1) $D_w = 12m$, $D = 10m$, $B = 30m$ $\Rightarrow D < D_w < D+B \Rightarrow$ case 2

$$\gamma' = \gamma - \gamma_w \left(1 - \left(\frac{D_w - D}{B}\right)\right) = 18.5 - 9.8\left(1 - \left(\frac{12-10}{30}\right)\right) = 9.4\ kN/m^3$$

$$q_{ult} = \underbrace{c' N_c S_c d_c i_c b_c g_c}_{c'=0} + \sigma'_{zD} N_q S_q d_q i_q b_q g_q + 0.5\gamma' B N_\gamma S_\gamma d_\gamma i_\gamma b_\gamma g_\gamma$$

For $\phi = 30°$ $N_q = 18.4$ $N_\gamma = 22.4$ (from table)

$$\sigma'_{zD} = \gamma D - u$$
$$= 18.5 \times 10 - 0$$
$$= 185\ kN/m^2$$

$$S_q = 1 + \left(\frac{B}{L}\right)\tan\phi = 1 + \left(\frac{30}{50}\right)\tan 30 = 1.35$$

$$k = \frac{D}{B} = \frac{10}{30} = 0.33$$

$$d_q = 1 + 2k\tan\phi'(1 - \sin\phi')^2$$
$$= 1 + 2\times(0.33)\tan 30°(1 - \sin 30)^2$$
$$= 1.10$$

$$S_\gamma = 1 - 0.4\left(\frac{B}{L}\right) = 1 - 0.4\,(30/50) = 0.76$$

i, b and g factors are "1"

$$q_{uH} = 0 + 185\,(18.4)(1.35)(1.10) + 0.5\,(9.4)(30)(22.4)(0.76)$$
$$= 7455\ kN/m^2$$

2) $C' = 24\ kN/m^2$ $\quad \gamma = 16\ kN/m^3$ $\quad \phi = 20°$ $\quad D_f = 1.5m$ $\quad B = 1.5m$ $\quad L = 2.5m$ $\quad FS = 3.0$

$$q_{ult} = cN_cS_cD_c + \gamma D_f N_q S_q D_q + 0.5\gamma B N_\gamma S_\gamma D_\gamma$$

$N_c = 14.83$ $\quad N_q = 6.40$ $\quad N_\gamma = 2.87$ from table for $\phi = 20°$

$$S_c = 1 + 0.2K_p(B/L)$$
$$= 1 + 0.2 \times 2.04\,(1.5/2.5)$$
$$= 1.24$$

$$K_p = \tan^2(45 + \phi/2)$$
$$= \tan^2(45 + 20/2)$$
$$= 2.04$$

$$S_q = S_\gamma = 1 + 0.1K_p(B/L)$$
$$= 1 + 0.1 \times 2.04\,(1.5/2.5)$$
$$= 1.12$$

$$D_c = 1 + 0.2\sqrt{K_p}\,(B/L)$$
$$= 1 + 0.2\sqrt{2.04}\,(1.5/2.5)$$
$$= 1.17$$

$$D_q = D_\gamma = 1 + 0.1\sqrt{K_p}\,(D_f/B)$$
$$= 1 + 0.1\sqrt{2.04}\,(1.5/1.5)$$
$$= 1.14$$

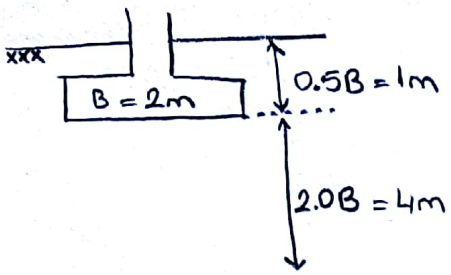
$$I_c = I_q = I_\gamma = 1$$

$$q_{ult} = 24 \times 14.83 \times 1.24 \times 1.17 + 16 \times 1.5 \times 6.40 \times 1.12 \times 1.14 + 0.5 \times 16 \times 2.87 \times 1.12 \times 1.14$$
$$= 742\ kN/m^2$$

$$q_{all} = \frac{q_{ult}}{FS}$$

$$q_{all} = \frac{742}{3.0} = 247\ kN/m^2$$

3)



Depth	N_{field}	σ_o'	C_N	$N_{cor.}$
1	8	18	2.0	16
2	14	36	1.63	23
3	11	50.5	1.38	15
4	16	61.5	1.25	20
5	18	72.5	1.15	21

$$N_{avg} = (16+23+15+20+21)/5$$
$$= 19$$

$$C_w = 0.5\left(1 + \frac{D_w}{D_f + B}\right)$$
$$= 0.5\left(1 + \frac{2.5}{1+2}\right)$$
$$= 0.92$$

$q_{all} = 190\ kN/m^2$ from figure

or

$$q_{all} = 11 \times N_{avg}$$
$$= 11 \times 19$$
$$= 209\ kN/m^2$$

$$q_{all\,(corrected)} = q_{all} \times C_w$$
$$= 209 \times 0.92$$
$$= 192\ kN/m^2$$

4) short term ; $q_u = C_u N_c + \sigma'_{zD}$ (Skempton)

long term ; $q_u = 1.3\, c' N_c + \sigma'_{zD} N_q + 0.4 \gamma' B N_\gamma$ (Terzaghi)

short term ; $N_c = 6 \times \left(1 + 0.2 \frac{D_f}{B}\right) \leq 9$ (Skempton)

$= 6 \times \left(1 + 0.2 \frac{2}{10}\right) = 6.24 \leq 9$ ✓

$$\boxed{q_u = 48 \times 6.24 + \sigma'_{zD}}$$ ✗

long term ; $\phi = 20° \Rightarrow N_c = 17.7 \; ; \; N_q = 7.4 \; ; \; N_\gamma = 4.4$

$q_u = 1.3 \times 5 \times 17.7 + \sigma'_{zD} \times 7.4 + 0.4 \times \gamma' \times 10 \times 4.4$

$$\boxed{q_u = 115.05 + 7.4\, \sigma'_{zD} + 17.6 \gamma'}$$ ✗

$z = 0$ m ; $\sigma'_{zD} = 2 \times (20-10) = 20$ kN/m²

$\gamma' = 20 - 10 = 10$ kN/m³

$z = 2$ m ; $\sigma'_{zD} = 2 \times 18 = 36$ kN/m²

$\gamma' = 20 - 10 = 10$ kN/m³

$z = 8$ m ; $\sigma'_{zD} = 2 \times 18 = 36$ kN/m²

$\gamma' = \frac{6 \times 18 + 4 \times (20-10)}{10} = 14.8$ kN/m³

$z = 15$m ; $\sigma'_{zD} = 2 \times 18 = 36$ kN/m²

$\gamma' = 18$ kN/m³

a) short term : $q_u = 299.52 + 20 = 319.52$ kN/m²

long term : $q_u = 115.05 + 7.4 \times 20 + 17.6 \times 10 = 439.05$ kN/m²

b) short term : $q_u = 299.52 + 36 = 335.52$ kN/m²

long term : $q_u = 115.05 + 7.4 \times 36 + 17.6 \times 10 = 557.45$ kN/m²

c) short term : $q_u = 299.52 + 36 = 335.52$ kN/m²

long term : $q_u = 115.05 + 7.4 \times 36 + 17.6 \times 14.8 = 641.93$ kN/m²

d) short term : $q_u = 299.52 + 36 = 335.52$ kN/m²

long term : $q_u = 115.05 + 7.4 \times 36 + 17.6 \times 18 = 698.25$ kN/m²

5) a) $q_{ult(site)} = q_{ult(test)}$ for clay

$q_{ult} = 650 \text{ kN/m}^2$

$q_{all} = \frac{650}{2.5} = 260 \text{ kN/m}^2$

b) $q_{ult(site)} = q_{ult(test)} \times \frac{B}{b}$ for sand

$q_{ult} = 650 \times \frac{2.5}{0.75}$

$= 2167 \text{ kN/m}^2$

$q_{all} = \frac{2167}{2.5} = 867 \text{ kN/m}^2$

6) $q_{ult} = 1.3c'N_c + qN_q + 0.4\gamma' B N_\gamma$ $\quad \gamma_w = 10\ kN/m^3$

$q = \gamma' D_f$ $\quad c' = 0$

$\phi = 35°$

from table $\Rightarrow$ $N_q = 41.44$ $\quad N_c = 57.75$ $\quad N_\gamma = 45.41$

a) $D_w = 5m$, $D_f = 1m$, $B = 2m$ $\Rightarrow$ CASE 3, $D_f + B \leq D_w$ $\Rightarrow \gamma' = \gamma = 18\ kN/m^3$

$q_{ult} = 1.3 \times 0 \times 57.75 + 18 \times 1 \times 41.44 + 0.4 \times 18 \times 2 \times 45.41 = 1400\ kN/m^2$

b) $D_w = 0m$, $D_f = 1m$, $B = 2m$ $\Rightarrow$ CASE 1, $D_w \leq D_f$ $\Rightarrow \gamma' = \gamma - \gamma_w = 18 - 10 = 8\ kN/m^3$

$q_{ult} = 1.3 \times 0 \times 57.75 + 8 \times 1 \times 41.44 + 0.4 \times 8 \times 2 \times 45.41 = 622\ kN/m^2$

c) $D_w = 1m$, $D_f = 1m$, $B = 2m$ $\Rightarrow$ CASE 1, $D_w \leq D_f$ $\Rightarrow \gamma' = \gamma - \gamma_w = 18 - 10 = 8\ kN/m^3$

Same result with "b" $\quad q_{ult} = 622\ kN/m^2$

d) $D_w = 2m$, $D_f = 1m$, $B = 2m$ $\Rightarrow$ CASE 2, $D_f < D_w \leq D_f + B$

$$\gamma' = \gamma - \gamma_w \left(1 - \left(\frac{D_w - D_f}{B}\right)\right)$$

$$= 18 - 10 \left(1 - \left(\frac{2-1}{2}\right)\right)$$

$$= 13\ kN/m^3$$

$q_{ult} = 1.3 \times 0 \times 57.75 + 13 \times 1 \times 41.44 + 0.4 \times 13 \times 2 \times 45.41 = 1011\ kN/m^2$