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Solution of Foundation Design Exam (2010)

(Q1)

$R = 120 + 80 = 200\,t$

$l_1 = \frac{80 * 3.10}{200} = 1.24\,m \qquad \therefore l_2 = 3.10 - 1.24 = 1.86$

$\frac{A}{2} = X + C_2 + \frac{a_2}{2} + l_2 = 0.30 + 0.50 + 0.3 + 1.86 = 2.96\,m$

$A = 5.92 \simeq 5.95\,m$

$C_1 = \frac{5.95}{2} - 0.30 - 0.4 - 1.24 = 1.035\,m$

$B = \frac{1.15 * 200}{15 * 5.95} = 2.57 = 2.60\,m$

Plain concrete Dim. $5.95 * 2.60 * 0.30$

$A_1 = 5.95 - 0.60 = 5.35\,m$
$B_1 = 2.60 - 0.60 = 2.00\,m$

$P_n = \frac{200 * 1.50}{5.35 * 2.00} = 28.0\,t/m^2 \qquad w = 56.07\,t/m'$

* Bending moment:-

$M_2 = 56.07 (0.515)^2/2 = 7.44\,m.t$
$M_1 = 56.07 (1.035)^2/2 = 30.03\,m.t$

M_{max} at zero shear

$56.07 * Z - 120 * 1.50 = 0.0 \qquad Z = 3.21\,m$

$$M_{max} = 56.07(3.21)^2/2 - 120*1.50(3.21-1.435) = 30.65 \ m.t$$

$$d = 5\sqrt{\frac{30.65*10^5}{250*200}} = 39.15 cm \qquad t = 45 cm$$

(1) check of shear:

$$Q_s = 120*1.50 - (1.035+0.80+0.5)*56.07 = 49.08 t$$

$$q_s = \frac{49.08 \times 10^3}{200*40} = 6.13 < 9.81 \qquad \text{safe.}$$

(2) check of punching:

$$Q_p = 120*1.50 - 28.0(0.80+0.40)(0.40+0.40) = 153.12 t$$

$$A_p = 2[(0.8+0.40)+(0.40+0.40)] = 4.0$$

$$q_p = \frac{153.12 \times 10^3}{4.0 \times 10^4} = 3.828 \ kg/cm^2 < 12.9 \qquad \text{o.k.}$$

(3) Design of Hidden Beams

Beam H.B₁ $\qquad w_1 = \frac{1.50*120}{2.00} = 90 \ t/m'$

$$M = 90*(2.0-04)^2/8 = 28.80 \ m.t$$

$$d = 5\sqrt{\frac{28.80 \times 10^5}{120*250}} = 48.98 > d \qquad \therefore \text{take } d = 50cm$$

Beam H.B2 $w_2 = \frac{80 * 1.50}{2} = 60\ t/m'$

$M = 60 * (2 - 0.4)^2 / 8 = 19.2\ m.t$

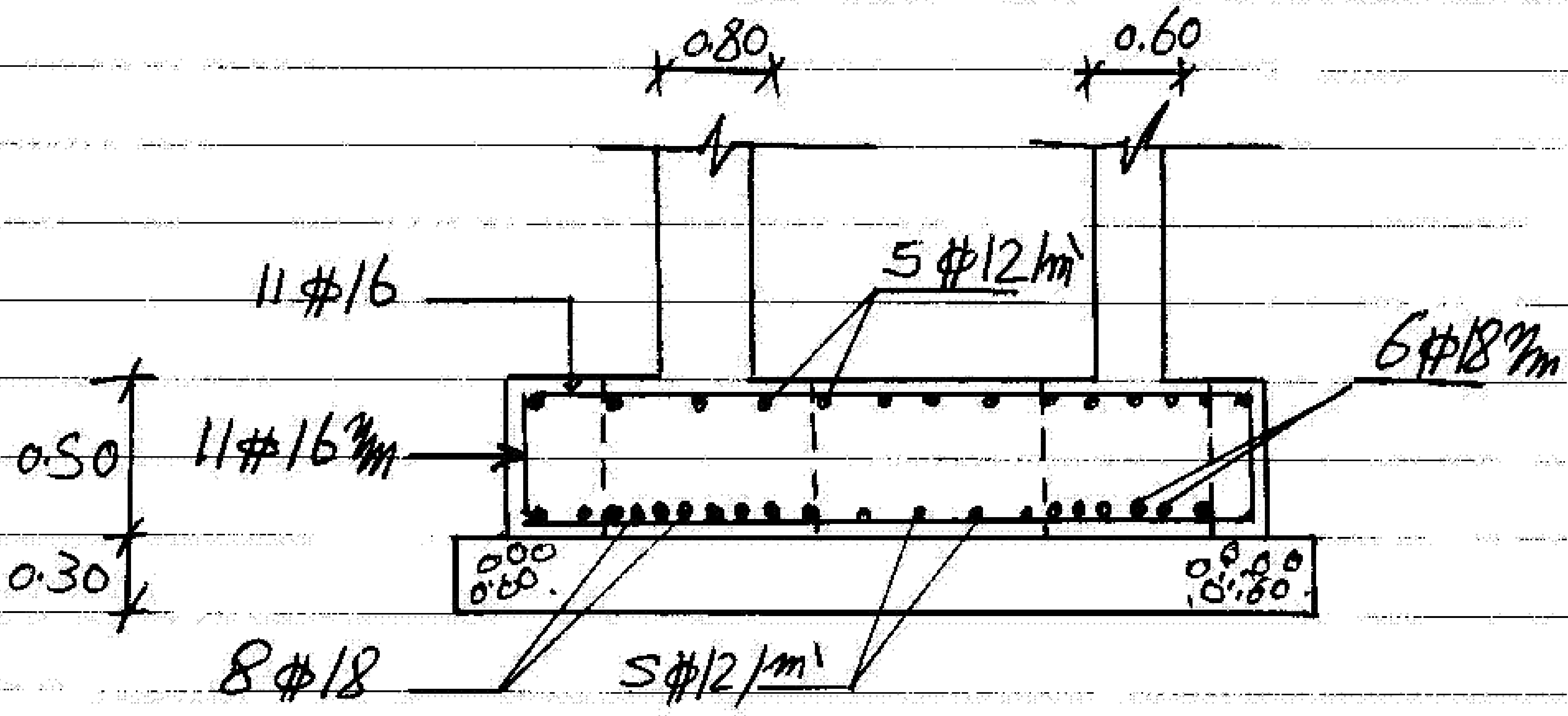
$d = 5\sqrt{\frac{19.20 \times 10^5}{100 * 250}} = 43.8 < 50cm$ o.k

$A_s(top) = \frac{30.65 * 10^5}{3600 * 50 * 0.826} = 20.61\ cm^2$ 11 Φ16 mm

$A_s(bot) = \frac{30.03 \times 10^5}{3600 * 50 * 0.826} = 20.19\ cm^2$ 11 Φ16 mm

$A_s(H.B1) = \frac{28.8 \times 10^5}{3600 * 50 * 0.826} = 19.37$ 8 Φ18 mm

$A_s(H.B2) = \frac{19.2 \times 10^5}{3600 * 50 * 0.826} = 12.91$ 6 Φ18 mm



Q2:

*External footing

$3.5 * R_e = n \times 10 * (1.5 + 1.0 + 2.00 - 0.2)$ $\therefore R_e = 12.29\,n\ t$

*Bearing capacity

$$\frac{12.29\,n}{2 \times 2} = 25 \qquad \therefore n = 8.14$$

* depth of footing and RFT

$$f_{n_e} = \frac{12.29\,n * 1.50}{2 * 2} = 4.61\,n \qquad w_e = 9.22\,n$$

$$\therefore M_u = 4.61 * n * \left(\frac{2-0.6}{2}\right)^2 / 2 = 1.13\,n$$

$$55 = 5\sqrt{\frac{1.13\,n \times 10^5}{250 * 100}} = \qquad n = 26.7$$

$$6 * 2 = \frac{1.13\,n * 10^5}{55 * 3600 * 0.826} \qquad n = 17.36$$

* check of shear.

$$Q_s = 1.13\,n * \left(\frac{2-0.6}{2} - 0.55\right) = 0.1695\,n$$

$$q_s = \frac{0.1695\,n * 10^3}{100 * 55} = 0.0308\,n = 9.68$$

$$\therefore n = 314$$

* Internal footing:-

$R_i = 20n * 1.5 = 30n$

* Bearing capacity

$\frac{1.15*30n}{3*3} = 25 \qquad n = 9.78 \simeq 7.00$

* Depth of footing and RFT

$P_{n_i} = \frac{30n}{3*3} = 3.33n \qquad w_i = 10n$

$M_u = 3.33n\left(\frac{3-0.6}{2}\right)^2/2 = 2.398n$

$55 = 5\sqrt{\frac{2.398n \times 10^5}{250*100}} \qquad \therefore n = 12.6 \simeq 12$

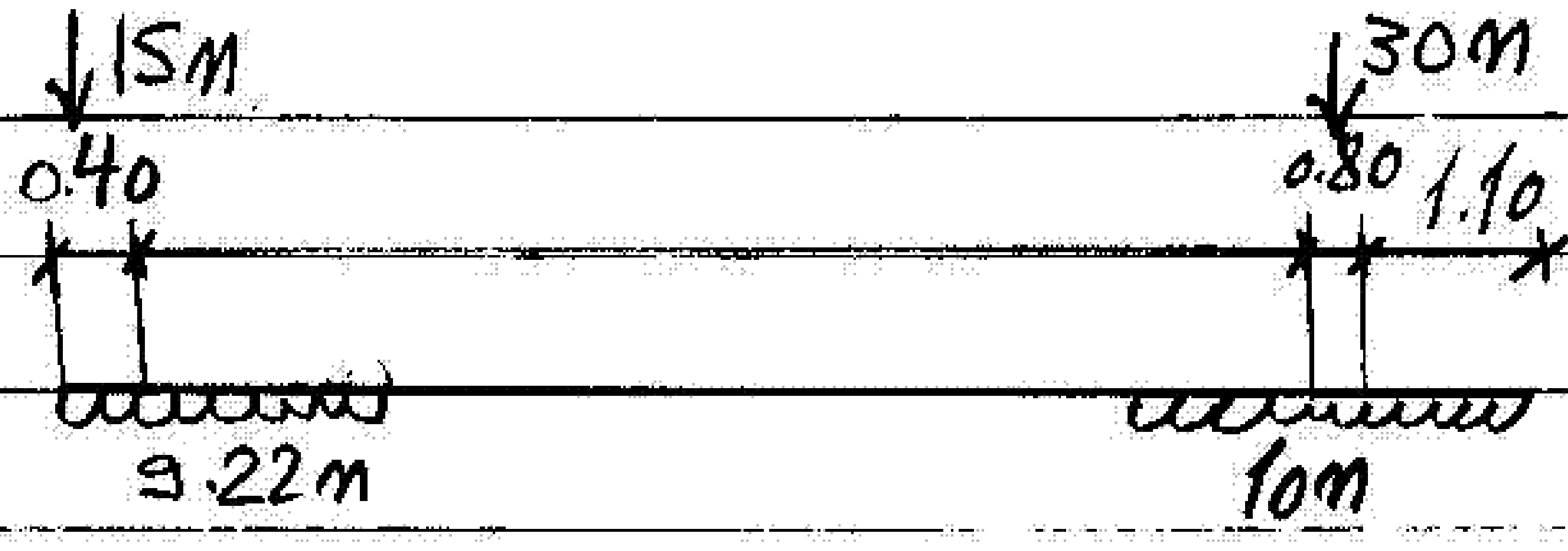
$12 = \frac{2.398n \times 10^5}{3600*55*0.826} \qquad n = 8.18 = 8$

* check of shear

$Q_s = 3.33n\left(\frac{3-0.6}{2} - 0.55\right) = 2.165n$

$q_s = \frac{2.165*n \times 10^3}{100*55} = 0.394n = 9.68 \qquad n = 24.57 = 24$

* Strap Beam



$w_e = 9.22m$

$w_i = 10m$

$M_1 = 10m * (1.10)^2/2 = 6.05\,m$

Mmax at zero shear

$15m - Z * 9.22m = 0.0 \quad Z = 1.63\,m$

$M_{max} = 15m(1.63 - 0.2) - 9.22m * \frac{(1.63)^2}{2} = 9.20m$

$115 = 5\sqrt{\frac{9.20m \times 10^5}{250 * 55}} \quad \therefore m = 7.9 \simeq 7$

Top $38 = \frac{9.20m \times 10^5}{3600 * 115 * 0.826} \qquad m = 14.12 \sim 14$

bot $30.4 = \frac{6.05m \times 10^5}{3600 * 115 * 0.826} \qquad m = 17.18 = 17$

* check of shear

$Q_s = 30m - 10m\,(1.10 + 0.80 + 1.15) = 0.5m$

$q_s = \frac{0.5m \times 10^3}{115 * 60} = 9.68 \qquad m = 133.5$

$\therefore$ total no of floors 8 floors

No of extra floors = 4 floors.

(Q4):

* ultimate capacity of pile (d = 45) & (L = 18 m)

$P_u = P_{bu} + P_{su}$

$P_{bu} = C N_c \lambda_c A_p = 2.325 * 10 * 9.33 * (0.45)^2 * \frac{\pi}{4} = 34.5 t$

$P_{su} = C_a * \pi d * L = 1.5375 * 10 * 0.5 * \pi * 0.45 * 18$
$= 195.62 t$

$P_u = 34.5 + 195.62 = 230.1 t$

* ultimate capacity of pile (d = 60 cm) & (L = 15 m)

$P_{bu} = C N_c \lambda_c A_p = 2.0625 * 10 * 9.33 (0.6)^2 * \frac{\pi}{4} = 54.4 t$

$P_{su} = C_a * \pi d * L = 1.40625 \times 10 * 0.5 * \pi * 0.60 * 15$
$= 198.88 t$

$P_u = 54.4 + 198.88 = 254.21$

* The short pile with greater diameter has a higher ultimate capacity.

(Q3)

ultimate load pile capacity

$$P_u = P_{bu} + P_{su}$$

$P_{bu} = q\, N_q\, \lambda_q\, A_p$

$q = \Sigma \gamma h = 2*1.9 + 2*1.8 + 10*0.90 = 16.4\, t/m^2$

$P_{bu} = 120 * 16.40 * (0.25)^2 = 123\, t$

$P_{su} = e_{av} * (4b)\, L * \tan\delta$

$e_{av} = (2*1.9 + 2*1.8 + 3*0.90)(1 - \sin 36)$
$e_{av} = 4.16\, t/m^2$

$P_{su} = 4.16 * 4 * 0.25 * 10 * \tan 27 = 21.21\, t$
(neglect friction fill layer)

$P_u = 123 + 21.21 = 144.2\, t$

$P_{all} = 144.2 / 2.5 = 57.68\, t$

$P_{mat} = 500 * 0.25 * 0.25 = 31.25\, t$

$P_{safe} = 31.25\, t$