Chapter 17

17.1 Shelby tube *A*:

$$\text{Eq. (17.6):}\quad A_R(\%) = \frac{D_o^2 - D_i^2}{D_i^2}(100) = \frac{(76.2)^2 - (73)^2}{(73)^2} \times 100 = \mathbf{8.96\% \le 10\%}$$

Samples can be considered undisturbed. Suitable for grain size distribution, Atterberg limits, consolidation and unconfined compression tests.

Shelby tube *B*:

$$\text{Eq. (17.6):}\quad A_R(\%) = \frac{D_o^2 - D_i^2}{D_i^2}(100) = \frac{(3.5)^2 - (3.375)^2}{(3.375)^2} \times 100 = \mathbf{7.54\% \le 10\%}$$

Samples can be considered undisturbed. Suitable for grain size distribution, Atterberg limits, consolidation and unconfined compression tests.

Split spoon sampler:

$$\text{Eq. (17.6):}\quad A_R(\%) = \frac{D_o^2 - D_i^2}{D_i^2}(100) = \frac{(50.8)^2 - (35)^2}{(35)^2} \times 100 = \mathbf{110\% \ge 10\%}$$

Samples can be considered as highly disturbed. Suitable for grain size distribution and Atterberg limits tests, but not for consolidation and unconfined compression tests.

17.2

Depth (m)	σ'_0 (kN/m^2)	$C_N = \left[\dfrac{\sigma'_0}{p_a}\right]^{-0.5}$	N_{60}	$(N_1)_{60} = C_N N_{60}$
2	34	1.71	7	**≈12**
4	68	1.21	10	**≈12**
6	102	0.99	11	**≈11**
8	136	0.857	14	**≈12**
10	170	0.767	9	**≈7**

17.3 $$\phi' = \tan^{-1}\left[\frac{N_{60}}{12.2 + 20.3\left(\dfrac{\sigma'_o}{p_a}\right)}\right]; \quad p_a \approx 100 \text{ kN/m}^2$$

Depth (m)	σ'_o (kN/m^2)	p_o (kN/m^2)	N_{60}	ϕ' (deg) [Eq. (17.20)]
2	34	100	7	20.1
4	68	100	10	21.0
6	102	100	11	18.48
8	136	100	14	19.37
10	170	100	9	10.9

Average $\phi' \approx$ **18º**

17.4 Eq. (17.18): $D_r\ (\%) = \left[\dfrac{N_{60}\left(0.23 + \dfrac{0.06}{D_{50}}\right)^{1.7}}{9}\left(\dfrac{98}{\sigma'_o}\right)\right]^{0.5}(100)$

Given $\gamma = 15.7$ kN/m^3. The following table can now be prepared.

Depth z (m)	$\sigma'_o = \gamma z$ (kN/m^2)	D_{50} (mm)	N_{60}	D_r (%)
1.5	23.55	0.3	9	**99.5 ≈ 100**
3.0	47.1	0.3	10	**74.2 ≈ 74**
4.5	70.65	0.3	14	**71.7 ≈ 72**
6.0	94.2	0.3	18	**70.4 ≈ 70**
7.5	117.75	0.3	20	**66.4 ≈ 66**

17.5 $(N_1)_{60} = C_N N_{60} = \left(\dfrac{\sigma'_0}{p_a}\right)^{-0.5} N_{60}\ ;\quad \phi' = 27.1 + 0.3(N_1)_{60} - 0.00054(N_1)^2_{60}$

Depth (m)	σ'_o (kN/m^2)	N_{60}	C_N	$(N_1)_{60}$	ϕ' (deg)
1.5	$1.5 \times 18 = 27$	8	1.924	$15.4 \approx 15$	31.4
3	$3 \times 18 = 54$	9	1.36	$12.24 \approx 12$	30.6
4.5	$4.5 \times 18 = 81$	11	1.11	$12.2 \approx 12$	30.6
6	$\begin{bmatrix}(5.3 \times 18) \\ +0.7(18.8 - 9.8)\end{bmatrix} = 101.7$	12	0.99	$11.89 \approx 12$	30.6
7.5	$101.7 + 1.5(18.8 - 9.8) = 115.2$	15	0.931	$13.96 \approx 14$	31.2
9	$115.2 + 1.5(18.8 - 9.8) = 128.7$	17	0.881	$14.97 \approx 15$	31.4

Average $\phi' \approx$ **31°**

17.6 a. The properties should be averaged over a distance of 2*B* or 4 m below the footing, i.e. up to a depth of 5.5 m.

Therefore, design N_{60} = (8 + 9 + 11) / 3 = **9.33 ≈ 9**

and design ϕ' (deg) = (31.4 + 30.6 + 30.6) / 3 = **30.8**

b. $F_d = 1 + 0.33\left(\dfrac{D_f}{B}\right) = 1 + (0.33)\left(\dfrac{1.5}{2}\right) = 1.247$

$$q_{\text{net}} = \frac{N_{60}}{0.08}\left(\frac{B+0.3}{B}\right)^2 F_d\left(\frac{S_e}{25}\right) = \frac{9}{0.08}\left(\frac{2+0.3}{2}\right)^2(1.247)\left(\frac{25}{25}\right) = 185.53\ \text{kN/m}^2$$

$Q_{\text{net}} = q_{\text{net}} \times B^2 = 185.53 \times 4 = \mathbf{742\ kN}$

17.7 Eq. (17.39): $\dfrac{\left(\dfrac{q_c}{p_a}\right)}{N_{60}} = 7.64 D_{50}^{0.26}$. Use $p_a \approx 100$ kN/m^2.

Depth (m)	N_{60}	D_{50} (mm)	q_c (kN/m^2)
1.5	8	0.28	**4,390**
3	9	0.28	**4,938**
4.5	11	0.28	**6,036**
6	12	0.28	**6,585**
7.5	15	0.28	**8,231**
9	17	0.28	**9,328**

17.8 Eq. (17.33): $E_s = 3q_c$

Using q_c from Problem 17.7:

Depth (m)	q_c (kN/m^2)	E_s (kN/m^2)
1.5	4,390	**13,170**
3	4,938	**14,814**
4.5	6,036	**18,108**
6	6,585	**19,755**
7.5	8,231	**24,693**
9	9,328	**27,984**

17.9 Eq. (17.35): $c_u = \dfrac{q_c - \sigma_c}{N_k}$; $N_k \approx 18.3$

$$c_u = \frac{26000 - (22)(118)}{18.3} = \mathbf{1278.9\ lb/ft^2}$$

17.10 From Eq. (17.43):

$$\text{Recovery ratio}, R = \left(\frac{4.5}{8}\right)(100) = \mathbf{56.25\%}$$