Problems

2.1 For a Shelby tube, given: outside diameter = 3 in. and inside diameter 2.874 in. What is the area ratio of the tube?

2.2 A soil profile is shown in Figure P2.2 along with the standard penetration numbers in the clay layer. Use Eqs. (2.8) and (2.9) to determine the variation of c_u and OCR with depth. What is the average value of c_u and OCR?

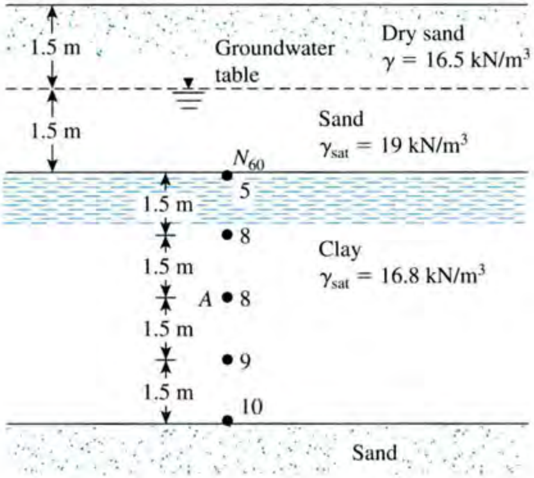

Figure P2.2

2.3 Following is the variation of the field standard penetration number (N_{60}) in a sand deposit:

Depth (m)	N_{60}
1.5	6
3	8
4.5	9
6	8
7.9	13
9	14

The groundwater table is located at a depth of 6 m. Given: the dry unit weight of sand from 0 to a depth of 6 m is 18 kN/m^3, and the saturated unit weight of sand for depth 6 to 12 m is 20.2 kN/m^3. Use the relationship of Skempton given in Eq. (2.12) to calculate the corrected penetration numbers.

2.4 For the soil profile described in Problem 2.3, estimate an average peak soil friction angle. Use Eq. (2.28).

2.5 Repeat Problem 2.4 using Eq. (2.27).

2.6 Refer to Problem 2.3. Using Eq. (2.20), determine the average relative density of sand.

2.7 The following table gives the variation of the field standard penetration number (N_{60}) in a sand deposit:

Depth (m)	N_{60}
1.5	5
3.0	11
4.5	14
6.0	18
7.5	16
9.0	21

2.15 In a deposit of normally consolidated dry sand, a cone penetration test was conducted. Following are the results:

Depth (m)	Point resistance of cone, q_c (MN/m^2)
1.5	2.06
3.0	4.23
4.5	6.01
6.0	8.18
7.5	9.97
9.0	12.42

Assuming the dry unit weight of sand to be 16 kN/m^3, estimate the average peak friction angle, ϕ', of the sand. Use Eq. (2.48).

2.16 Refer to Problem 2.15. Using Eq. (2.46), determine the variation of the relative density with depth.

2.17 In the soil profile shown in Figure P2.17, if the cone penetration resistance (q_c) at A (as determined by an electric friction-cone penetrometer) is 0.8 MN/m.^{2}, estimate

a. The undrained cohesion, c_u

b. The overconsolidation ratio, OCR

2.18 In a pressuremeter test in a soft saturated clay, the measuring cell volume V_o = 535 cm^3, p_o = 42.4 kN/m^2, p_f = 326.5 kN/m^2, v_o = 46 cm^3, and v_f = 180 cm^3. Assuming Poisson's ratio (μ_s) to be 0.5 and using Figure 2.32, calculate the pressuremeter modulus (E_p).

2.19 A dilatometer test was conducted in a clay deposit. The groundwater table was located at a depth of 3 m below the surface. At a depth of 8 m below the surface, the contact pressure (p_o) was 280 kN/m^2 and the expansion stress (p_1) was 350 kN/m^2. Determine the following:

a. Coefficient of at-rest earth pressure, K_o

b. Overconsolidation ratio, OCR

c. Modulus of elasticity, E_s

Assume σ'_o at a depth of 8 m to be 95 kN/m^2 and μ_s = 0.35.

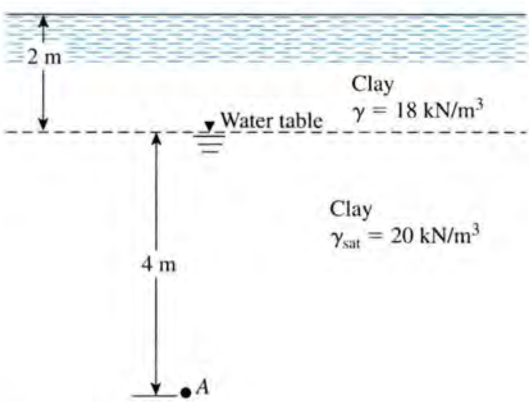

Figure P2.17

2.20 A dilatometer test was conducted in a sand deposit at a depth of 6 m. The groundwater table was located at a depth of 2 m below the ground surface. Given, for the sand: $\gamma_d = 14.5 \text{ kN/m}^3$ and $\gamma_{sat} = 19.8 \text{ kN/m}^3$. The contact stress during the test was 260 kN/m^2. Estimate the soil friction angle, ϕ'.

2.21 The *P*-wave velocity in a soil is 1900 m/sec. Assuming Poisson's ratio to be 0.32, calculate the modulus of elasticity of the soil. Assume that the unit weight of soil is 18 kN/m^3.

2.22 The results of a refraction survey (Figure 2.42a) at a site are given in the following table. Determine the thickness and the *P*-wave velocity of the materials encountered.

Distance from the source of disturbance (m)	Time of first arrival of *P*-waves (sec × 10^3)
2.5	5.08
5.0	10.16
7.5	15.24
10.0	17.01
15.0	20.02
20.0	24.2
25.0	27.1
30.0	28.0
40.0	31.1
50.0	33.9

Correlation between N_{60} and Relative Density of Granular Soil

An approximate relationship between the corrected standard penetration number and the relative density of sand is given in Table 2.8. The values are approximate primarily because the effective overburden pressure and the stress history of the soil significantly influence the N_{60} values of sand. Kulhawy and Mayne (1990) modified an empirical relationship for relative density that was given by Marcuson and Bieganousky (1977), which can be expressed as

$$D_r(\%) = 12.2 + 0.75\left[222N_{60} + 2311 - 711\text{OCR} - 779\left(\frac{\sigma'_o}{p_a}\right) - 50C_u^2\right]^{0.5} \tag{2.19}$$

where

D_r = relative density
σ'_o = effective overburden pressure
C_u = uniformity coefficient of sand

$$\text{OCR} = \frac{\text{preconsolidation pressure}, \sigma'_c}{\text{effective overburden pressure}, \sigma'_o}$$

p_a = atmospheric pressure

Meyerhof (1957) developed a correlation between D_r and N_{60} as

$$N_{60} = \left[17 + 24\left(\frac{\sigma'_o}{p_a}\right)\right]D_r^2$$

or

$$D_r = \left\{\frac{N_{60}}{\left[17 + 24\left(\frac{\sigma'_o}{p_a}\right)\right]}\right\}^{0.5} \tag{2.20}$$

Equation (2.20) provides a reasonable estimate only for clean, medium fine sand.

Cubrinovski and Ishihara (1999) also proposed a correlation between N_{60} and the relative density of sand (D_r) that can be expressed as

$$D_r(\%) = \left[\frac{N_{60}\left(0.23 + \frac{0.06}{D_{50}}\right)^{1.7}}{9}\left(\frac{1}{\frac{\sigma'_o}{p_a}}\right)\right]^{0.5}(100) \tag{2.21}$$

Table 2.8 Relation between the Corrected $(N_1)_{60}$ Values and the Relative Density in Sands

Standard penetration number, $(N_1)_{60}$	**Approximate relative density, D_r (%)**
0–5	0–5
5–10	5–30
10–30	30–60
30–50	60–95