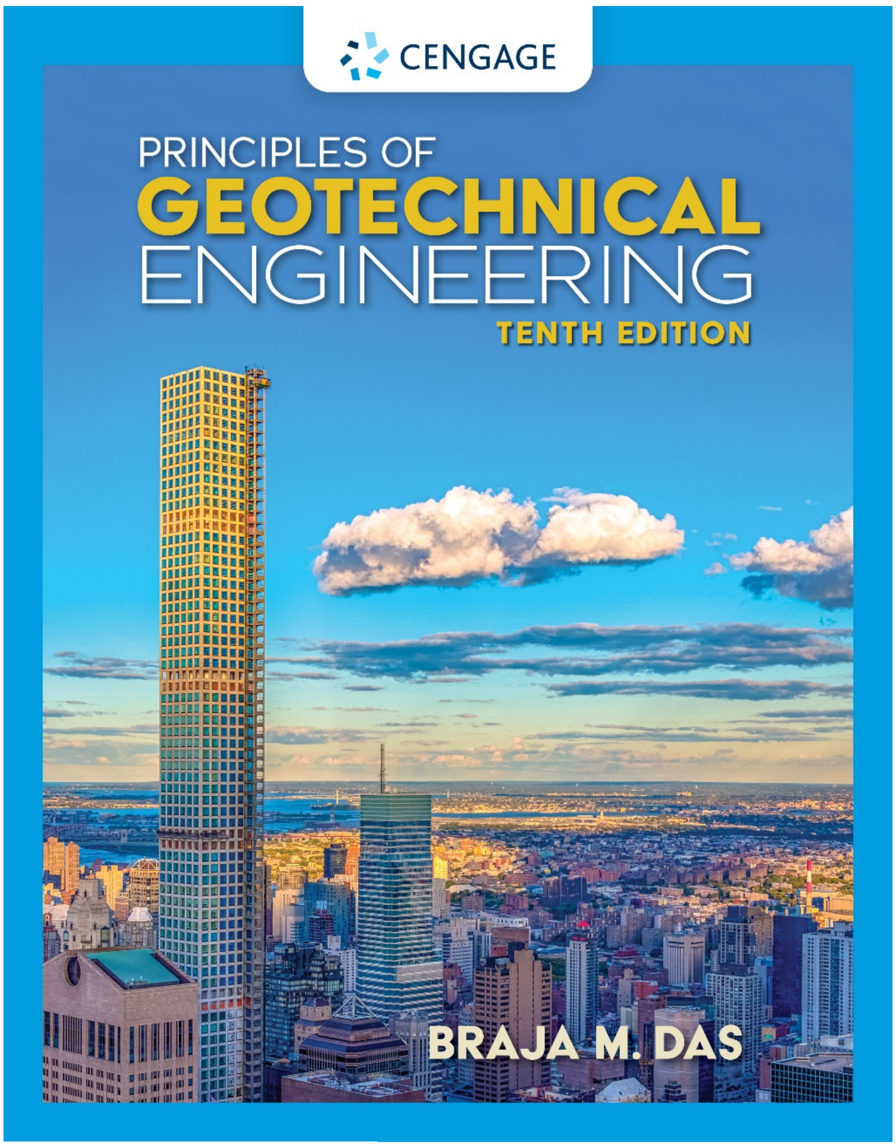
A SOLUTION AND ANSWER GUIDE TO ACCOMPANY

PRINCIPLES OF GEOTECHNICAL ENGINEERING,

TENTH EDITION

BRAJA M. DAS



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ISBN: 978-0-357-42049-2

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SOLUTION AND ANSWER GUIDE

TO ACCOMPANY

Principles of Geotechnical Engineering

Tenth Edition

BRAJA M. DAS

California State University

Contents

Chapter 2

2.1 $C_u = \dfrac{D_{60}}{D_{10}} = \dfrac{0.41}{0.08} = \mathbf{5.13}$

$$C_c = \frac{(D_{30})^2}{(D_{10})(D_{60})} = \frac{(0.22)^2}{(0.08)(0.41)} = \mathbf{1.48}$$

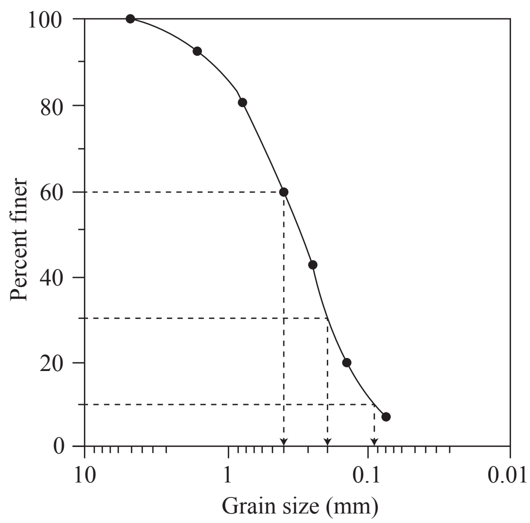
2.2 $C_u = \dfrac{D_{60}}{D_{10}} = \dfrac{1.81}{0.24} = \mathbf{7.54}$

$$C_c = \frac{(D_{30})^2}{(D_{10})(D_{60})} = \frac{(0.82)^2}{(0.24)(1.81)} = \mathbf{1.55}$$

2.3 a.

Sieve no.	Mass of soil retained on each sieve (g)	Percent retained on each sieve	Percent finer
4	0.0	0.0	**100.0**
10	18.5	4.4	**95.6**
20	53.2	12.6	**83.0**
40	90.5	21.5	**61.5**
60	81.8	19.4	**42.1**
100	92.2	21.9	**20.2**
200	58.5	13.9	**6.3**
Pan	26.5	6.3	**0**
	$\sum$ 421.2 g		

The grain-size distribution is shown in the figure.



b. D_{60} = **0.4 mm**; D_{30} = **0.2 mm**; D_{10} = **0.095 mm**

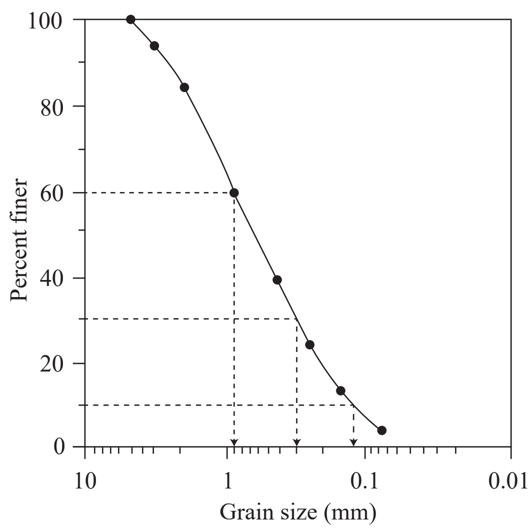
c. $C_u = \dfrac{D_{60}}{D_{10}} = \dfrac{0.4}{0.095} = \mathbf{4.21}$

d. $C_c = \dfrac{(D_{30})^2}{(D_{10})(D_{60})} = \dfrac{(0.2)^2}{(0.4)(0.095)} = \mathbf{1.05}$

2.4 a.

Sieve no.	Mass of soil retained on each sieve (g)	Percent retained on each sieve	Percent finer
4	0.0	0.0	**100**
6	30	6.0	**94.0**
10	48.7	9.74	**84.26**
20	127.3	25.46	**58.80**
40	96.8	19.36	**39.44**
60	76.6	15.32	**24.12**
100	55.2	11.04	**13.08**
200	43.4	8.68	**4.40**
Pan	22	4.40	**0**
	Σ 500 g		

The grain-size distribution is shown in the figure.



b. D_{10} = **0.13 mm**; D_{30} = **0.3 mm**; D_{60} = **0.9 mm**

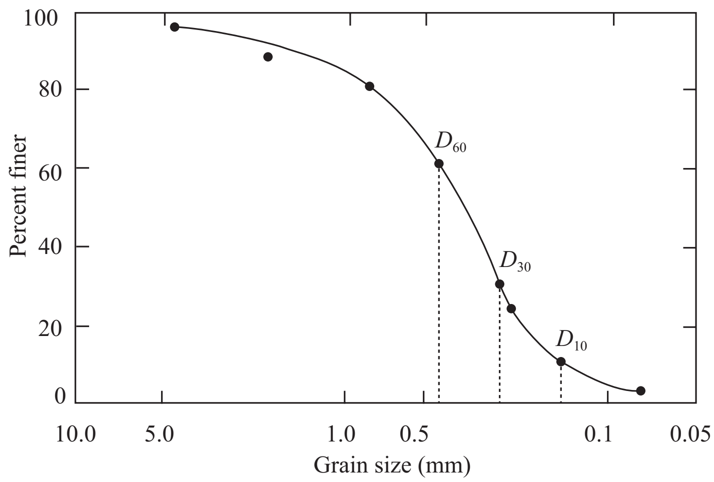
c. $C_u = \dfrac{D_{60}}{D_{10}} = \dfrac{0.9}{0.13} = \mathbf{6.923 \approx 6.92}$

d. $C_c = \dfrac{D_{30}^2}{(D_{60})(D_{10})} = \dfrac{0.3^2}{(0.9)(0.13)} = \mathbf{0.769 \approx 0.77}$

2.5 a.

Sieve no.	Mass retained (g)	Percent retained on each sieve	Percent finer
4	28	4.54	95.46
10	42	6.81	88.65
20	48	7.78	80.87
40	128	20.75	60.12
60	221	35.82	24.3
100	86	13.94	10.36
200	40	6.48	3.88
Pan	24	3.88	0
	Σ 617 g		

The graph for percent finer versus grain size is shown.



b. From the graph, D_{10} = **0.14 mm**, D_{30} = **0.27 mm**, D_{60} = **0.42 mm**

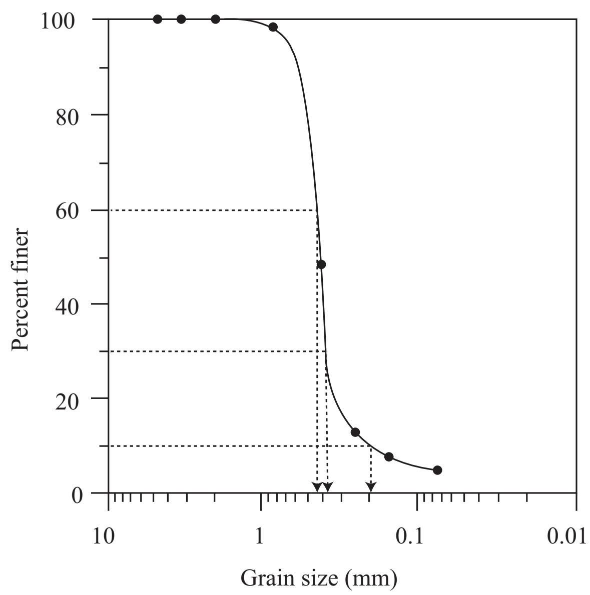
c. $C_u = \dfrac{D_{60}}{D_{10}} = \dfrac{0.42}{0.14} = \mathbf{3}$

d. $C_c = \dfrac{(D_{30})^2}{(D_{60})(D_{10})} = \dfrac{(0.27)^2}{(0.42)(0.14)} = \mathbf{1.24}$

2.6 a.

Sieve no.	Mass of soil retained on each sieve (g)	Percent retained on each sieve	Percent finer
4	0	0.0	**100**
6	0	0.0	**100**
10	0	0.0	**100**
20	9.1	1.82	**98.18**
40	249.4	49.88	**48.3**
60	179.8	35.96	**12.34**
100	22.7	4.54	**7.8**
200	15.5	3.1	**4.7**
Pan	23.5	4.7	**0**
	Σ 500 g		

The grain-size distribution is shown in the figure.

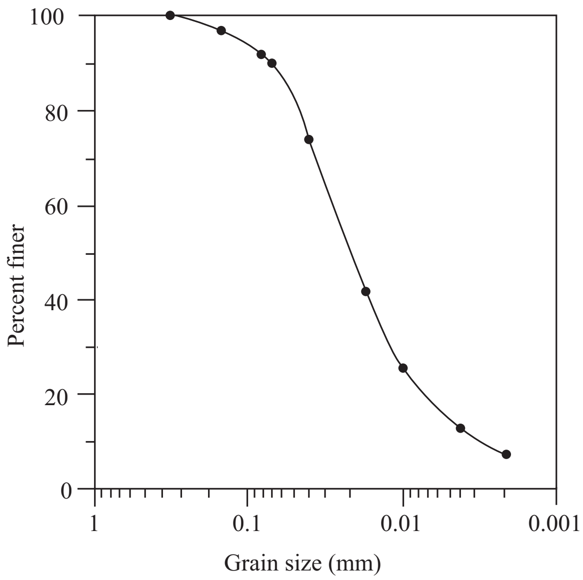


b. D_{10} = **0.21 mm**; D_{30} = **0.39 mm**; D_{60} = **0.45 mm**

c. $C_u = \dfrac{D_{60}}{D_{10}} = \dfrac{0.45}{0.21} = \mathbf{2.142 \approx 2.14}$

d. $C_c = \dfrac{D_{30}^2}{(D_{60})(D_{10})} = \dfrac{0.39^2}{(0.45)(0.21)} = \mathbf{1.609 \approx 1.61}$

2.7 a. The grain-size distribution curve is shown in the figure.



b. Percent passing 2 mm = 100 GRAVEL: 100 − 100 = **0%**

Percent passing 0.06 mm = 84 SAND: 100 − 84 = **16%**

Percent passing 0.002 mm = 11 SILT: 84 − 11 = **73%**

CLAY: 11 − 0 = **11%**

c. Percent passing 2 mm = 100 GRAVEL: 100 − 100 = **0%**

Percent passing 0.05 mm = 80 SAND: 100 − 80 = **20%**

Percent passing 0.002 mm = 11 SILT: 80 − 11 = **69%**

CLAY: 11 − 0 = **11%**

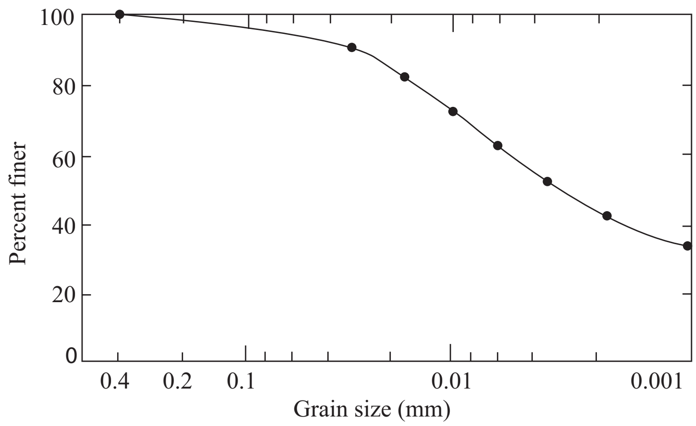
d. Percent passing 2 mm = 100 GRAVEL: 100 − 100 = **0%**

Percent passing 0.075 mm = 90 SAND: 100 − 90 = **10%**

Percent passing 0.002 mm = 11 SILT: 90 − 11 = **79%**

CLAY: 11 − 0 = **11%**

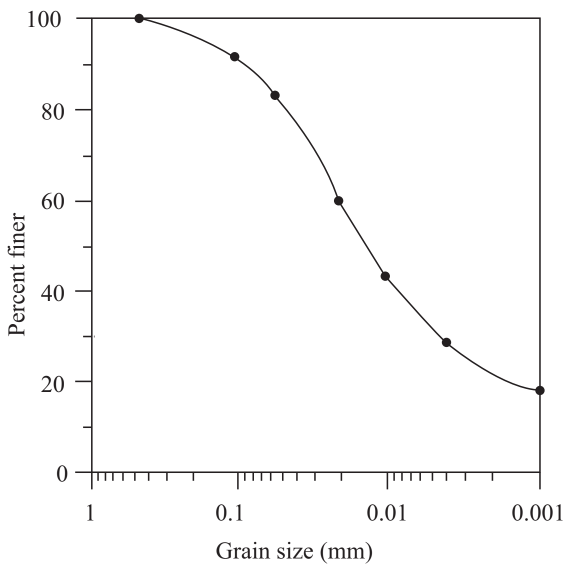
2.8 The grain-size distribution curve is shown in the figure.



a. Percent passing 2 mm = 100	GRAVEL: 100 – 100 = **0%**
Percent passing 0.05 mm = 94	SAND: 100 – 94 = **6%**
Percent passing 0.002 mm = 42	SILT: 94 – 42 = **52%**
	CLAY: 42 – 0 = **42%**

b. Percent passing 2 mm = 100	GRAVEL: 100 – 100 = **0%**
Percent passing 0.075 mm = 97	SAND: 100 – 97 = **3%**
Percent passing 0.002 mm = 42	SILT: 97 – 42 = **55%**
	CLAY: 42 – 0 = **42%**

2.9 a. The grain-size distribution curve is shown below.



b. Percent passing 2 mm = 100 — GRAVEL: 100 − 100 = **0%**
Percent passing 0.06 mm = 84 — SAND: 100 − 84 = **16%**
Percent passing 0.002 mm = 28 — SILT: 84 − 28 = **56%**
CLAY: 28 − 0 = **28%**

c. Percent passing 2 mm = 100 — GRAVEL: 100 − 100 = **0%**
Percent passing 0.05 mm = 83 — SAND: 100 − 83 = **17%**
Percent passing 0.002 mm = 28 — SILT: 83 − 28 = **55%**
CLAY: 28 − 0 = **28%**

d. Percent passing 2 mm = 100 — GRAVEL: 100 − 100 = **0%**
Percent passing 0.075 mm = 90 — SAND: 100 − 90 = **10%**
Percent passing 0.002 mm = 28 — SILT: 90 − 28 = **62%**
CLAY: 28 − 0 = **28%**

2.10 $G_s = 2.60$; temperature = 24°; $R = 43$; time = 60 min. Referring to Table 2.10, $L = 9.2$.

Eq. (2.6): $D \text{ (mm)} = K\sqrt{\dfrac{L(\text{cm})}{t(\text{min})}}$

From Table 2.9 for $G_s = 2.60$ and temperature = 24°, $K = 0.01321$.

$$D = 0.01321\sqrt{\frac{9.2}{60}} = \mathbf{0.0052\ mm}$$

2.11 For $G_s = 2.70$ and temperature = 23°, $K = 0.01297$ (Table 2.9);

$R = 25$, $L = 12.2$ (Table 2.10).

$$D(\text{mm}) = K\sqrt{\frac{L(\text{cm})}{t(\text{min})}} = 0.01297\sqrt{\frac{12.2}{120}} = \mathbf{0.0041\ mm}$$

2.12 a. Total mass in the ternary mix = $8000 \times 3 = 24{,}000$ kg

Percent of each soil in the mix = $\dfrac{8000}{24{,}000} \times 100 = 33.33\%$

Mass of each soil used in the sieve analysis, $\Sigma m_A = \Sigma m_B = \Sigma m_C = 500\,\text{g}$

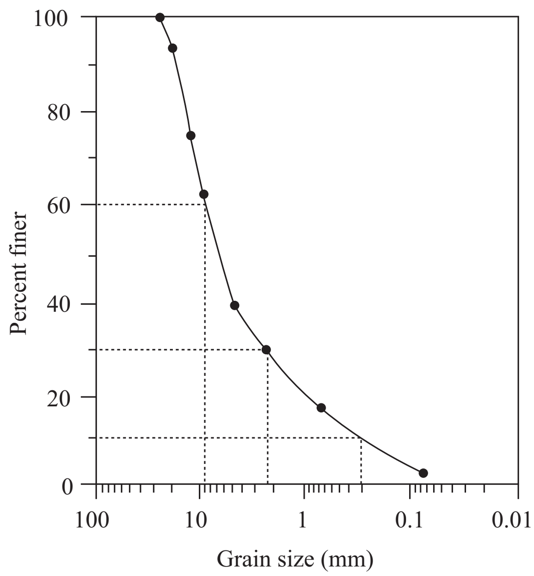
If a sieve analysis is conducted on the ternary mix using the same set of sieves, the percent of mass retained on each sieve, $m_M(\%)$, can be computed as follows:

$$m_M(\%) = 0.333\left(\frac{m_A}{500} \times 100\right) + 0.333\left(\frac{m_B}{500} \times 100\right) + 0.333\left(\frac{m_C}{500} \times 100\right)$$

The calculated values are shown in the following table.

Sieve size (mm)	m_A (g)	Mass retained m_B (g)	m_C (g)	m_M (%)	Percent passing for the mixture
25.0	0.0	0	0	**0.0**	**100**
19.0	60	10	30	**6.66**	**93.34**
12.7	130	75	75	**18.65**	**74.69**
9.5	65	80	45	**12.65**	**62.04**
4.75	100	165	90	**23.64**	**38.4**
2.36	50	25	65	**9.32**	**29.08**
0.6	40	60	75	**11.65**	**17.43**
0.075	50	70	105	**14.98**	**2.45**
Pan	5	15	15	**2.33**	≈ **0**

b. The grain-size distribution curve for the mixture is drawn below.



From the curve, $D_{10} = 0.21$; $D_{30} = 2.5$; $D_{60} = 9.0$;

$$C_u = \frac{D_{60}}{D_{10}} = \frac{9.0}{0.21} = \mathbf{42.85}\,;\quad C_x = \frac{D_{30}^2}{(D_{60})(D_{10})} = \frac{2.5^2}{(9.0)(0.21)} = \mathbf{3.31}$$

Chapter 3

3.1 a. $\gamma_{\text{sat}} = \dfrac{(G_s + e)\gamma_w}{1+e} = \dfrac{G_s\gamma_w}{1+e} + \dfrac{e\gamma_w}{1+e} = \gamma_d + \left(\dfrac{e}{1+e}\right)\gamma_w$

b. $\gamma_d = \dfrac{G_s\gamma_w}{(1+e)} = \dfrac{\left(Se/w\right)\gamma_w}{(1+e)} = \dfrac{eS\gamma_w}{(1+e)w}$

c. $\gamma_{\text{sat}} = \dfrac{(G_s + e)\gamma_w}{1+e} = \dfrac{G_s\gamma_w}{1+e} + \dfrac{e\gamma_w}{1+e} = \gamma_d + \left(\dfrac{e}{1+e}\right)\gamma_w$

Rearranging, $\gamma_{\text{sat}}(1+e) = \gamma_d(1+e) + e\gamma_w$

Therefore, $e = \dfrac{\gamma_{\text{sat}} - \gamma_d}{\gamma_d - \gamma_{\text{sat}} + \gamma_w}$

d. $\gamma_{\text{sat}} = \left(\dfrac{1+w_{\text{sat}}}{1+e}\right)G_s\gamma_w = \left(\dfrac{1+w_{\text{sat}}}{1+e}\right)\dfrac{e\gamma_w}{w_{\text{sat}}} = \dfrac{(1+w_{\text{sat}})n\gamma_w}{w_{\text{sat}}}$

Rearranging, $w_{\text{sat}}(\gamma_{\text{sat}} - n\gamma_w) = n\gamma_w$

Therefore, $w_{\text{sat}} = \dfrac{n\gamma_w}{\gamma_{\text{sat}} - n\gamma_w}$

3.2 a. $w = \left(\dfrac{711.2 - 623.9}{623.9}\right)(100) = \mathbf{14\%}$

b. $\rho = \dfrac{M}{V} = \dfrac{711.2}{0.4} = \mathbf{1778\ kg/m^3}$

c. $\rho_d = \dfrac{623.9}{0.4} = \mathbf{1559.75\ kg/m^3}$

d. $\rho_d = \dfrac{G_s\rho_w}{1+e}$

$e = \dfrac{G_s\rho_w}{\rho_d} - 1 = \dfrac{(2.68)(1000)}{1559.75} - 1 = \mathbf{0.718}$

e. $n = \dfrac{e}{1+e} = \dfrac{0.718}{1+0.718} = \mathbf{0.418}$

3.3 a. $\gamma_d = \dfrac{\gamma}{(1+w)} = \dfrac{17.8}{(1+0.14)} = \mathbf{15.6\ kN/m^3}$

b. $e = \dfrac{G_s\gamma_w}{\gamma_d} - 1 = \dfrac{(2.69)(9.81)}{15.6} - 1 = \mathbf{0.69}$

c. $S = \dfrac{wG_s}{e} = \dfrac{(0.14)(2.69)}{0.69} = 0.545 = \mathbf{54.5\%}$

3.4 a. $\gamma = \dfrac{W}{V} = \dfrac{23}{0.2} = \mathbf{115\ lb/ft^3}$

b. $\gamma_d = \dfrac{\gamma}{1+w} = \dfrac{115}{1+0.11} = \mathbf{103.6\ lb/ft^3}$

c. $e = \dfrac{G_s\gamma_w}{\gamma_d} - 1 = \dfrac{(2.7)(62.4)}{103.6} - 1 = \mathbf{0.626}$

d. $n = \dfrac{e}{1+e} = \dfrac{0.626}{1+0.626} = \mathbf{0.385}$

e. $S = \dfrac{wG_s}{e} = \left[\dfrac{(0.11)(2.7)}{0.626}\right](100) = \mathbf{47.4\%}$

f. $W_s = \dfrac{W}{1+w} = \dfrac{23}{1+0.11} = 20.72\ \text{lb}$

$W_w = 23 - 20.72 = 2.28\ \text{lb}$

$V_w = \dfrac{W_w}{\gamma_w} = \dfrac{2.28}{62.4} = \mathbf{0.0365\ ft^3}$

3.5 a. $\gamma_d = \dfrac{\gamma_{\text{sat}}}{1+w} = \dfrac{19.8}{1+0.171} = \mathbf{16.91\ kN/m^3}$

b. $\gamma_d = \dfrac{G_s\gamma_w}{1+e}$; $16.91 = \dfrac{(G_s)(9.81)}{1+0.171G_s}$; $G_s = \mathbf{2.44}$

c. $e = wG_s = (0.171)(2.44) = \mathbf{0.417}$

3.6 a. $\gamma = \dfrac{G_s\gamma_w + wG_s\gamma_w}{1+e}$; $G_s = \dfrac{Se}{w}$; $wG_s = Se$

$$\gamma = \frac{\left(\dfrac{Se}{w}\right)\gamma_w + Se\gamma_w}{1+e}$$

$$95 = \frac{\left[\dfrac{(0.6)(e)}{0.192}\right](62.4) + (0.6)(e)(62.4)}{1+e}; e = \mathbf{0.69}$$

b. $G_s = \dfrac{Se}{w} = \dfrac{(0.6)(0.69)}{0.192} = \mathbf{2.16}$

c. $\gamma_{\text{sat}} = \dfrac{\gamma_w(G_s+e)}{1+e} = \dfrac{(62.4)(2.16+0.69)}{1+0.69} = \mathbf{105.2\ lb/ft^3}$

3.7 a. $\gamma_d = \dfrac{\gamma}{1+w} = \dfrac{112}{1+0.108} = \mathbf{101.1\ lb/ft^3}$

b. $e = \dfrac{G_s\gamma_w}{\gamma_d} - 1 = \dfrac{(2.67)(62.4)}{101.1} - 1 = \mathbf{0.648}$

c. $n = \dfrac{e}{1+e} = \dfrac{0.648}{1+0.648} = \mathbf{0.39}$

d. $S = \dfrac{wG_s}{e} = \left[\dfrac{(0.108)(2.67)}{0.648}\right](100) = \mathbf{44.5\%}$

3.8 a. $\gamma = \dfrac{(G_s+Se)\gamma_w}{1+e} = \dfrac{[2.67+(0.8)(0.648)](62.4)}{1+0.648} = 120.73\ \text{lb/ft}^3$

Water to be added: $120.73 - 112 = \mathbf{8.73\ lb/ft^3}$

b. $\gamma = \dfrac{(G_s+Se)\gamma_w}{1+e} = \dfrac{(2.67+0.648)(62.4)}{1.648} = 125.6\ \text{lb/ft}^3$

Water to be added: $125.6 - 112 = \mathbf{13.6\ lb/ft^3}$

3.9 a. $\rho_d = \dfrac{\rho}{1+w} = \dfrac{1680}{1+0.18} = \mathbf{1423.7\ kg/m^3}$

b. $e = \dfrac{G_s\rho_w}{\rho_d} - 1 = \dfrac{(2.73)(1000)}{1423.7} - 1 = 0.918$

$$n = \frac{e}{1+e} = \frac{0.918}{1+0.918} = \mathbf{0.479}$$

c. $S = \frac{wG_s}{e} = \left[\frac{(0.18)(2.73)}{0.918}\right](100) = \mathbf{53.5\%}$

d. $\rho_{\text{sat}} = \frac{(G_s + e)\gamma_w}{1+e} = \frac{(2.73 + 0.918)(1000)}{1 + 0.918} = 1901.98 \text{ kg/m}^3$

Water to be added: $\rho_{\text{sat}} - \rho = 1901.98 - 1680 \approx \mathbf{222\ kg/m^3}$

3.10 $\gamma_d = \frac{(1780)(9.81)}{1000} = 17.46 \text{ kN/m}^3;\ e = \frac{G_s\gamma_w}{\gamma_d} - 1 = \frac{(2.68)(9.81)}{17.46} - 1 = 0.506$

$w = \frac{e}{G_s} = \left(\frac{0.506}{2.68}\right)(100) = \mathbf{18.88\%}$

3.11 a. $e = \frac{0.35}{1 - 0.35} = 0.538$

$\gamma_{\text{sat}} = \frac{(G_s + e)\gamma_w}{1+e} = \frac{(2.69 + 0.538)(9.81)}{1 + 0.538} = \mathbf{20.59\ kN/m^3}$

b. $\gamma = \frac{G_s\gamma_w(1+w)}{1+e};\ 17.5 = \frac{(2.69)(9.81)(1+w)}{1 + 0.538}; w = \mathbf{1.99\%}$

3.12 $e = wG_s = (0.23)(2.62) = 0.603$

$\rho_d = \frac{G_s\rho_w}{1+e} = \frac{(2.62)(1000)}{1 + 0.603} = \mathbf{1634.4\ kg/m^3}$

$\rho_{\text{sat}} = \rho_d(1+w) = (1634.4)(1 + 0.23) = \mathbf{2010.3\ kg/m^3}$

3.13 a. $\gamma = \frac{G_s\gamma_w(1+w)}{1+e} = \frac{(2.71)(62.4)(1 + 0.215)}{1 + 0.75} = \mathbf{117.4\ lb/ft^3}$

b. $\gamma_d = \frac{\gamma}{1+w} = \frac{117.4}{1 + 0.215} = \mathbf{96.6\ lb/ft^3}$

c. $S = \frac{wG_s}{e} = \left[\frac{(0.215)(2.71)}{0.75}\right](100) = \mathbf{77.7\%}$

3.14 $e = \frac{wG_s}{S} = \frac{(0.182)(2.67)}{0.8} = 0.607$

$\gamma_d = \frac{G_s\gamma_w}{1+e} = \frac{(2.67)(62.4)}{1.607} = \mathbf{103.7\ lb/ft^3}$

$\gamma = \gamma_d(1+w) = (103.7)(1.182) = \mathbf{122.6\ lb/ft^3}$

3.15 a. $\gamma = \dfrac{G_s \gamma_w (1+w)}{1+e}$; $112.32 = \dfrac{(2.7)(62.4)(1.1)}{1+e}$; $e = \mathbf{0.65}$

b. $\gamma_{\text{sat}} = \dfrac{\gamma_w (G_s + e)}{1+e} = \dfrac{(62.4)(2.7+0.65)}{1.65} = \mathbf{126.7\ lb/ft^3}$

3.16 a. $\gamma = \dfrac{\gamma_w (G_s + Se)}{1+e}$; $105.73 = \dfrac{(62.4)(G_s + 0.5e)}{1+e}$

$G_s = 1.694 + 1.194e$ (a)

$112.67 = \dfrac{(62.4)(G_s + 0.75e)}{1+e}$ (b)

From Eqs. (a) and (b),

$112.67 = \dfrac{(62.4)(1.694 + 1.194e + 0.75e)}{1+e}$; $e = \mathbf{0.81}$

b. From Eq. (a):

$G_s = 1.694 + (1.194)(0.81) = \mathbf{2.66}$

3.17 $\gamma_d = \dfrac{G_s \gamma_w}{1+e} = \dfrac{(2.66)(62.4)}{1+0.81} = 917\ \text{lb/ft}^3$

$\gamma_{\text{sat}} = \dfrac{\gamma_w (G_s + e)}{1+e} = \dfrac{(62.4)(2.66+0.81)}{1+0.81} = 119.6\ \text{lb/ft}^3$

Water = $(2.5)(\gamma_{\text{sat}} - \gamma_d) = (2.5)(119.6 - 91.7) = \mathbf{69.75\ lb}$

3.18 For the borrow pit, $\gamma_{d-\text{borrow}} = \dfrac{G_s \gamma_w}{1+e_{\text{borrow}}} = \dfrac{G_s \gamma_w}{1+1.1} = 0.476 G_s \gamma_w$

For the compacted backfill, $\gamma_{d-\text{backfill}} = \dfrac{G_s \gamma_w}{1+e_{\text{backfill}}} = \dfrac{G_s \gamma_w}{1+0.8} = 0.555 G_s \gamma_w$

Volume of borrow soil needed = $\left(\dfrac{\gamma_{d-\text{backfill}}}{\gamma_{d-\text{borrow}}}\right)(V) = \dfrac{0.555 G_s \gamma_w}{0.476 G_s \gamma_w}(1) = \mathbf{1.16\ m^3}$

3.19 a. $\gamma_{\text{borrow}} = \dfrac{(1+w) G_s \gamma_w}{1+e_{\text{borrow}}} = \dfrac{(1+0.11)(2.7)(9.81)}{1+1.1} = \mathbf{14\ kN/m^3}$

b. $S = \dfrac{w G_s}{e_{\text{borrow}}} = \dfrac{(0.11)(2.7)}{1.1} = 0.27 = \mathbf{27\%}$

c. $\gamma_{\text{backfill}} = \dfrac{(1+w) G_s \gamma_w}{1+e_{\text{backfill}}} = \dfrac{(1+0.11)(2.7)(9.81)}{1+0.8} = \mathbf{16.3\ kN/m^3}$

3.20 $e = e_{\max} - D_r(e_{\max} - e_{\min}) = 0.78 - (0.65)(0.78 - 0.43) = 0.553$

$$\gamma = \frac{G_s \gamma_w}{1+e} = \frac{(2.67)(9.81)}{1+0.553} = \mathbf{16.87\ kN/m^3}$$

3.21 $e = e_{\max} - D_r(e_{\max} - e_{\min}) = 0.75 - (0.78)(0.75 - 0.46) = 0.524$

$$\gamma = \frac{G_s \gamma_w (1+w)}{1+e} = \frac{(2.68)(9.81)(1.09)}{1.524} = \mathbf{18.8\ kN/m^3}$$

3.22 $\gamma_{d(\min)} = \dfrac{G_s \gamma_w}{1+e_{\max}};\ 92 = \dfrac{(2.65)(62.4)}{1+e_{\max}};\ e_{\max} = 0.8$

$$\gamma_{d(\max)} = \frac{G_s \gamma_w}{1+e_{\min}};\ 108 = \frac{(2.65)(62.4)}{1+e_{\min}};\ e_{\min} = 0.532$$

$$e = e_{\max} - D_r(e_{\max} - e_{\min}) = 0.8 - (0.6)(0.8 - 0.532) = 0.639$$

$$\gamma = \frac{G_s \gamma_w (1+w)}{1+e} = \frac{(2.65)(62.4)(1.08)}{1.639} = \mathbf{109\ lb/ft^3}$$

3.23 a. $\gamma_d = \dfrac{G_s \gamma_w}{1+e};\ 100 = \dfrac{(2.65)(62.4)}{1+e};\ e = 0.654$

$$S = \frac{wG_s}{e} = \frac{(0.184)(2.65)}{0.654} = \mathbf{74.6\%}$$

b. This is when $S = 100\%$, so $e = wG_s = (0.184)(2.65) = 0.488$

$$\gamma_d = \frac{G_s \gamma_w}{1+e} = \frac{(2.65)(62.4)}{1+0.488} = \mathbf{111.1\ lb/ft^3}$$

3.24 a. $D_r = \dfrac{e_{\max} - e_1}{e_{\max} - e_{\min}}$

$$e_1 = e_{\max} - D_r(e_{\max} - e_{\min}) = 0.9 - (0.4)(0.9 - 0.46) = 0.724$$

$$\gamma_d = \frac{G_s \gamma_w}{1+e_1} = \frac{(2.65)(62.4)}{1+0.724} = \mathbf{95.9\ lb/ft^3}$$

b. $e_2 = e_{\max} - D_r(e_{\max} - e_{\min}) = 0.9 - (0.75)(0.9 - 0.46) = 0.57$

$$\frac{\Delta H}{H} = \frac{\Delta e}{1+e_1} = \frac{e_1 - e_2}{1+e_1};\ \frac{\Delta H}{6} = \frac{0.724 - 0.57}{1+0.724}$$

$$\Delta H = 0.536\ \text{ft} = \mathbf{6.43\ in.}$$

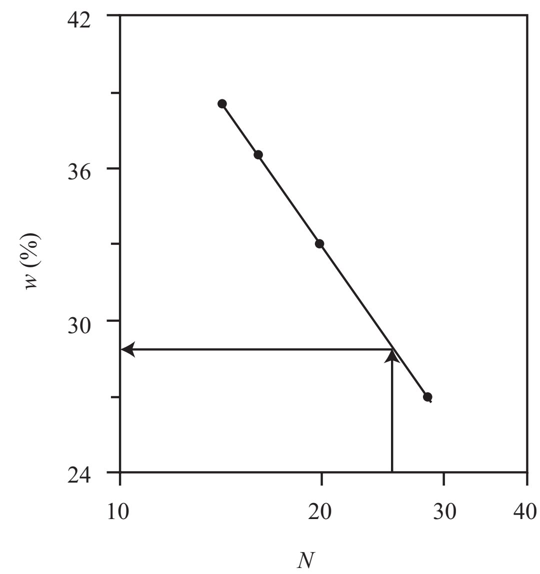
Chapter 4

4.1. a. Refer to the plot of w versus N.

LL = **29.0**

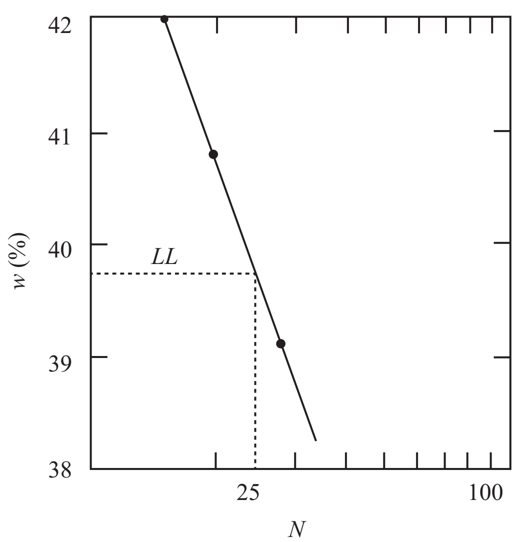
b. $PI = LL - PL$

$= 29.0 - 13.4 =$ **15.6**



4.2 $LI = \dfrac{w - PL}{LL - PL} = \dfrac{32 - 13.4}{15.6} = \mathbf{1.19}$

4.3 a. From the plot, LL = **39.7**



b. $PI = LL - PL = 39.7 - 18.7 =$ **21**

4.4 $LI = \dfrac{w - PL}{LL - PL} = \dfrac{26 - 18.7}{39.7 - 18.7} = \mathbf{0.384}$

4.5 $LL = 28.5$; $PL = 12.2$

$PI = 28.5 - 12.2 = 16.3$

Eq. (4.14):

$$SL = 46.4\left(\frac{LL + 43.5}{PI + 46.4}\right) - 43.5$$

$$= 46.4\left(\frac{28.5 + 43.5}{16.3 + 46.4}\right) - 43.5 = \mathbf{9.78}$$

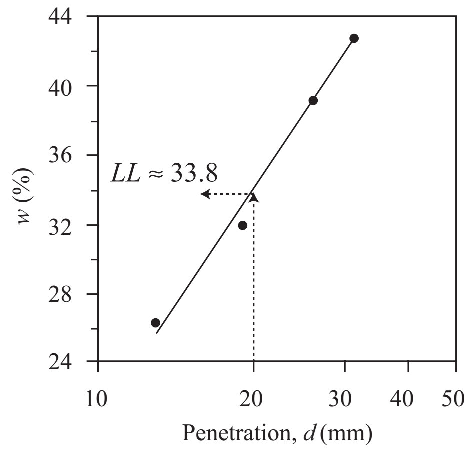
4.6 $$SL = 46.4\left(\frac{LL + 43.5}{PI + 46.4}\right) - 43.5$$

$$= 46.4\left(\frac{39.7 + 43.5}{21 + 46.4}\right) - 43.5 = \mathbf{13.78}$$

4.7 From the plot, $LL \approx \mathbf{33.8}$

$$I_{FC} = \frac{w_2(\%) - w_1(\%)}{\log d_2 - \log d_1}$$

$$= \frac{42.6 - 26.3}{\log(31) - \log(13)} \approx \mathbf{43.2}$$



4.8 Eq. (4.5): $LL = \dfrac{w}{0.77 \log d} = \dfrac{30.5}{(0.77)\log(17)} = \mathbf{32.2}$

Eq. (4.6): $LL = \dfrac{w}{0.65 + 0.0175d} = \dfrac{30.5}{0.65 + (0.0175)(17)} = \mathbf{32.19}$

Eq. (4.7): $LL = w\left(\dfrac{20}{d}\right)^{0.33} = (30.5)\left(\dfrac{20}{17}\right)^{0.33} = \mathbf{32.18}$