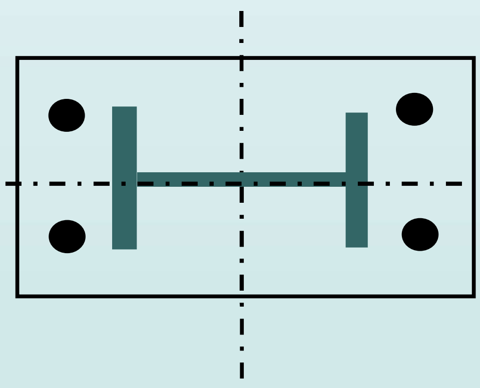
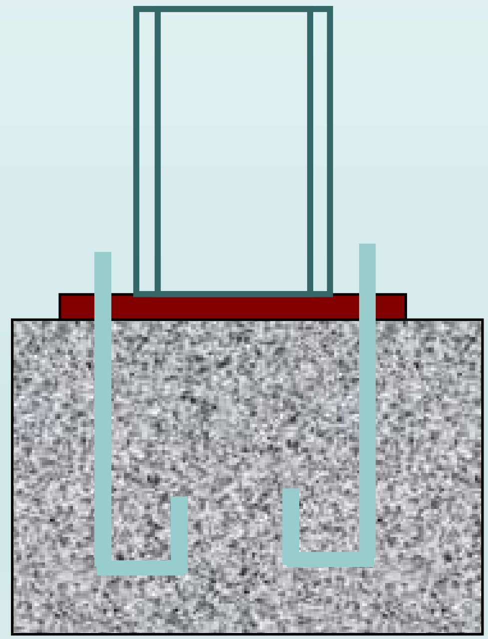
Design of Base Plates

- We are looking for design of concentrically loaded columns. These base plates are connected using anchor bolts to concrete or masonry footings

- The column load shall spread over a large area of the bearing surface underneath the base plate





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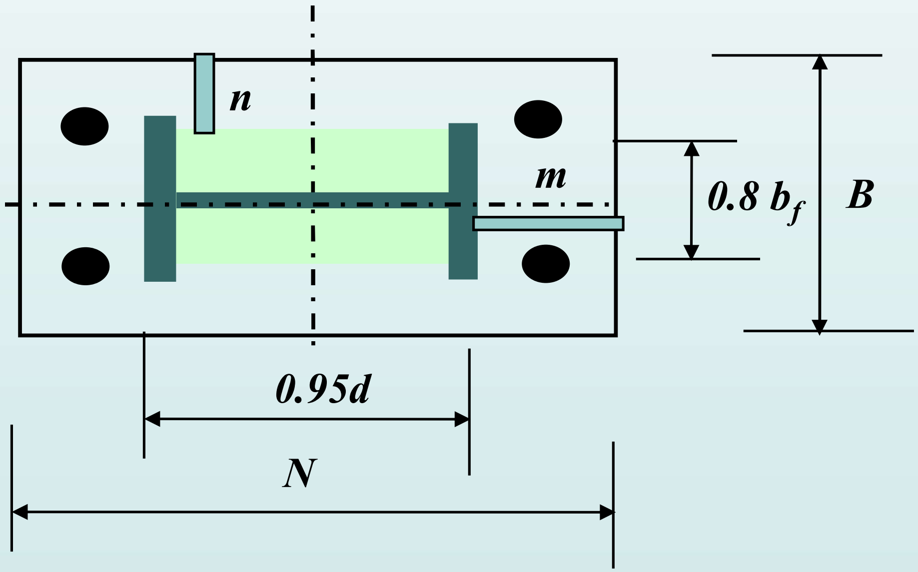
Design of Base Plates

- **The design approach presented here combines three design approaches for light, heavy loaded, small and large concentrically loaded base plates**



- **The dimensions of the plate are computed such that *m* and *n* are approximately equal.**

Area of Plate is computed such that

$$\phi P_p < P_u$$

where:

$$\phi = 0.6$$

If plate covers the area of the footing

$$P_P = 0.85 f_c' A_1$$

If plate covers part of the area of the footing

$$P_P = 0.85 f_c' A_1 \sqrt{\frac{A_2}{A_1}} \le 1.7 f_c' A_1$$

A_1 = area of base plate

A_2 = area of footing

f'_c = compressive strength of concrete used for footing

Design of Base Plates

Thickness of plate

$$t_{pl} = l\sqrt{\frac{2P_u}{0.9\,B\,N\,F_y}} \approx 1.5\,l\sqrt{\frac{P_u}{B\,NF_y}}$$

$$l = \max\begin{cases} m \\ n \\ \lambda\, n' \end{cases}$$

$$m = \frac{N - 0.95\,d}{2}$$

$$n = \frac{B - 0.8\,b_f}{2}$$

$$n'\lambda = \frac{1}{4}\sqrt{db_f}\,\lambda$$

$$\lambda = \frac{2\sqrt{X}}{1-\sqrt{1-X}}$$

$$X = \left[\frac{4db_f}{(d+b_f)^2}\right]\frac{P_u}{\phi_c P_p}$$

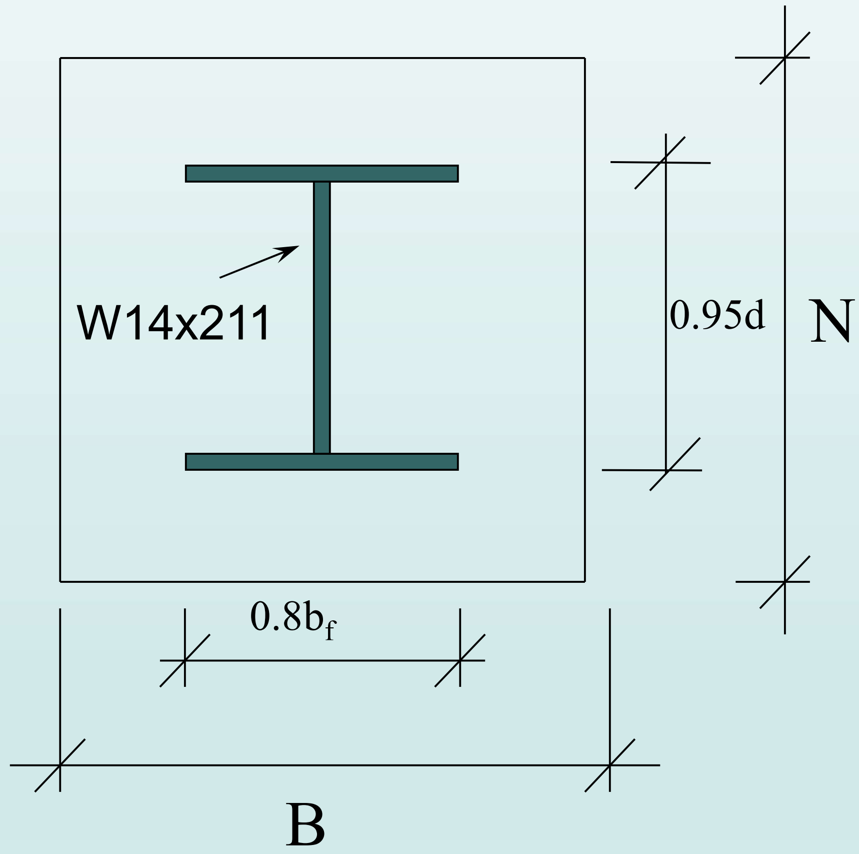
$$\phi_c = 0.6$$

$P_p =$ **Nominal bearing strength**

However λ may be conservatively taken as 1

Ex. 5.5 – Design of Base Plate

- For the column base shown in the figure, design a base plate if the factored load on the column is 10000 kN. Assume 3 m x 3 m concrete footing with concrete strength of 20 MPa.



Ex. 4.7- Design of Base Plate

- **Step I:** Plate dimensions
  - Assume $\sqrt{\dfrac{A_2}{A_1}} > 2$ thus:

$$\phi P_p = 1.7 f'_c A_1 = P_u$$

$$0.6 \times 1.7 \times 20 \times A_1 = 10000 \times 10^3$$

$$A_1 = 490.2 \times 10^3 \ mm^2$$

$$\sqrt{\frac{A_2}{A_1}} = 4.28 > 2$$

  - Assume m = n

$$N = 0.95d + 2m = 0.95 \times 399 + 2m = 379 + 2m$$

$$B = 0.8b_f + 2m = 0.8 \times 401 + 2m = 321 + 2m$$

$$A_1 = NB = (379 + 2m)(321 + 2m) = 490.2 \times 10^3 \ \Rightarrow m = 175.4 \ mm$$

  - N = 729.8 mm say N = 730 mm
    B = 671.8 mm say B = 680 mm

Ex. 4.7- Design of Base Plate

- **Step II:** Plate thickness

$$t_p = 1.5(m, n, or\ n')\sqrt{\frac{f_p}{F_y}}$$

$$m = (N - 0.95d)/2 = 175.5\,mm$$

$$n = (B - 0.8b_f)/2 = 179.5\,mm$$

$$n' = \frac{1}{4}\sqrt{db_f} = 100\,mm$$

Ex. 4.7- Design of Base Plate

- Selecting the largest cantilever length

$$f_p = \frac{10000 \times 10^3}{680 \times 730} = 20.14\ MPa$$

$$t_{req} = 1.5(179.5)\sqrt{\frac{20.14}{248}} = 76.7\ mm$$

- use 730 mm x 680 mm x 80 mm Plate

Eccentrically Loaded Columns

- For eccentrically loaded columns
- Compute dimensions such that stress (*q*) is less than concrete compressive strength.
- Compute thickness so that the ultimate moment on the plate equals the full plastic moment multiplied by ϕ, where ϕ = 0.9.

$$q_{\max} = \frac{P_u}{BN}\left(1 + \frac{6e}{N\,or\,B}\right) \le f'_c$$

$$q_{\min} = \frac{P_u}{BN}\left(1 - \frac{6e}{N\,or\,B}\right) \ge 0$$

no tension e = eccentricity

$$t_p = 2.1\sqrt{\frac{M_u}{F_y}}$$

M_u = ultimate moment per (mm) width on the plate