DESIGN OF AXIALLY LOADED SLOPED FOOTING WITH PEDESTAL

DATA:
- Load on column: 800 KN
- Column size: 350 x 350 mm
- SBC of soil: 200 KN/m²
- Concrete Mix: M20
- Steel Grade: Fe 415
- Clear cover of bottom slab: 50 mm

DESIGN:

1. SIZE OF FOOTING:

   Load on column \( P = 800 \) KN
   Self weight of footing 10% \( = 80 \) KN
   Total load on soil \( P1 = 880 \) KN
   SBC of soil \( = 200 \) KN/m²
   Area of footing required \( = 880 / 200 = 4.4 \) m²

   Provide 2.10 x 2.10 m square footing.
   Area provided \( = 4.41 \) m² > 4.4 m²

2. SIZE OF PEDESTAL:

   A pedestal of 650 mm x 650 mm is used.

   \[ q_0 = \frac{800 \times 10^3}{650 \times 650} = 1.89 \text{ N/mm}^2 \]

   \[ \tan \alpha < 0.9 \sqrt{\frac{100xq_0}{fck}} + 1 \]

   \[ \tan \alpha < 0.9 \sqrt{100 \times 1.89/20} + 1 \]
   \[ \tan \alpha < 2.91 \]
   Projection of pedestal = 150 mm
   Depth of pedestal 0.15 x 2.91 = 0.44 m
   Use 600 mm deep pedestal.
3. NET UPWARD SOIL PRESSURE:
Load from column = 800 KN
Area of footing = 4.41 m²
Net upward soil pressure \( p \) = 800 / 4.41 = 181.41 KN/m² < 200 KN/m² (SBC) O.K.

4. BENDING MOMENT:

Cantilever projection = 2100 - 650 = 725 mm
Mxx = Myy = 181.41 x 2.10 x 0.725 /2 =100.12 KN.m

Ultimate B.M. Mux = 1.50 x 100.12 =150.18 KN.m.

Check for effective depth:
For M20 concrete Steel Fe415
Moment of resistance =0.138 fck b d^2 =2.76 b d^2
Mux = M.R.
2.76 b d^2 =150.18 x 10^6

Width of resisting section =650 +150 mm = 800 mm
effective depth ‘d’ required = \sqrt{150.18 x 10^6/ (2.76x 800)}
=260.80 mm

To select depth:
For p =200 KN/m^2  D/A value =1/4.50

Overall Depth of footing  D= A/4.50 =2100/4.50
=466.67 mm

For sloped footing increased depth by 20%=1.20  x 466.67
=560 mm

(OR) Depth of footing =650 x projection of footing
=650 x 0.725
=471.25 mm

Take D=500 mm.

Effective depth available dx =500-50- 12/6 =444 mm
dy=444 – 12 =432 mm.

4.REINFORCEMENT :

Mu = 150.18 KN.m
\[ K = \frac{Mu}{b \cdot d^2} \]
\[ = \frac{150.18 \times 10^6}{800 \times 432^2} \]
\[ = 1.01 \]

Pt from Table 2 of Design Aid to IS 456-1978 = 0.298

\[ \text{Ast required} = \frac{0.298 \times 800 \times 432}{100} = 1030 \text{ mm}^2 \]

Assume depth of footing at edge = 200 mm

\[ \text{Average depth} = \frac{200+500}{2} = 350 \text{ mm} \]

\[ \text{Minimum Ast} = \frac{0.12 \times 2100 \times 350}{100} = 882 \text{ mm}^2 \]

Provide 12 Nos. 12 mm Φ RTS on both the direction.

\[ \text{Ast provided} = 1356 \text{ mm}^2 > 1030 \text{ mm}^2 \]

5. **CHECK FOR CRACKING**:

Clear distance between bars = \( \frac{2100-50-12}{11} - 12 \)

\[ = 173.27 \text{ mm} < 180 \text{ mm} \text{ O.K.} \]
6. CHECK FOR ONE WAY SHEAR:

Shear at a distance $d=432$ mm from face of the pedestal

$= 181.41 \times 2.10 \times 0.293$
= 111.62 KN.
Factored SF = 1.50 x 111.62 = 167.43 KN.
b = 650 + 2 x 432 = 1514 mm
d = 135 + 293 x 300
    725
    = 256.24 mm
Mu at the section = 1.5 x 181.41 x 2.1 x \( \frac{0.293}{2} \)
    = 24.53 KN.m
\( \zeta_v \) = \( \frac{V_u - Mu \tan \beta}{bd} \) where \( \tan \beta = \frac{300}{725} = 0.414 \)
\[ \zeta_v = \frac{167.43 - 24.53 \times 0.414}{0.256} \times 10^3 \times \frac{1}{1514 \times 256.24} \]
= 0.329 N/mm²
Pt = \( \frac{1356 \times 100}{1514 \times 256.24} \)
= 0.35%
\( \zeta_c \) from Table 61 of Design Aid = 0.408 N/mm²
> 0.329 N/mm²  O.K.
7. CHECK FOR TWO WAY SHEAR:
Average depth = 0.5(444 + 432) = 438 mm  
Two way shear is checked at \( d_{avg} = \frac{438}{2} = 219 \) mm from face of the pedestal.

Shear force = 181.41 \times (2.10^2 - 1.088^2) = 585.28 KN.

Factored SF = 1.50 \times 585.28 = 877.92 KN.

\[ b = 4 \times 1088 = 4352 \text{ mm} \]
\[ d = 135 + \frac{506 \times 300}{725} = 344.38 \text{ mm} \]

Actual shear stress \( \zeta_v = \frac{877.92 \times 10^3}{4352 \times 344.38} = 0.59 \text{ N/mm}^2 \)

Design shear strength = \( K_s \times \zeta_v \) where \( K_s = (0.5 + \beta_c) \)

And \( \beta_c = \frac{\text{short side of column}}{\text{Long side of column}} = \frac{1}{1} = 1 \)

\( K_s = (0.5 + 1) = 1.50 \)

\( K_s > 1 \) Take \( K_s = 1 \)

\( \zeta_c = 0.25 \sqrt{f_{ck}} = 0.25 \sqrt{20} = 1.12 \text{ N/mm}^2 \)

\( K_s \times \zeta_c = 1 \times 1.12 = 1.12 \text{ N/mm}^2 \)

\( \zeta_v < K_s \times \zeta_c \) O.K.
8. CHECK FOR LOAD OF TRANSFER AT BASE OF COLUMN:

Nominal bearing stress = \( \frac{Axial\ load\ on\ footing}{Top\ area\ of\ frustrum} \)

\[
= \frac{800 \times 10^3}{650 \times 650} = 1.89\ \text{N/mm}^2
\]

At the base of pedestal allowable bearing force

\[
= 0.45 \times 20 \times 650 \times 650 \times 10^{-3} = 3802\ \text{KN.}
\]

At the top of footing allowable bearing force

\[
= 2 \times 0.45 \times 20 \times 650 \times 650 \times 10^{-3} = 7605\ \text{KN.}
\]

Minimum dowel area = \( \frac{0.5 \times 650 \times 650}{100} \)

\[= 2112\ \text{mm}^2\]

Use 8 Nos. 16 Φ RTS column bars as dowel bars.

Dowel length in footing = 700+450

\[= 1150\ \text{mm}\]

Use 1150 mm dowel length in footing.

The dowels are extended in column and lapped with 8- 16 Φ column bars in middle half length of the column.

9. CHECK FOR DEVELOPMENT LENGTH:

Development length = 47 Φ = 47 \times 12 = 564\ mm

Available anchorage = 725 – 50 (cover) = 675\ mm > 564\ mm \ O.K.

10. CHECK FOR SELF WEIGHT OF FOOTING:

Weight of upper prism
\[
= 0.20/6(0.65^2 + 2.1^2 + 4\times1.375^2)\times25
\]
=10.33 KN

Weight of lower prism = 2.1 \times 2.1 \times 0.20 \times 25 = 22.05 KN

Additional weight of pedestal = (0.65^2 - 0.35^2) \times 0.6 \times 25
= 4.5 KN

Total weight = 10.33 + 22.05 + 4.50 = 36.88 KN < 80 KN.

10. SKETCH:

![Plan view sketch](image)