

2019

RANK Improvement **WORKBOOK**



**Answer key and Hint of
Objective & Conventional Questions**

Civil Engineering
Soil Mechanics and Foundation Engg.



MADE EASY
Publications

1

Properties of Soil

LEVEL 1 Objective Questions

1. (b)
2. (c)
3. (b)
4. (b)
5. (b)
6. (b)
7. (c)
8. (d)
9. (c)
10. (c)
11. (a)
12. (c)
13. (a)

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LEVEL 2 Objective Questions

14. (b)
15. (a)
16. (d)
17. (c)
18. (c)
19. (d)
20. (a)
21. (b)
22. (c)
23. (d)
24. (d)

LEVEL 3 Conventional Questions**Solution : 1**

$$V_1 = 3558.59 \text{ m}^3, W_1 = 56937.44 \text{ kN}$$

$$V_2 = 3666.43 \text{ m}^3, W_2 = 58662.83 \text{ kN}$$

Solution : 2

1. 48.2 g

2. 49.981%

Solution : 3

0.5035 m

Solution : 4

(i) 3295.19 g

(ii) 134.19 g

Solution : 5

Borrow area D is most economical.

Solution : 6

(i) Soil B

(ii) Soil B

(iii) Soil B

(iv) Soil B

(v) Soil B

Solution : 7

20936 kg

Solution 8

2.63

Solution : 9

$$\gamma_t = 1.82 \text{ g/cc}, \gamma_d = 1.65 \text{ g/cc}, I = 0.61, S = 45.4\%, W = 23\%, \gamma_{\text{sat}} = 2.02 \text{ g/cc}$$

Solution : 10

$$W_s = 23.41\%, G = 2.66, SR = 1.64$$



2

Classification of Soils

LEVEL 1 Objective Questions

1. (c)
2. (d)
3. (a)
4. (a)
5. (c)
6. (b)
7. (a)
8. (d)
9. (a)
10. (a)
11. (a)

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LEVEL 2 Objective Questions

12. (c)
13. (d)
14. (d)
15. (b)
16. (b)
17. (d)

LEVEL 3 Conventional Questions

Solution : 1

- (a) 3%, 91%, 6. %
- (b) 0.15 mm
- (c) 13.33
- (d) 0.602
- (e) Poorly graded

■■■■

3

Effective Stress and Permeability

LEVEL 1 Objective Questions

1. (b)
2. (a)
3. (a)
4. (b)
5. (d)
6. (c)
7. (d)
8. (a)

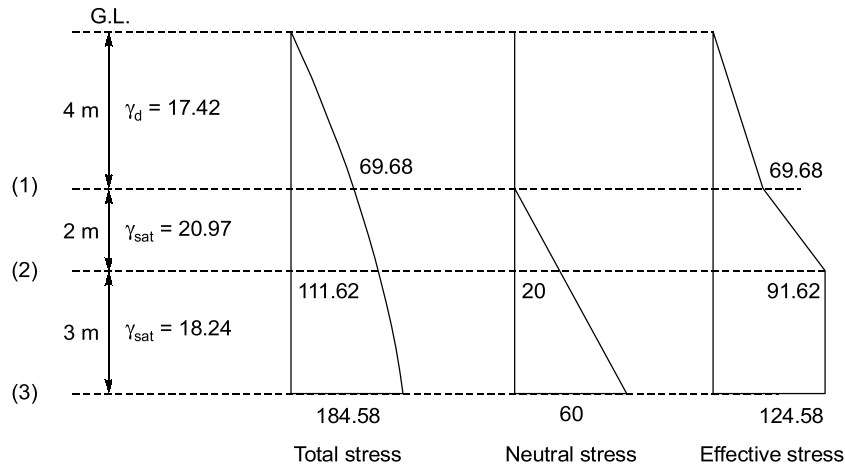
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LEVEL 2 Objective Questions

9. (c)
10. (a)
11. (c)
12. (a)
13. (b)
14. (a)
15. (b)

LEVEL 3 Conventional Questions

Solution : 1



Solution : 2

- (i) $\bar{\sigma}_{AA} = 41.1 \text{ kN/m}^2$
 $\bar{\sigma}_{BB} = 69.1 \text{ kN/m}^2$
 $\bar{\sigma}_{CC} = 97.1 \text{ kN/m}^2$
- (ii) $\bar{\sigma}_{AA} = 57.7 \text{ kN/m}^2$
 $\bar{\sigma}_{BB} = 69.1 \text{ kN/m}^2$
 $\bar{\sigma}_{CC} = 97.1 \text{ kN/m}^2$
- (iii) $\bar{\sigma}_{AA} = 57.7 \text{ kN/m}^2$
 $\bar{\sigma}_{BB} = 85.7 \text{ kN/m}^2$
 $\bar{\sigma}_{CC} = 113.7 \text{ kN/m}^2$

Solution : 3

- (i) 40 cm
- (ii) 24 cm, 64 cm
- (iii) 0.033 cm/s
- (iv) 0.02 ml/s

Solution : 4

1.537. 3.759



4

Seepage Analysis

LEVEL 1 Objective Questions

1. (d)

2. (c)

3. (a)

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LEVEL 2 Objective Questions

4. (a)

5. (d)

6. (b)

7. (c)

8. (d)

9. (b)

10. (c)

LEVEL 3 Conventional Questions

Solution : 1

3.382 m

■■■■

5

Compaction of Soil

LEVEL 1 Objective Questions

1. (b)
2. (b)
3. (a)
4. (a)
5. (c)

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LEVEL 2 Objective Questions

6. (c)
7. (d)
8. (c)
9. (a)
10. (b)

6

Compressibility and Consolidation

LEVEL 1 Objective Questions

1. (b)

2. (a)

3. (b)

4. (a)

5. (c)

6. (c)

7. (b)

8. (c)

LEVEL 2 Objective Questions

9. (c)

10. (d)

11. (a)

12. (a)

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LEVEL 3 Conventional Questions

Solution : 1

$4.91 \times 10^{-4} \text{ cm}^2/\text{s}$
104.17 days, 450 days

Solution : 2

324.54 mm, 215.69 mm

Solution : 3

(i) 423 mm
(ii) 42.3 mm
(iii) 64.59 mm

Solution : 4

104 days

Solution : 5

82.79%



7

Vertical Stress

LEVEL 1 Objective Questions

1. (b)
2. (a)
3. (c)
4. (a)
5. (b)
6. (d)
7. (b)
8. (d)

LEVEL 2 Objective Questions

9. (b)
10. (c)
11. (b)
12. (d)
13. (a)
14. (b)

LEVEL 3 Conventional Questions

Solution : 1

15.76 kN/m²

Solution : 2

71.136 kN/m²

Solution : 3

(i) 18.09 kN/m²

(ii) $\sigma_1 = 103$ kPa, $\sigma_3 = 34.5$ kPa, $\theta = 17^\circ$

Solution : 4

21.5 kN/m², 9.186 %

■■■■

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8

Shear Strength of Soil

LEVEL 1 Objective Questions

1. (b)

2. (c)

3. (c)

4. (b)

5. (a)

6. (c)

7. (d)

8. (b)

9. (c)

10. (a)

11. (c)

12. (d)

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LEVEL 2 Objective Questions

13. (d)

14. (c)

15. (d)

16. (c)

17. (a)

18. (d)

19. (a)

20. (d)

21. (b)

22. (d)

23. (b)

LEVEL 3 Conventional Questions**Solution : 1**

$$C = 0.044 \text{ N/mm}^2, \phi = 26.56^\circ$$

Solution : 2

- (i) 31°
- (ii) $\sigma_1 = 411.82 \text{ kPa}, \sigma_3 = 131.82 \text{ kPa}$
- (iii) σ_1 makes an angle 60.5° to horizontal

Solution : 3

$$C' = 0, \phi' = 22^\circ, \phi_u = 15.8^\circ, \sigma_1/s_3 = 1.75, \frac{\sigma_1'}{\sigma_3'} = 2.2, A = 0.5$$

Solution : 4

- (i) 32.242°
- (ii) $\sigma_{1f} = 139.33 \text{ kPa}, \sigma_{3f} = 42.39 \text{ kPa}$
- (iii) $0^\circ, 61.12^\circ, 151^\circ, 14.12^\circ$

Solution : 5

$$C = 24.33 \text{ kPa}, \phi = 15.5^\circ, C' = 3.58 \text{ kPa}, \phi' = 27.7^\circ$$

Solution : 6

$$C = 61.984 \text{ kPa}, \phi = 20.137^\circ, C' = 28.23 \text{ kPa}, \phi' = 29.23^\circ$$

Solution : 7

$$137.62 \text{ kPa}$$

Solution : 8

$$\phi = 23.58^\circ, \phi_c = 87.28 \text{ kPa}, \sigma_1 = 966.7 \text{ kPa}, \Delta\sigma_d = 666.7 \text{ kPa}$$



9

Retaining Wall & Earth Pressure

LEVEL 1 Objective Questions

1. (c)

2. (b)

3. (b)

4. (c)

5. (a)

6. (b)

7. (c)

8. (b)

9. (a)

10. (c)

11. (c)

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LEVEL 2 Objective Questions

12. (d)

13. (a)

14. (b)

15. (d)

16. (a)

LEVEL 3 Conventional Questions
Solution : 1

9.46 m

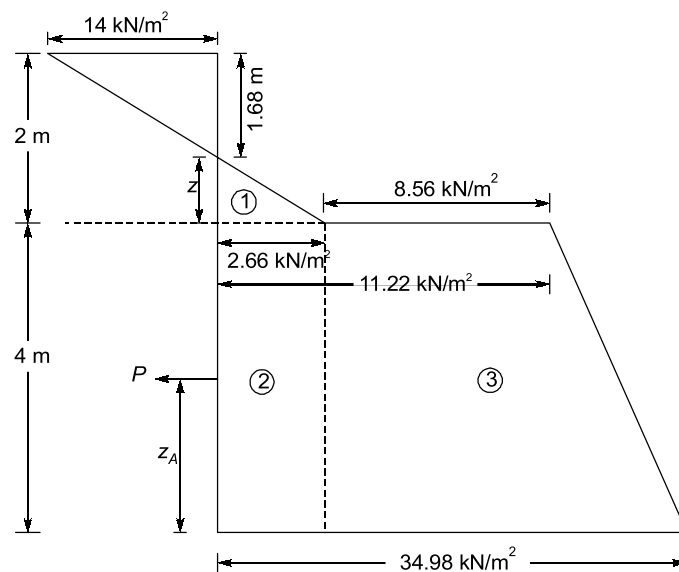
Solution : 2

637.8 kN, 3.62 m

Change of application of force = -0.38 m.

Solution : 3

2.16 m

Solution : 4**Solution : 5**44.53 kN/m²

(i) If tension cracks are developed = 0.99 m

(ii) If tension cracks are not developed = 0.147 m

Solution : 6

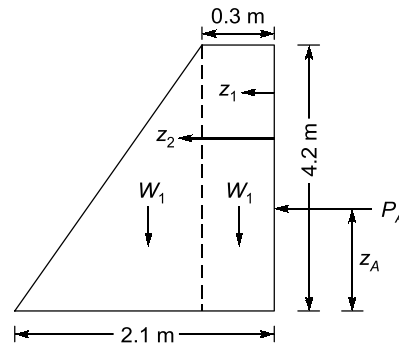
1.063 m

Solution : 7

$$k_a = \frac{1 - \sin 30^\circ}{1 + \sin 30^\circ} = \frac{1}{3}$$

$$P_A = \frac{1}{2} k_a \gamma H^2 = \frac{1}{2} \times \frac{1}{3} \times 15 \times 4.2^2 = 44.1 \text{ kN/m}$$

$$z_A = \frac{4.2}{3} = 1.4 \text{ m from base}$$



$$W_1 = 0.3 \times 4.2 \times 24 = 30.24 \text{ kN/m}$$

$$W_2 = \frac{1}{2} \times 4.2 \times 1.8 \times 24 = 90.72 \text{ kN/m}$$

$$z_1 = \frac{0.3}{2} = 0.15 \text{ m} \quad (\text{from vertical face})$$

$$z_2 = 0.3 + \frac{(2.1 - 0.3)}{3} = 0.9 \text{ m}$$

$$R_v = W_1 + W_2 = 120.96 \text{ kN/m}$$

$$\bar{x} = \frac{\Sigma M}{R_v}$$

$$\bar{x} = \frac{P_A z_A + W_1 z_1 + W_2 z_2}{R_v}$$

$$= \frac{(44.1 \times 1.4) + (30.24 \times 0.15) + (90.72 \times 0.9)}{120.96} = 1.22 \text{ m}$$

$$e = \bar{x} - \frac{b}{2} = 1.22 - \frac{2.1}{2} = 0.17 \text{ m}$$

$$\frac{b}{6} = 0.35 \text{ m}$$

Therefore,

$$e < \frac{b}{6}$$

∴ Resultant is within the middle third

$$f = \frac{R_v}{b} \left(1 \pm \frac{6e}{b} \right) = \frac{120.96}{2.1} \left(1 \pm \frac{6 \times 0.17}{2.1} \right) = 57.6(1 \pm 0.49)$$

$$f_1 = 57.6(1 + 0.49) = 85.82 \text{ kN/m}^2$$

$$f_2 = 57.6(1 - 0.49) = 29.38 \text{ kN/m}^2$$

$$P_A = 44.1 \text{ kN/m} \text{ and it comes under } f_1 \text{ and } f_2$$

Since,

Therefore no tension is developed.

Assuming coefficient of friction = 0.7

$$\text{FOS against sliding} = \frac{\mu \times R_V}{P_A} = \frac{0.7 \times 120.96}{44.1} = 1.92 > 1.5$$

Hence the wall is safe against sliding.

Solution : 8

33.172 kN/m

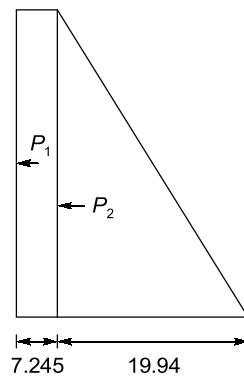
Solution : 9

$$\phi' = 41^\circ, K_A = \frac{1 - \sin 41^\circ}{1 + \sin 41^\circ} = 0.2077$$

For a cantilever retaining wall, the active pressure is calculated on the vertical plane passing through the heel of the wall. Since no shear stresses act on this plane, Rankine's theory can be used without introducing any error or approximation

$$\begin{aligned} p_A &= K_A p_v = K_A (\gamma z + q) \\ \text{At } z &= 6 \text{ m,} \\ p_A &= 0.2077 \times 35 + 0.2077 \times 16 \times 6 \\ &= (7.245 + 19.94) \text{ kN/m}^2 \end{aligned}$$

The active pressure distribution is shown in figure (b)



To determine the distance \bar{x} of the base reaction from the heel H, the moments of the forces about the heel are taken. Consider 1 m length of the wall.

Force (kN)	Moment arm (m)	Moment kNm
1. $P_1 = 7.245 \times 6 = 43.47$	3	130.41
2. $P_2 = \frac{1}{2} \times 19.94 \times 6 = 59.82$	2	119.64
3. Horizontal component $R_H = 43.47 + 59.82 = 103.29$		
4. Weight of stem = $5.50 \times 0.4 \times 24 = 52.8$	2.2	116.16
5. Weight of base = $3.50 \times 0.5 \times 24 = 42.0$	1.75	73.50
6. Weight of backfill = $5.50 \times 2.0 \times 16 = 176.0$	1.0	176.00
7. Surcharge load = $2.0 \times 35 = 70.0$	1.0	70.00
8. Vertical component $R_V = 340.8 (3 + 4 + 5 + 6)$		$\Sigma M = 685.71$

$$\bar{x} = \frac{\Sigma M}{R_V}$$

$$R_v \bar{x} = 685.71$$

$$\bar{x} = \frac{685.71}{340.8} = 2.01 \text{ m}$$

Hence, the resultant acts within the middle-third of the base.
Eccentricity of the resultant (base reaction),

$$e = \bar{x} - \frac{B}{2} = 2.01 - 1.75 = 0.26 \text{ m}$$

The maximum and minimum base pressure are given by:

$$q_{\max} = \frac{R_v}{B} \left(1 + \frac{6e}{B} \right) = \frac{340.8}{3.5} \left(1 + \frac{6 \times 0.26}{3.5} \right) = 140.76 \text{ kN/m}^2$$

and

$$q_{\min} = \frac{R_v}{B} \left(1 - \frac{6e}{B} \right) = \frac{340.8}{3.5} \left(1 - \frac{6 \times 0.26}{3.5} \right) = 54 \text{ kN/m}^2$$

q_{\max} is less than the safe bearing capacity of the soil and q_{\min} is positive. Hence OK

$$\text{Factory of safety, F against sliding} = \frac{R_v \tan \delta'}{R_H} = \frac{340.8 \times \tan \left(\frac{2}{3} \times 41 \right)}{103.29} = 1.7 > 1.5$$

Hence OK.



LEVEL 1 Objective Questions

1. (a)

2. (c)

3. (c)

4. (c)

5. (c)

LEVEL 2 Objective Questions

6. (d)

7. (a)

8. (d)

9. (a)

10. (c)

11. (b)

LEVEL 3 Conventional Questions**Solution : 1**

(i) 4.47

(ii) 1.37

Solution : 2 57° **Solution : 3**

2.15

 $f_{C \min} = 2.07$ **Solution : 4**

1.67, 0.697

Solution : 5

(a) 1.36

(b) 1.26

 $F_s = 1.31, F_\phi = 1.84, F_c = 1.95$

■■■■

LEVEL 1 Objective Questions

1. (b)

2. (c)

3. (d)

4. (a)

5. (d)

6. (c)

7. (a)

8. (a)

9. (d)

10. (a)

LEVEL 2 Objective Questions

11. (d)

12. (b)

13. (a)

14. (c)

15. (b)

16. (b)

17. (b)

18. (c)

19. (c)

20. (c)

LEVEL 3 Conventional Questions**Solution : 1**

374.796 kN

Solution : 2

2.2 m

Solution : 3

322.78 kN/m

Solution : 4(i) 106.63 kN/m²

(ii) 55.71 mm

Solution : 5(i) 127.035 kN/m²(ii) 121.62 kN/m²**Solution : 6**(i) 810 kN/m²(ii) 794.4 kN/m²**Solution : 7**

1.65 m × 1.65 m

■■■■

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LEVEL 1 Objective Questions

1. (c)
2. (b)
3. (c)
4. (b)
5. (d)
6. (d)
7. (d)
8. (b)

LEVEL 2 Objective Questions

9. (d)
10. (b)
11. (b)

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12. (c)

13. (c)

14. (b)

15. (b)

16. (a)

17. (d)

18. (d)

19. (d)

LEVEL 3 Conventional Questions**Solution : 1**

$$5386.08 \text{ kN}, \quad \eta_g = 48.4\%$$

Solution : 2

$$559.14 \text{ kN}$$

Solution : 3

$$5218.97 \text{ kN}$$

■■■■

13

Soil Exploration and Dynamics

LEVEL 1 Objective Questions

1. (a)
2. (a)
3. (b)
4. (c)
5. (b)

LEVEL 2 Objective Questions

6. (c)
7. (b)
8. (a)

LEVEL 3 Conventional Questions

Solution : 1

$$C_i = 2.85\%, \quad C_o = 1.33\%, \quad A_R = 17.87\%$$

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