PROBLEMS AND SOLUTIONS

Problem 4.1. What is the shear strength in terms of effective stress on a plane within a saturated soil mass at a point where the total normal stress is 295 kN/m² and the pore water pressure 120 kN/m² ? The effective stress parameters for the soil are c' = 12 kN/m² and $\phi' = 30^0$.

Solution 4.1:

$\sigma_n = 295\ kN/m^2$ $\quad u = 120 kN/m^2$ $\quad c' = 12\ kN/m^2$ $\quad \phi' = 30^0$

$\tau' = c' + \sigma'_n \tan \phi'$

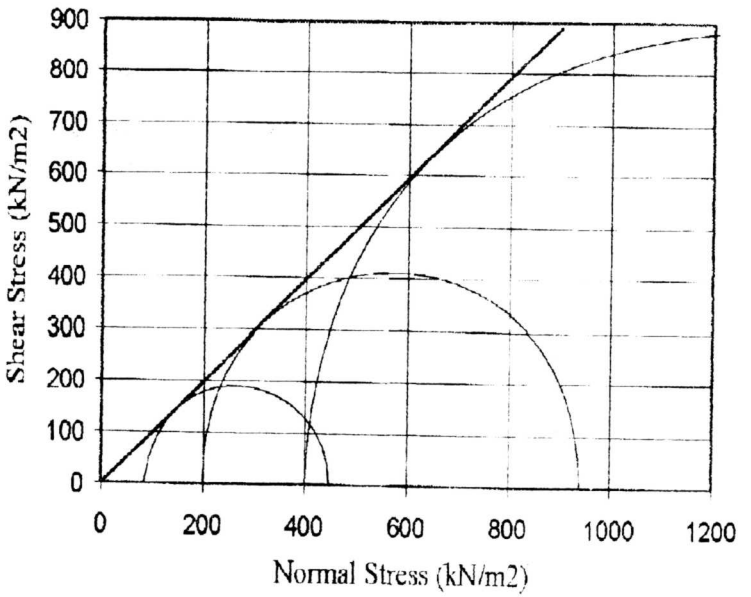
$\tau' = 12 + (295 - 120) \tan 30^0 = \mathbf{113\ kN/m^2}$

Problem 4.2. A series of drained triaxial tests was carried out on specimens of a sand prepared at the same porosity and the following results were obtained at failure. Determine the value of the angle of shearing resistance ϕ'.

All-round pressure (kN/m²)	100	200	400	800
Principal stress difference (kN/m²)	452	908	1810	3624

Solution 4.2:

σ_3	(kN/m²)	100	200	400	800
σ_1	(kN/m²)	552	1108	2210	4424



$\phi' = 44^0$

Problem 4.10. The data obtained from a direct shear test are as follows;

	Load Ring Reading		
Displacement	Fn = 24.5 kg	Fn = 54.5 kg	Fn = 74.5 kg
1.00	0	0	0
1.15	11.5	37.5	51.0
1.30	14.0	41.2	71.0
1.60	39.5	50.3	86.2
2.20	67.0	62.3	90.2
2.80	81.2	77.6	134.5
3.40	93.0	83.6	149.5
4.00	105.6	114.0	188.0
4.60	115.6	135.0	222.3
5.20	**119.4**	162.4	247.5
5.80	115.4	172.3	**250.5**
6.40	111.3	**185.0**	224.0
7.00	105.0	160.0	212.3
7.60	95.2	147.3	203.2
8.20	88.6	142.3	194.0
8.80	85.1	135.0	188.2
9.40	84.0	134.5	184.9
10.00	**84.0**	**134.5**	**184.9**

Area of specimen = 36 cm^2

Use the following expression for data conversion:

$$Y = 4.67 * X$$

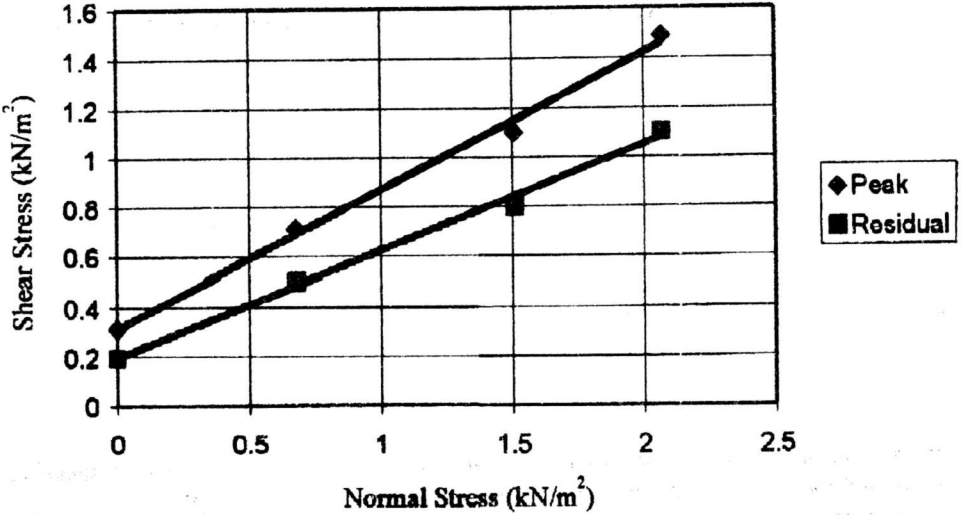
Where;

Y = load ring reading
X = Shear load in kg

Calculate peak and residual shear strength parameters of this soil by using of the given data.

Solution 4.10:

Normal stress (kg/cm^2)	0.68	1.51	2.07
Peak shear stress (kg/cm^2)	0.71	1.1	1.49
Residual shear stress (kg/cm^2)	0.5	0.8	1.1

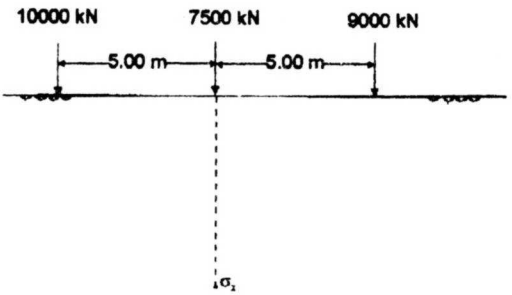


C_p =0.3131 kg/cm^2
$\phi_p = 29^0$

C_r=0.1947 kg/cm^2
$\phi_r = 23^0$

Problem 5.2. Three point loads, 10000 kN, 7500 kN and 9000 kN, act in line 5 m apart near the surface of a soil mass. Calculate the vertical stress at a depth of 4 m vertically below the center (7500 kN) load.

Solution 5.2:



$$\sigma_z = \frac{3Q}{2\pi z^2}\left(\frac{1}{1+(r/z)^2}\right)^{5/2}$$

σ_{z1} caused by 10000 kN is;

Q = 10000 kN r = 5 m z = 4 m

$\sigma_{z1} = 28.4$ kN/m^2

σ_{z2} caused by 7500 kN is;

Q = 7500 kN r = 0 m z = 4 m

$\sigma_{z2} = 223.8$ kN/m^2

σ_{z3} caused by 9000 kN is;

Q = 9000 kN r = 5 m z = 4 m

$\sigma_{z3} = 25.5$ kN/m^2

$\sigma_z = \sigma_{z1} + \sigma_{z2} + \sigma_{z3}$

$\sigma_z = 28.4 + 223.8 + 25.5$

$\sigma_z = 277.7$ kN/m^2

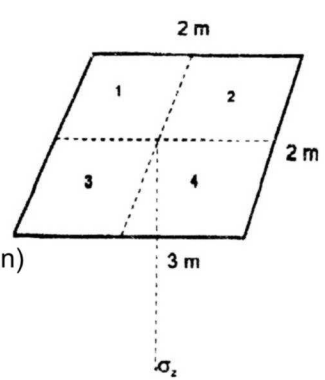
Problem 5.3. Determine the vertical stress at a depth of 3 m below the center of a shallow foundation 2m x 2m carrying a uniform pressure of 250 kN/m^2.

Solution 5.3:

P = 250 kN/m^2 z = 3 m

m x z = 2 meters m = 1/3

n x z = 2 meters n = 1/3



$I_r = 0.045$ (9. Konu Sayfa 8 deki Abaktan)

$\sigma_z = \sigma_{z1} + \sigma_{z2} + \sigma_{z3} + \sigma_{z4}$

$\sigma_{z1} = \sigma_{z2} = \sigma_{z3} = \sigma_{z4}$

$\sigma_{z1} = P \times I_r$

$\sigma_{z1} = 250 \times 0.045 = 11.25 \text{ kN/m}^2 \quad \Rightarrow \quad \sigma_z = 4\sigma_{z1} = \mathbf{45 \text{ kN/m}^2}$

Problem 6.2. A load of 425 kN/m is carried on strip footing 2 m. wide at a depth of 1 m in a stiff clay saturated unit weight 21 kN/m^3, the water table being at ground level. Determine the factor of safety with respect to shear failure (a) when c_u=105 kN/m^2 and ϕ_u=0°, (b) when c'=10 kN/m^2 and ϕ'=28°.

Solution 6.2.

Load= 425 kN/m
B=2 m.
D=1 m.
γ=21 kN/m^3

a) if c_u=105 kN/m^2 ϕ=0° F=?

for strip footing B/L=0 D/B=0.5⇒N_c=5.75 from Fig. 6.1.

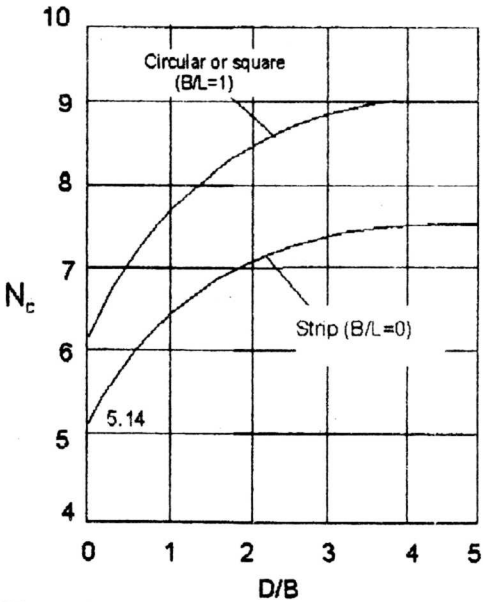


Figure 6.1. Skempton's value of N_c for ϕ_u=0°

$q_{nf}=c_u x N_c=105x5.75=603.75$ kN/m^3

q_n=load/area =425/2=212.5 kN/m^2

$$F=\frac{q_{nf}}{q_n}=\frac{603.75}{212.5}=2.8$$

b) if $c'=10$ kN/m^2 $\phi=28° \Rightarrow N\gamma=16$, $N_q=17$, $N_c=27$ were found from Figure 6.2.

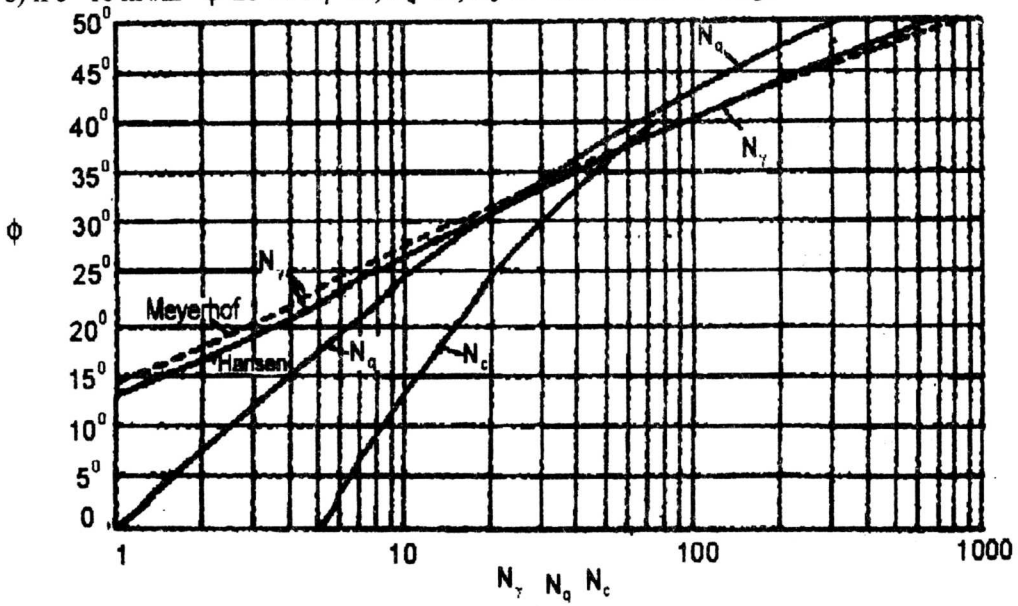


Figure 6.2. Bearing capacity factors for shallow foundations

$q_f=0.5x\gamma' xN_\gamma+\gamma' xDxN_q+cxN_c$
$q_f=(0.5x(21-9.8)x2x16)+((21-9.8)x1x17)+(27x10)$
$q_f=639.6$
$q_{nf}=q_f-(\gamma xD)=639.6-(21x1)=618.6$ kN/m^2
$q_n=425/2=212.5$ kN/m^2

$$F=\frac{q_{nf}}{q_n}=\frac{618.6}{212.5}=2.9$$

Problem 6.3. A strip footing 1.5m. wide is locate at a depth of 0.75 m. in a sand of unit weight 18 kN/m^3, the water table being well below foundation level. The shear strength parameters are $c'=0$ and $\phi'=38°$. The footing carries a load of 500 kN/m. Determine the factor of safety with respect to shear failure (a) if the load is vertical, (b) if the load is inclined at 10° to the vertical.

Solution 6.3.

a)
B=1.5 m.
D=0.75m.
$\gamma=18$ kN/m^3
$c'=0$
$\phi'=38° \Rightarrow N_\gamma=67$, $N_q=49$, $N_c=0$ (from Figure 6.2.)

Problem 7.2. The following results were obtained from an oedometer test on a specimen of saturated clay:

Pressure (kN/m²)	27	54	107	214	429
Void ratio	1.243	1.217	1.144	1.068	0.994

A layer of this clay 8 m. thick lies below a 4 m. depth of sand, the water table being at the surface. The saturated unit weight for both soils is 19 kN/m³. A 4m. depth of fill of unit weight 21 kN/m³ is placed on the sand over an extensive area. Determine the final settlement due to consolidation of the clay.

Solution 7.2:

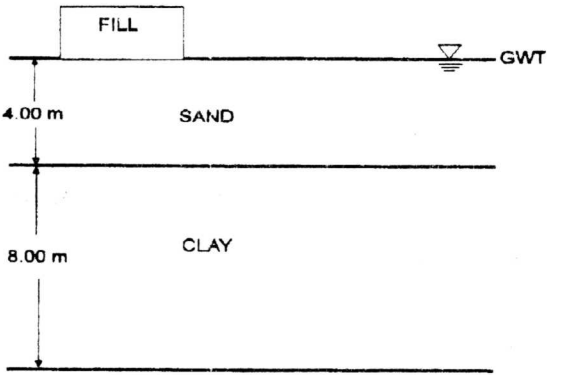
$\gamma_{fill} = 21$ kN/m^3
x 4 = 84 kN/m^2

weight of fill = 21

γ_{sat} for both soil = 19 kN/m^3
kN/m^2

weight of sand = 19 x 4 = 76

pore water press. (u) = 9.8 x 4 = 39.2 kN/m^2



$\sigma_0 = 36.8$ kN/m^2
$\sigma_1 = 36.8 + 84 = 120.8$ kN/m^2
$e_0 = 1.225$
$e_1 = 1.125$

$$m_v = \frac{1}{e_0}\left(\frac{e_0 - e_1}{\sigma_1 - \sigma_1}\right)$$

$m_v = 5.4 \times 10^{-4}$ m^2/kN
$S_c = 5.4 \times 10^{-4} \times (120.8 - 36.8)*8$

$S_c = m_v \times \Delta\sigma \times H$ $S_c =$ **0.362 m**

Problem 9.3. For the given failure surface, determine the factor of safety in terms of effective stress for the slope detailed in following figure, using the ordinary method. The unit weight of the soil is 21 kN/m³ and the relevant shear strength parameters are c'=8 kN/m² and ϕ'=32° .

Solution 9.3:

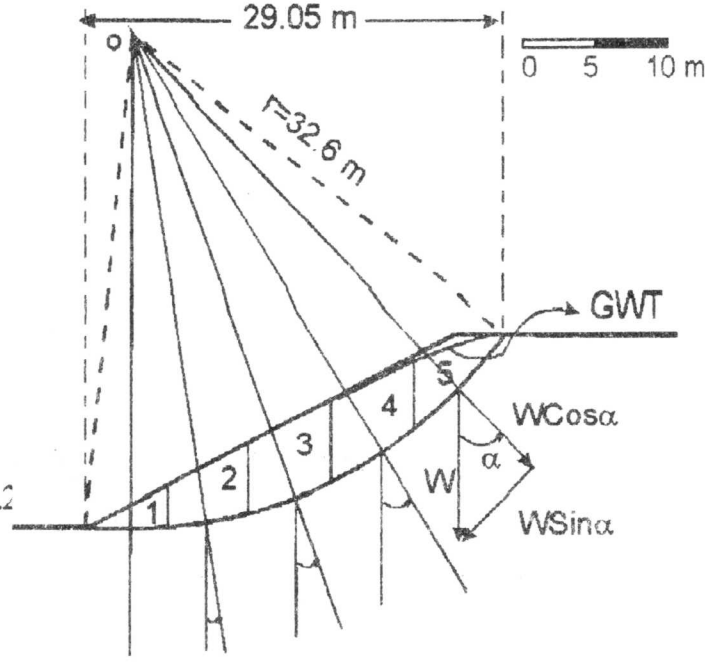
$c' = 8\ kN/m^2$

$\phi' = 32°$

$\gamma = 21\ kN/m^3$

$$L = \frac{Q \times \pi \times r}{180}$$

$$L = \frac{62 \times \pi \times 32.6}{180} = 35.2$$



Slice No	Area (m^2)	Weight (W)(kN/m)	Wcosα	Wsinα	u	ul	Wcosα-ul
1	9.64	202.44	202.44	0	20.34	138.81	63.63
2	26.52	556.98	548.51	96.72	44.74	254.43	294.08
3	33.76	708.88	657.26	265.55	56.94	388.57	268.69
4	36.17	759.51	629.66	424.71	61.01	485.74	143.92
5	16.88	354.44	232.53	267.50	28.47	242.88	-10.33
			Total =	1054.48		Total =	759.99

$$F_s = \frac{c'L + \tan\phi' \sum W\cos\alpha - ul}{\sum W\sin\alpha}$$

$$F_s = \frac{8 \times 35.26 + \tan 32 \times (759.99)}{1054.48} = 0.72$$