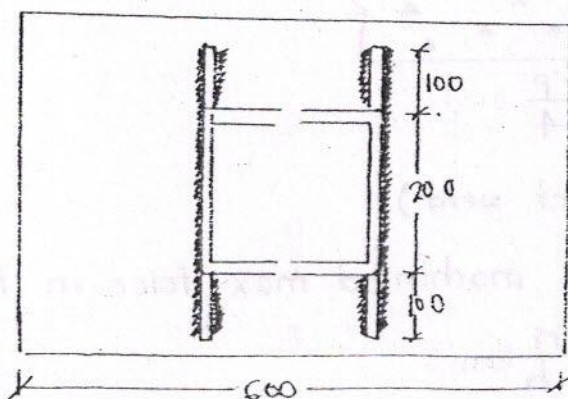
$$76 = f_s \times (1 \text{ mm}) \times (0.7 \times 1 \text{ mm})$$

$$f_s = 108.5 \text{ N/mm}^2 \quad (\text{permissible shear stress in weld})$$

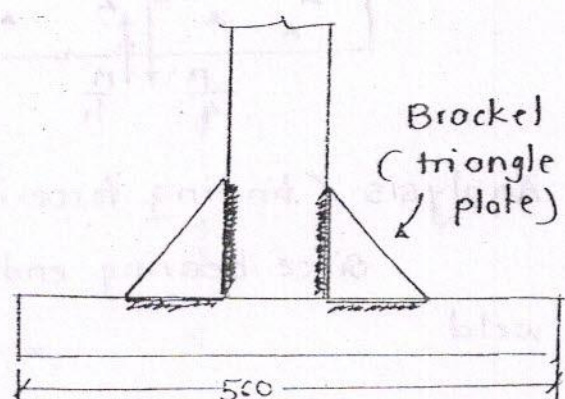
$$\text{Total load, } P = f_s \times l_{eff} \times t_t$$

$$450 \times 10^3 = 108.5 \times l_{eff} \times (0.7 \times 10)$$

$$l_{eff} = 592.5 \text{ mm} \approx 600 \text{ mm (on each side)}$$



top view



side view