11-06-2020

Problem - 01: Foundation Design

A Wall thickness of 18" is to carry a D.L of 15 K/ft and L.L of 10 K/ft. In the locality bearing capacity of soil is 5 ksf. The base of the footing will have to be placed 5' below the ground level. Take $f'_c = 3.5$ ksi, $f_y = 50$ ksi. Assume weight of fill or, soil as 100 Pcf. Design the footing.

Sol:

Step - 01: Let depth of foundation OR, thickness of foundation

$= h = 12"$

Effective depth $= d = 12 - 3.5 = 8.5"$

Step - 02: Total Weight $= W_{concrete} + W_{soil}$

$= \frac{12}{12} * 150 + 4 * 100 = 550$ Psf

$\simeq 0.55$ ksf.

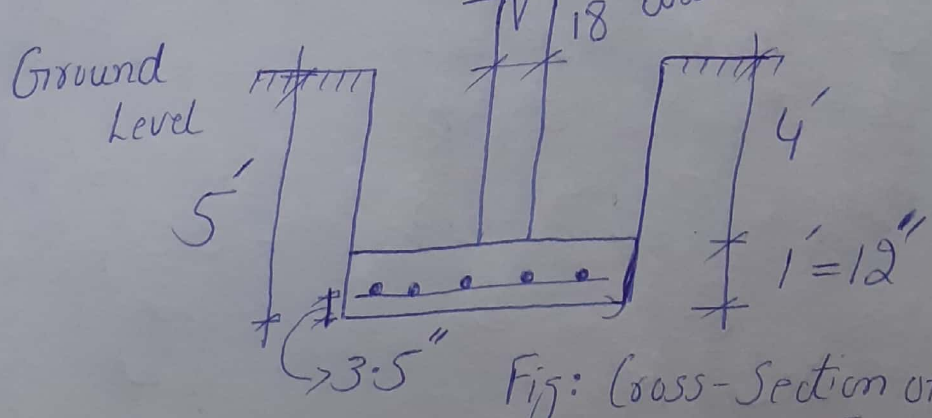

Fig: Cross-Section of Wall Foundation.

Step-03: Effective Bearing Capacity

$$q_e = q_a - W = 5 - 0.55 = 4.45\,ksf$$

Step-04: Bearing Area:

$$A = \frac{\text{Service load}}{q_e} = \frac{15+10}{4.45} = 5.62\,ft^2.$$

$$\approx 5.62 * 1' \text{ or, } 5.75 * 1$$

$$\approx 5'\text{-}9'' * 1'$$

Step-05: Design Pressure on the base of footing due to factored loads.

$$q_{up} = \frac{\text{Factored load}}{\text{Footing Area}} = \frac{1.2 * 15 + 1.6 * 10}{5.75' * 1'}$$

$$q_{up} = 5.91\,ksf.$$

Step-06: Check of Beam Shear Capacity

$$V_{ud} = q_{up} * \left[\frac{(B-S)}{2} - d \right]$$

where; B = Breadth of foundation

S = Wall thickness

d = Effective depth.

$$V_{ud} = 5.91 * \left[\frac{(5.75 - 18/12)}{2} - \frac{8.5}{12} \right]$$

$$V_{ud} = 8.37\,K$$

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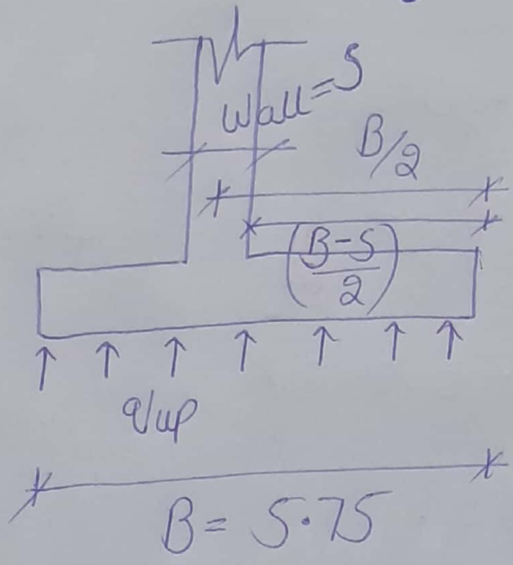

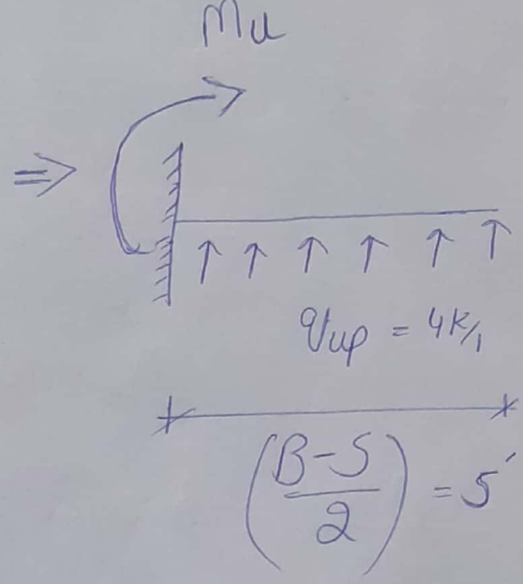

$$M_u = q_{up} * \left(\frac{B-S}{2}\right) * \frac{1}{2} * \left(\frac{B-S}{2}\right)$$

$$= \frac{q_{up}}{8} * (B-S)^2$$

Step-07: Beam Section Self Shear Capacity.

$$\phi V_c = \phi 2\sqrt{f'_c}\, b\, d = \frac{0.75 * 2 * \sqrt{3500} * 12 * 8.5}{1000}$$

$$\phi V_c = 9.05\, kip$$

Step-08: Actual Value of Effective depth from "ϕV_c".

$$\phi V_c = \phi * 2 * \sqrt{f'_c} * b * d$$

OR,

$$d = \frac{\phi V_c * 1000}{2 * \sqrt{f'_c} * b} = \frac{8.37 * 1000}{2 * \sqrt{3500} * 12} = 7.9'' < 8.5'' \text{ (Assumed)}$$

O.K

Take $\phi V_c \approx V_{ud} = 8.37K$

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Step-09: $M_u = \frac{q_{up}}{8} * (B-S)^2$

$= \frac{5.91}{8} * \left[5.75 - \frac{18}{12}\right]^2 = 13.34\, k'$

$M_u = 160.08\, k\text{-inch}$

Step-10: Area of Steel:

By Trial and Repeat Method.

Trial # 01: Let $a = 0.2 * d = 1.6''$

$A_s = \frac{M_u}{\phi * f_y * (d - \frac{a}{2})} = 0.47\ in^2/ft$

Trial # 02:

$a = \frac{A_s * f_y}{0.85 * f'_c * b} = 0.65''$

$A_s = \frac{160.08}{0.90 * 50 * (8 - \frac{0.65}{2})} = 0.44\ in^2/ft$

Trial # 03:

$a = \frac{0.44 * 50}{0.85 * 3.5 * 12} = 0.61''$

$A_s = \frac{160.08}{0.90 * 50 * (8 - \frac{0.61}{2})} = 0.44\ in^2/ft$

Step-11: Code ductility Requirements;

$$As_{min} = 0.002 * b * h = 0.002 * 12 * 12$$

$$= 0.29 \ in^2/ft$$

$$As_{max} = \rho_{max} * b * d$$

$$= 0.85^2 * \frac{f'_c}{f_y} * \left[\frac{\varepsilon_t}{\varepsilon_t + \varepsilon_y}\right] * b * d$$

$$= 0.85^2 * \frac{3.5}{50} * \left[\frac{0.003}{0.003 + 0.005}\right] * 12 * 8.5$$

$$As_{max} = 1.93 \ in^2/ft > 0.44 \ in^2/ft \quad OK$$

Step-12: Spacing b/w Main & Distribution bars.

Main Bars: Use #5 having $A_b = 0.31 \ in^2$.

$$Spacing = \frac{A_b}{A_s} * 12 = \frac{0.31}{0.44} * 12$$

$$\cong 8\frac{1}{2}'' \ c/c$$

Distribution Bars: Try #4 having $A_b = 0.20 \ in^2$

$$Spacing = \frac{A_b}{As_{min}} * 12 = \frac{0.20}{0.29} * 12$$

$$\approx 8'' \ c/c$$