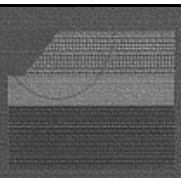
LESSON 12

Solutions to Student Exercises

SOILS AND FOUNDATIONS WORKSHOP



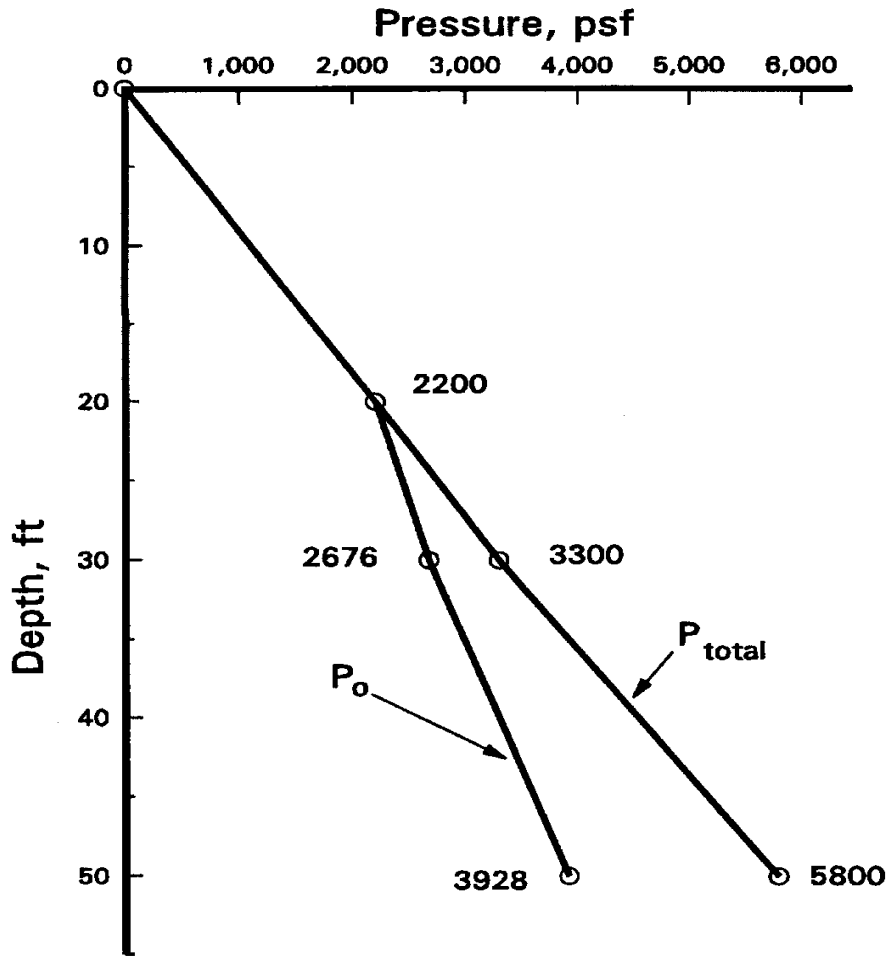
Solution to Exercise No. 1

Depth Feet	Δ Layer Thick, Feet	γ_t pcf	P_{total} psf	Pore Pressure psf	P_o * psf
20	20	110	2200	0	2200
30	10	110	1100+2200 = 3300	10 x 62.4 624	2676
50	20	125	2500+3300 = 5800	30 x 62.4 1872	3928

** P_o could also be computed using γ_b below water table.*

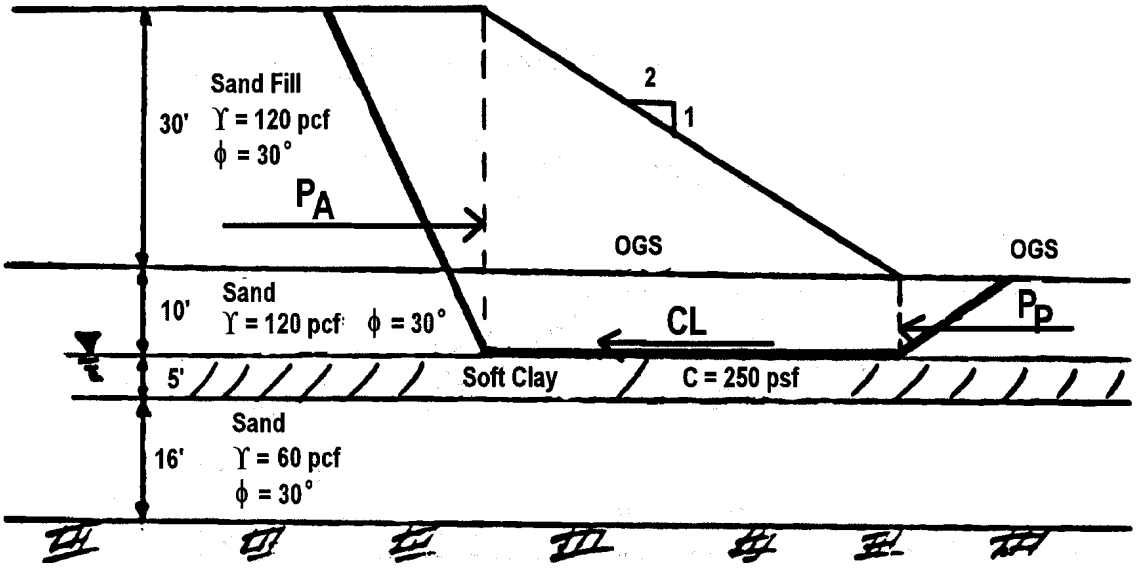
SOILS AND FOUNDATIONS WORKSHOP

Solution to Exercise No. 1 (Cont'd)



SOILS AND FOUNDATIONS WORKSHOP

STUDENT EXERCISE NO. 2 - SOLUTION



$$K_A = Tan^2(45° - \phi/2) = Tan^2(45° - 30°/2) = 0.33$$

$$K_P = Tan^2(45° - \phi/2) = Tan^2(45° + 30°/2) = 3.0$$

$$(per\ ft.)P_A = \tfrac{1}{2}\gamma H^2 K_A = \tfrac{1}{2}(0.120KCF)(40Ft)^2(0.33)(1Ft) = 32K \rightarrow$$

$$P_P = \tfrac{1}{2}\gamma H^2 K_P = \tfrac{1}{2}(0.120KCF)(10Ft)^2(3.0)(1Ft) = 18K \leftarrow$$

$$CL = (0.250KSF)(60Ft)(1Ft) = 15K \leftarrow$$

Summing forces horizontally:

$$F.S. = \frac{\Sigma\ Resisting\ Forces}{\Sigma\ Driving\ Forces} = \frac{P_P + CL}{P_A} = \frac{18K + 15K}{32K}$$

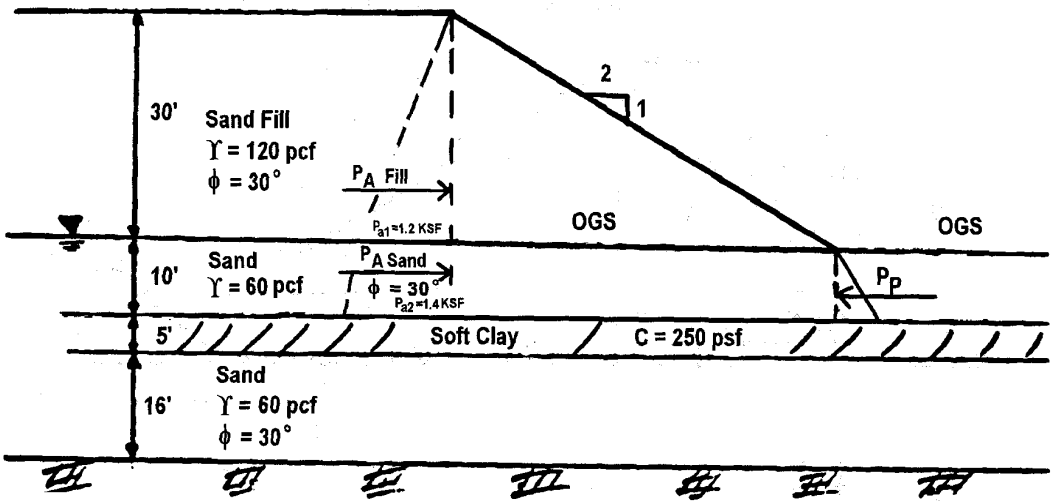
F.S. = 1.03 – TOO LOW!!

SOILS AND FOUNDATIONS WORKSHOP

STUDENT EXERCISE NO. 2 - SOLUTION

(2) EFFECT OF RISE IN WATER TABLE

Recompute the F.S. for problem 1 assuming that water table rises 10' to the original ground surface.



$$P_{a1} = \gamma_1 H_1 K_{A1} = (0.120KCF)(30')(0.33) = 1.2KSF\,(per\ foot)$$

$$P_{AFill} = (1.2KSF)(30')(1/2)(1') = 18K \rightarrow$$

$$P_{a2} = 1.2KSF + (0.060KCF)(10')(0.33) = 1.4KSF\,(per\ foot)$$

$$P_{ASand} = \frac{(1.2KSF + 1.4KSF)}{2}(10')(1') = 13K \rightarrow$$

$$P_{ATotal} = 18K + 13K = 31K \rightarrow$$

$$P_P = 1/2\,\gamma_b H^2 K_P\ 1/2\,(0.060)(10)^2(3) = 9K \leftarrow\!<< 18K\ Previous$$

$$CL = (0.250KSF)(60')(1') = 15K$$

$$F.S. = \frac{P_P + CL}{P_A} = \frac{9K + 15K}{31K} = 0.77$$

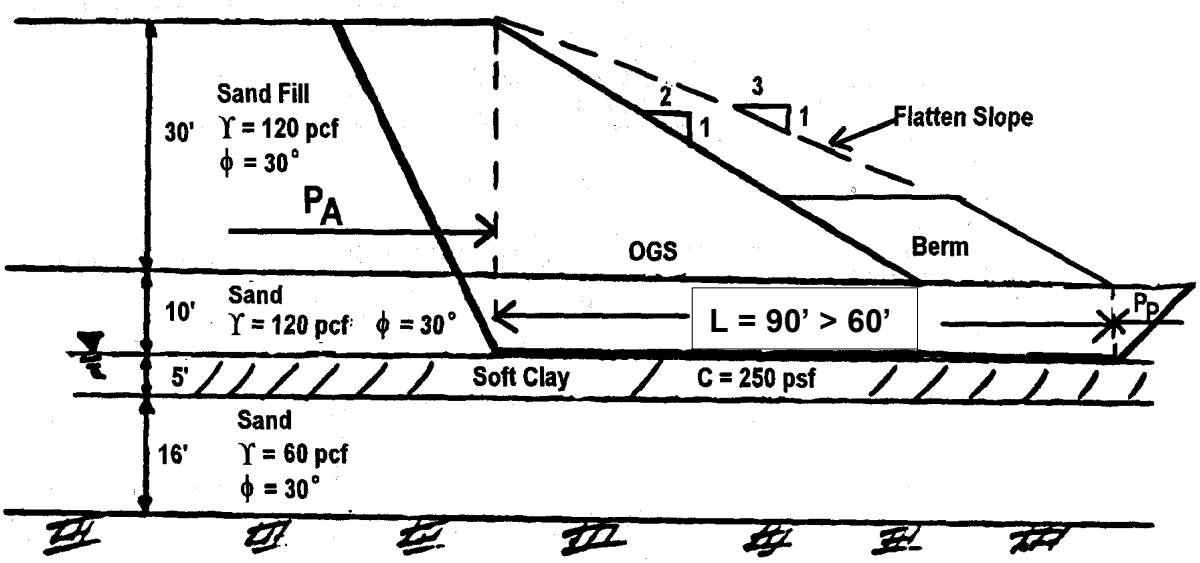
NOTE: 10' rise in water table lowers F.S. from 1.03 to 0.77

SOILS AND FOUNDATIONS WORKSHOP

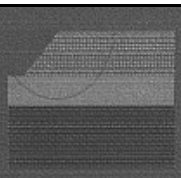
STUDENT EXERCISE – NO. 2 SOLUTION

(3) METHODS TO INCREASE F.S.

(a) Method – Flatten Slope or Place Berm Effect – Increase CL



SOILS AND FOUNDATIONS WORKSHOP



STUDENT EXERCISE – NO. 2 SOLUTION

METHODS TO INCREASE F.S.

(a) Method – Flatten Slope or Place Berm

EXAMPLE: ***Flatten Slope to 3:1***
or
Place 30' Wide Berm

(per ft) $CL = (0.250KSF)(90Ft)(1Ft) = 22.5K > 15K$

$$F.S. = \frac{P_P + CL}{P_A} = \frac{18K + 22.5K}{32K} = 1.27 > 1.03$$
ok

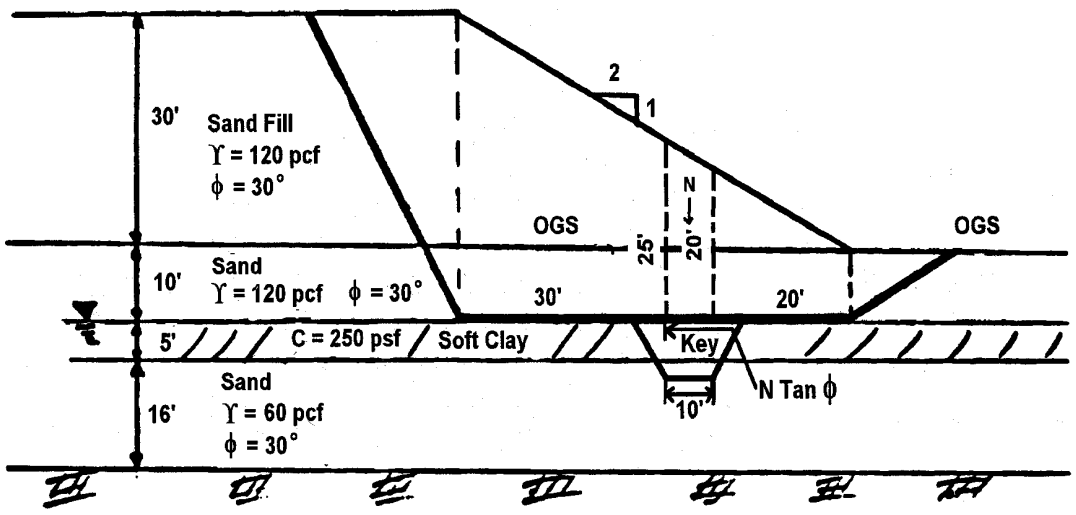
SOILS AND FOUNDATIONS WORKSHOP

STUDENT EXERCISE – NO. 2 SOLUTION

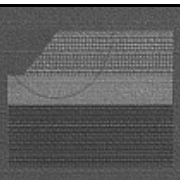
METHODS TO INCREASE F.S.

(b) Method – Excavate a portion of soft clay layer under fill slope and place sand shear key.

Effect - Adds N Tan ϕ to Resisting



SOILS AND FOUNDATIONS WORKSHOP



STUDENT EXERCISE – NO. 2 SOLUTION

METHODS TO INCREASE F.S.

(b) Method – Excavate a portion of soft clay layer under fill slope and place sand shear key.

EXAMPLE: Place 10' wide Shear Key at location shown above.

$$(\text{per ft})\ N = \frac{(20'+25')}{2}(10')(1')(.120KCF) = 27K$$

$$N\,Tan\phi = 27K(Tan30°) = 16K$$

$$CL = (50')(1')(.250KSF) = 12.5K$$

$$F.S. = \frac{P_P + CL + NTan\phi}{P_A} = \frac{18K + 12.5K + 16K}{32K} = 1.45 > 1.03$$

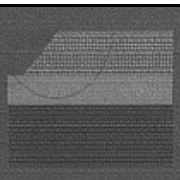
OK

SOILS AND FOUNDATIONS WORKSHOP

Solution to exercise No. 3

Depth	*N*	*Po (psf)*	*N′/N*	*N′*	*C′*
5	*6*	*550*	*1.90*	*11*	*48*
10	*10*	*1100*	*1.28*	*13*	*52*
15	*15*	*1650*	*0.98*	*15*	*58*
20	*17*	*2200*	*0.92*	*16*	*60*
25	*16*	*2438*	*0.88*	*14*	*57*

SOILS AND FOUNDATIONS WORKSHOP



SOLUTION TO EXERCISE NO. 4

1.Compute Primary Settlement

$$\Delta H = H\frac{C_C}{1+e_0}Log\frac{P_F}{P_0}$$

$$= 6\left(\frac{1.1}{1+2.10}\right)Log\frac{4400}{1500}$$

$$\Delta H = 1.0'$$

2. Compute Time for 90% Primary Settlement

$$t = \frac{TH_V^{\,2}}{C_V}$$

Double drainage as clay layer between two granular soils

$$H_V = \frac{6'}{2} = 3'$$

$$t_{90} = \frac{(0.848)(3)^2}{0.0175}$$

$$t_{90} = 436 \quad \text{Days or 15 Months}$$

Note: Time for any % of total settlement may be computed for this problem.

$$t = \frac{(3)^2}{0.0175}T = 515T$$

SOILS AND FOUNDATIONS WORKSHOP

SOLUTION TO EXERCISE No. 5

Footing $\frac{Length}{Width} = \frac{50}{10} = 5 > 9$

∴ Use Rectangular Formula

$\frac{Water\ Level}{Width} = \frac{30 - 4}{10} = 2.6$ **= 2.6 > 1.5 Footing Widths below Footing Base**

∴ No Water Effect

$$q_{ult} = \gamma D N_q + 0.4 \gamma B N_\gamma$$

= (115)(4)(37) + (0.4)(115)(10)(42)

= 17,020 + 19,320

= 36,340 PSF

$$Q_{all} = \frac{36,340}{3} = 12,113\ psf$$

STUDENT EXERCISE NO. 6 SOLUTION
Footing Settlement

Sand Layer

$$\Delta H_{sand} = H \frac{1}{C'} \text{Log} \frac{P_F}{P_o}$$

5' – 15'

$$\Delta H_s = 10 \frac{1}{132} \text{Log} \frac{3780}{1000} (12) = 0.5"$$

15' – 25'

$$\Delta H_s = 10 \frac{1}{132} \text{Log} \frac{3460}{2000} (12) = 0.2"$$

Clay Layer

$$\Delta H_{clay} = H \frac{C_C}{1 + e_o} \text{Log} \frac{P_F}{P_o}$$

25' – 35'

$$\Delta H_c = 10 \frac{0.25}{1 + 0.90} \text{Log} \frac{3630}{2810} (12) = 1.8"$$

35' – 45'

$$\Delta H_c = 10 \frac{0.25}{1 + 0.90} \text{Log} \frac{4000}{3420} (12) = 1.1"$$

Total Footing Settlement (inches) = 3.6"

Student Exercise No. 7 SOLUTION

SKIN FRICTION

Clay Layer 2′- 12′

$q_s = C_a C_d D$

$C_a = 950$ psf
$C_d = 4′$

$q_s = (950)(4)10$
$q_s = 19$ tons

Sand Layer 12′- 42′

$q_s = K_\delta (C_F) P_d \sin \delta C_d D$

$V = 1$ Cu.ft./ft.
$\delta/\phi = 0.77$
$\delta = (0.77)(30) = 23.1°$
$K_\delta = 1.15$
$C_F = 0.90$
$P_{0\ avg\ 27′} = 2230$

Student Exercise No. 7 SOLUTION (cont'd)

$q_s = (1.15)(0.90)(2230)(\text{Sin } 23.1)(4)(30)$

$\underline{q_s = 54.3 \text{ tons}}$

END BEARING

a. $Q_p = A_P \alpha P_d N'_q$
$= (1)(0.5)(3000)(30)$
$Q_p = 22.5 \text{ tons}$

b. $Q_{lim} = (A_P)(q_{lim})$
$= (1)(6.5)$
$Q_{lim} = 6.5 \text{ tons}$

$\therefore \underline{Q_p = 6.5 \text{ tons}}$

$Q_{TOTAL} = 19 + 54.3 + 6.5$
$\underline{Q_T = 79.8 \text{ tons}}$

SOLUTION TO EXERCISE NO. 8

		OK	N.G.
Pile 1: 0.250″ wall thickness (9.77 in^2)			
Maximum Stress	42	☐	☒
Blow Count	112	☒	☐
Pile 2: 0.312″ wall thickness (12.19 in^2)			
Maximum Stress	36	☐	☒
Blow Count	73	☒	☐
Pile 3: 0.375″ wall thickness (14.60 in^2)			
Maximum Stress	30.4	☒	☐
Blow Count	59	☒	☐

Select Pile 3, 0.375″ Wall Thickness, Which meets both the Blow Count and Stress Criteria.

SOLUTION TO EXERCISE NO. 9

Acceptable Driving Stresses:
Maximum Compressive Stress = (0.85 × 5,000 psi) – 700 psi = **3,550 psi**
Maximum Tensile Stress = (3 × √5,000 psi) + 700 psi = **912 psi**

Acceptable Blow Count Range: **30-144** blows/foot

Wave Equation Results: 300 Kips Driving Resistance

Max (compressive) stress = 1.9 ksi = 1,900 psi < 3,550 psi okay
Min (tensile) stress = -0.28 ksi = -280 psi < -912 psi okay
Blow Count = 47 bpf between 30 & 144 bpf okay

HAMMER APPROVED ✓

SOILS AND FOUNDATIONS WORKSHOP

SOLUTION TO EXERCISE NO. 10

Use $\delta = \frac{PL}{AE}$ to find δ @ P = 400 tons (800 kips)

$$\delta = \frac{800{,}000 \text{ lbs} \times 35 \text{ ft} \times 12 \text{ in/ft.}}{196 \text{ in}^2 \times 4{,}000{,}000 \text{ lbs/in}^2} = 0.43 \text{ in}$$

X = 0.15 in + 14/120 = 0.27 in