Answers to Selected Problems

Chapter 2

2.1

At GL-2m, σ_v=23.6 $\mathrm{kN/m^2}$, u_w=0, σ'_v=23.6 $\mathrm{kN/m^2}$

At GL-21m, σ_v=359.9 $\mathrm{kN/m^2}$, u_w=186.4 $\mathrm{kN/m^2}$, σ'_v=173.5 $\mathrm{kN/m^2}$

At GL-40m, σ_v==696.2 $\mathrm{kN/m^2}$, u_w=372.8 $\mathrm{kN/m^2}$, σ'_v=323.4 $\mathrm{kN/m^2}$

2.3

(1) Short term

At GL-5.0m, σ_v=66 $\mathrm{kN/m^2}$, u_w=0, σ'_v=66 $\mathrm{kN/m^2}$

At GL-27.5m, σ_v=529.5 $\mathrm{kN/m^2}$, u_w=220.7 $\mathrm{kN/m^2}$, σ'_v=308.8 $\mathrm{kN/m^2}$

At GL-50m, σ_v=993 $\mathrm{kN/m^2}$, u_w=441.5 $\mathrm{kN/m^2}$, σ'_v=551.5 $\mathrm{kN/m^2}$

(2) Long term:

At GL-5.0m, σ_v=66 $\mathrm{kN/m^2}$, u_w=0, σ'_v=66 $\mathrm{kN/m^2}$

At GL-27.5m, σ_v=529.5 $\mathrm{kN/m^2}$, u_w=196.2 $\mathrm{kN/m^2}$, σ'_v=333.3 $\mathrm{kN/m^2}$

At GL-50m, σ_v=993 $\mathrm{kN/m^2}$, u_w=392.4 $\mathrm{kN/m^2}$, σ'_v=600.6 $\mathrm{kN/m^2}$

2.5

The undrained shear strength (i.e., shear stress on the failure surface) =32.0 $\mathrm{kN/m^2}$

2.9

NC clay, $c' = 0$ (1) 196.2 $\mathrm{kN/m^2}$ (2) $45+\phi'/2$=60 degree

2.11

$\sigma_1 = 164.41\ \mathrm{kN/m^2}$

(1) $s_u = (\sigma_1 - \sigma_3)/2 = 33.16\ \mathrm{kN/m^2}$

(2) 58.23 $\mathrm{kN/m^2}$

(3) 45+27/2=58.5 degree

2.13

Effective confining pressure after sampling equals $59.76\,\mathrm{kN/m^2}$, the corresponding water content equals 27%，

(1) The major effective principal stress=66 $\mathrm{kN/m^2}$, the minor effective principal stress=352 $\mathrm{kN/m^2}$

(2) Excess porewater pressure at failure=98.1-32=66.1 $\mathrm{kN/m^2}$

2.15

Based on Table 2.12, $s_u(TC)/s_u(DSS) \approx 1.64$, Therefore, s_u/σ'_v =0.28/1.64=0.17 can be used for design.

2.17

The average undrained shear strength used for design: s_u/σ'_v =(0.32+0.32)/2=0.27

2.19

$s_{u,avg}$ =50 $\mathrm{kN/m^2}$, $q_u = cN_c = 50 \times 5.7 = 285\ \mathrm{kN/m^2}$

Chapter 4

4.1

Total lateral force =513.1 kN/m, z =2.87 m (from foundation bottom)

4.3

(a) P_a =1721.2 kN/m, z=8.67 m (from the wall bottom) (b) $P_{a,h}$=1306.4kN/m, z= 8.67 m (c) $P_{a,h}$=1387.1 kN/m, z=8.67 m

4.5

(a) Rankine, $P_{p,h} = 5{,}385$kN/m

(b) Coulomb, $P_{p,h} = 23{,}895$kN/m

(c) Caquot-Kerisel, $P_{p,h} = 11{,}853$kN/m

z=4.33 m (from the wall bottom)

4.7

Depth of tension crack=4.0 m, consider the porewater pressure in the tension crack, when z=0m, $s_u = 100\ \ \mathrm{kN/m^2}$; z=4m(-)，$s_u = 100\ \ \mathrm{kN/m^2}$, z=4m(+)，$s_u = 0.3\,\sigma'_v$

=9.83 kN/m^2; z=40m, $s_u = 0.3\sigma_v'$ =98.28 kN/m^2

(a) z=0m, σ_a = -200 kN/m^2, $\sigma_w = 0$; z=4m(-), σ_a = -128 kN/m^2 , $\sigma_w = 39.24$ kN/m^2; z=4m(+), σ_a = 52.34 kN/m^2; z=40m, σ_a = 523.44 kN/m^2; P_a = 10,443 kN/m, z=13.3 m (from the wall bottom) (b) z=0m, σ_a = -245 kN/m^2, $\sigma_w = 0$; z=4m(-); σ_a = -173 kN/m^2, $\sigma_w = 39.24$ kN/m^2; z=4m(+), σ_a = 47.92 kN/m^2; z=40m, σ_a = 479.21 kN/m^2; P_a =9,567 kN/m, z=12.3 m

4.9

(a) P_p =6480 kN/m, z=7.8 m (from the wall bottom) (b) P_p =7114 kN/m, z= 7.8 m

4.11

Assume the porewater pressure is linearly distributed between GL-4.0 m and GL - 19.0 m (a) P_a =2,389 kN/m, z=5.3 m (from the wall bottom) (b) P_p =1,167 kN/m. z=3.7 m

4.13

Lateral force due to line load=293.6 kN/m; Active pressure resultant= 2852 kN/m (water pressure in the tension crack is considered)

4.15

Lateral force due to line load =566 kN/m, location of line of action =6.0 m (from the wall bottom) ; Active pressure resultant =7845 kN/m (water pressure in the tension crack is considered), location of line of action =9.4 m

4.17

K_a =0.27, K_p =9.7 (a) water pressure at the wall bottom= 264.87 kN/m^2, P_a =4,618 kN/m, z=9.25 m (from the wall bottom), P_p =10,316 kN, z=4.99 m

(b) water pressure at the wall bottom=185.09 kN/m^2, P_a =4,832.8kN/m, z=9.3 m , P_p =8,134.7 kN, z =5.1 m

(c) water pressure at the wall bottom=198.6 kN/m^2, P_a =3,920.8kN/m, z =9.3 m (from the wall bottom) , P_p=6470.3 kN, z =5.1 m

Chapter 5

5.1

$K_a = K_{a,h}$=0.33, $K_p = K_{p,h}$=3.0, $H_{p,cal}$=2.72m, $H_{p,d}$=2.72*1.5=4.08 m

5.3

$\tan\phi'_m = \tan\phi' / FS_s$ $\phi'_m = 21.2^\circ$ $K_a = K_{a,h} = 0.47$ $K_p = K_{p,h} = 2.2$, $H_{p,d} = 5.1$m

5.5

Load factor method, Hp=1.30 m; Strength factor method, Hp=2.84 m; Slip circle method, Hp=1.99 m

5.7

Slip circle method:

B=20 m and 100 m,

When $H_p = 15$ m, $F_b = 1.44$; When $H_p = 20$ m, $F_b = 1.46$

5.9

Slip circle method; H_p = 8.32 m; Load factor method, H_p = 7.74 m; Strength factor method; H_p = 10.16 m

5.11

Fb is unrelated to Hp

B=20 m, Fb=(5.7*77.74*14.14)/(4836-34.3*19)=1.49

B=100m, Fb=(5.7*151.9*70.7)/(342*70.7-34.3*19)=2.6

Fb is unrelated to Hp

5.12

Nc=6.8. Take Su,avg between GL-(19-14.14) m and GL-(19+14.14) m, Su,avg=59.21 kPa, F_b=1.18. Take Su,avg between GL-19 m and GL-(19+14.14) m, Su,avg=77.74 kPa, F_b=1.55

5.13

B=50 m is a critical section

(1) Terzaghi method: Fb=2.45 (2) Bjerrum and Eide's method: Fb=2.30

5.15

Terzaghi's method: $s_{u1,avg}$ =27 $\mathrm{kN/m^2}$; $s_{u2,avg}$ =75 $\mathrm{kN/m^2}$, F_b=1.37

Bjerrum and Eide's method: $s_{u,avg}$ =55.7 kPa, N_c =6.5, F_b=1.11

5.17

$K_{a,h}=0.23$, $K_{p,h}$=7.35; d_0=4.57 m, $H_p=1.2d_0$=5.48 m

S=713.15 kN/m，R=626.87 kN/m; S > R; The required depth H_p=5.48 m

5.19

$K_{a,h}=0.211$, $K_{p,h}=7.346$, $H_p=3.79\,\mathrm{m}$, $H_{p,d}=1.5\times3.79=5.69\,\mathrm{m}$

5.21

$K_a=0.283$, $K_p=0.354$, $H_p=0.99\,\mathrm{m}$, $H_{p,d}=1.5\times0.99=1.5\,\mathrm{m}$

5.23

H_p=9.4 m, $H_{p,d}$=(1.5)(9.4)=14.1 m

Chapter 6

6.5

Excavation in soft clay and high strut stiffness, concave settlement profile. Assume $\delta_{hm}=0.5\%H_e$, $\delta_{vm}=0.75\delta_{hm}$, the maximum lateral movement, maximum settlement and primary settlement influence zone are

When GL-5.0 m, $\delta_{hm}=2.5$ cm, $\delta_{vm}=1.88$ cm, $PIZ=32$ m
When GL-8.55 m, $\delta_{hm}=3.4$ cm, $\delta_{vm}=2.40$ cm, $PIZ=32$ m
When GL-12.4 m, $\delta_{hm}=5.0$ cm, $\delta_{vm}=3.5$ cm, $PIZ=32$ m
When GL-15.4 m, $\delta_{hm}=7.7$ cm, $\delta_{vm}=5.8$ cm, $PIZ=32$ m
When GL-16.9 m, $\delta_{hm}=8.5$ cm, $\delta_{vm}=6.4$ cm, $PIZ=32$ m
When GL-20.0 m, $\delta_{hm}=10$ cm, $\delta_{vm}=7.5$ cm，$PIZ=32$ m

6.7

Ou and Hsieh's method is more reasonable.

6.9

Ou and Hsieh's method: about 1/333

Clough and O'Rourke's method: 0

Bowles's method: 1/830

6.21

$s_{u,avg}$=21.5 kN / m^2, $\gamma H_e / s_{u,avg}$=11.47>4.0

$s_{u,b}$=82.6 kN / m^2, $N_b = \gamma H_e / s_{u,b}$=2.99<4.0, take *m*=1

$P_a = \gamma H_e - 4s_u$=160.6 kN / m^2; $P_a = 0.3\gamma H_e$=74 kN / m^2; $P_a =$ =160.6 kN / m^2

Strut load at the 1st level of struts=125 *kN/m*
Strut load at the 2nd level of struts =405 *kN/m*
Strut load at the 3rd level of struts =578 *kN/m*
Strut load at the 4th level of struts =578 *kN/m*

6.28

$K_{a,h} = 0.24$, $K_{p,h} = 7.3$, Assume F_p=1.0; $F_p = M_r / M_d$, d_0=3.5 m

The bending moment and shear of the wall at various depth is

Depth (m)	Shear (kN/m)	Bending moment (kN-m/m)
0	0	0
1	-6.2	2
2	-25	17
3	-56	56
4	-87	130
5	-43	202
6	-88	187
7	305	0

Chapter 9
9.5
Theis' method: s=1.48 m; Jacob's method: s=1.47 m
9.7
Theis' method: s=6.99 m; Jacob's method: s=6.96 m
9.9

Total *Q*=1.524 m^3 / min . Assume r_w=0.1 m, Q_w=0.64 m^3 / min ,

$$Q_{\max} = 2\pi r_w D \frac{\sqrt{k}}{15} = 2 \times \pi \times 0.1 \times 40 \times \frac{\sqrt{0.00005}}{15} = 0.71\,\mathrm{m}^3/\mathrm{min}$$

Number of wells=1.524/0.64=2.4, take 3 wells

Drawdown induced by each well =2.38 m. Drawdown induced by 4 wells =2.38*3=7.14 m < 7.5 m (NG), take four wells

9.11

Assume drawdown is much less than thickness of the aquifer, then Theis' or Jacob's formula can be used. s=0.20 m

9.13

$$s = \frac{Q}{4\pi T}(-0.5772 - \ln u) = 1.42\,\mathrm{m}$$

9.15

r_w=0.1 m, Q_w=1.77 $\mathrm{m}^3/\mathrm{min}$, 14 wells

9.17

$R_w = (a+b)/\pi = 38.2\,\mathrm{m}$, the required total $Q_{tot} = 3.291\,\mathrm{m}^3/\mathrm{min}$

$r_w = 0.1\,\mathrm{m}$, $Q_w = 1.14\,\mathrm{m}^3/\mathrm{min}$, $n = Q_{tot}/Q_w = 3.291/1.14 = 2.9$, take 3 wells

9.19

$S = 3.47 \times 10^{-4}$