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Subject: 602: Foundation Engineering

1) Merits and demerits of Direct Shear Test :-

→ Merits :
- The sample preparation is simple and easy
- As the thickness of the sample is relatively small, the drainage is quick and easy
- The apparatus is cheap

→ Demerits :
- The stress conditions are only known at failure. The condition prior to the failure are indeterminate and hence mohr circle cannot be drawn.
- The stress distribution at failure plane is not uniform
- The orientation of the failure plane is fixed. The plane may not be the weakest plane.

The triaxial test is used for the determination of shear characteristics of all types of soil under different drainage condition. In the first stage the specimen is subjected to all around confining pressure (σ_3), this stage is known as consolidation stage. In the second stage, called as the shearing stage, a deviator stress (σ_d) is applied. The axial stresses increase and the shear stress develop on the inclined planes. Depending upon the drainage condition, there are three types of test -

i) Consolidated drained Test - The drainage is permitted in both the stages very slow test.

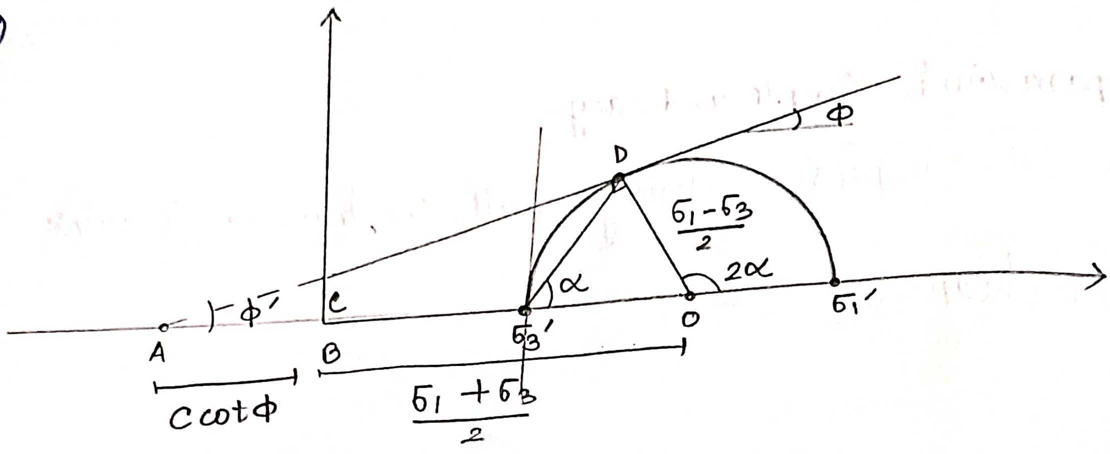
Real Life example: Building a structure on compacted soil layer

(ii) Consolidated undrained Test - drainage value is opened in consolidation stage but prevented in shear stage

(Rapid loading on saturated soil)

(iii) unconsolidated undrained Test - drainage valve is opened in both the layers

(2)



In Δ AOD,

$$\sin\phi = \frac{OD}{OA} = \frac{OD}{OB+AB}$$

$$\sin\phi = \frac{\frac{\sigma_1'-\sigma_3'}{2}}{\frac{\sigma_1'+\sigma_3'}{2}+c\cot\phi}$$

$$\frac{\sigma_1'-\sigma_3'}{2} = \frac{\sigma_1'+\sigma_3'}{2}\sin\phi + \sin\phi\cot\phi\, c$$

$$\frac{\sigma_1'-\sigma_3'}{2} - \frac{\sigma_1'+\sigma_3'}{2}\sin\phi = \cancel{\sin\phi}\cdot c \cdot \frac{\cos\phi}{\cancel{\sin\phi}}$$

$$\frac{\sigma_1'}{2}(1-\sin\phi) - \frac{\sigma_3}{2}(1+\sin\phi) = c\cdot\cos\phi$$

$$\frac{\sigma_1'}{2}(1-\sin\phi) = \frac{\sigma_3'}{2}(1+\sin\phi) + c\cdot\cos\phi$$

$$\sigma_1' = \frac{2c\cos\phi}{1-\sin\phi} + \sigma_3\frac{(1+\sin\phi)}{1-\sin\phi}$$

$$\sigma_1' = 2c\frac{\left(1+\tan\frac{\phi}{2}\right)}{1-\tan\frac{\phi}{2}} + \sigma_3'\left[\frac{1+\tan\phi/2}{1-\tan\frac{\phi}{2}}\right]^2$$

$$\sigma_1' = 2c\tan\left(45^\circ+\frac{\phi}{2}\right) + \sigma_3\underbrace{\tan^2\left(45+\frac{\phi}{2}\right)}_{N\phi}$$

$$\therefore \sigma_1' = 2c\sqrt{N\phi} + \sigma_3 N\phi$$

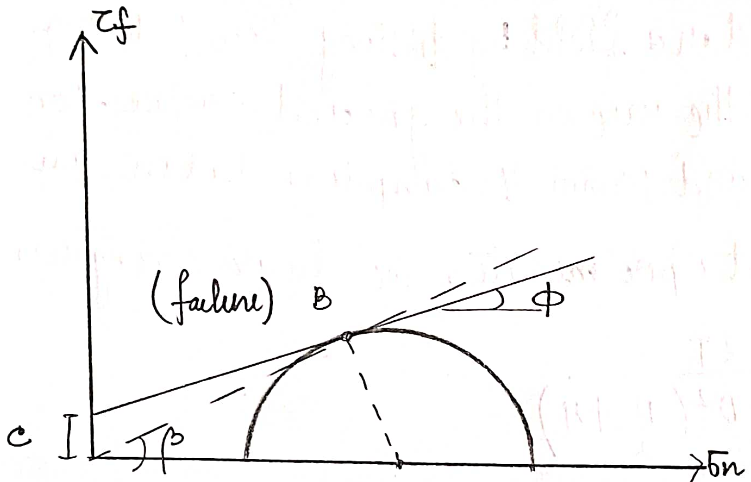
(3) The shear on the particle occurs due to slippage of particles. The shear on the failure plane is a function on normal stress. The soil fails when the shear is a unique function of normal stress

$$\tau_f = f(\sigma)$$

A plot can be made between τ_f and σ_n that will be a straight line, is known as Mohr Envelope. Failure of material occurs when the mohr circle touches the mohr envelope

The shear strength on that particular plane is given by coloumb.

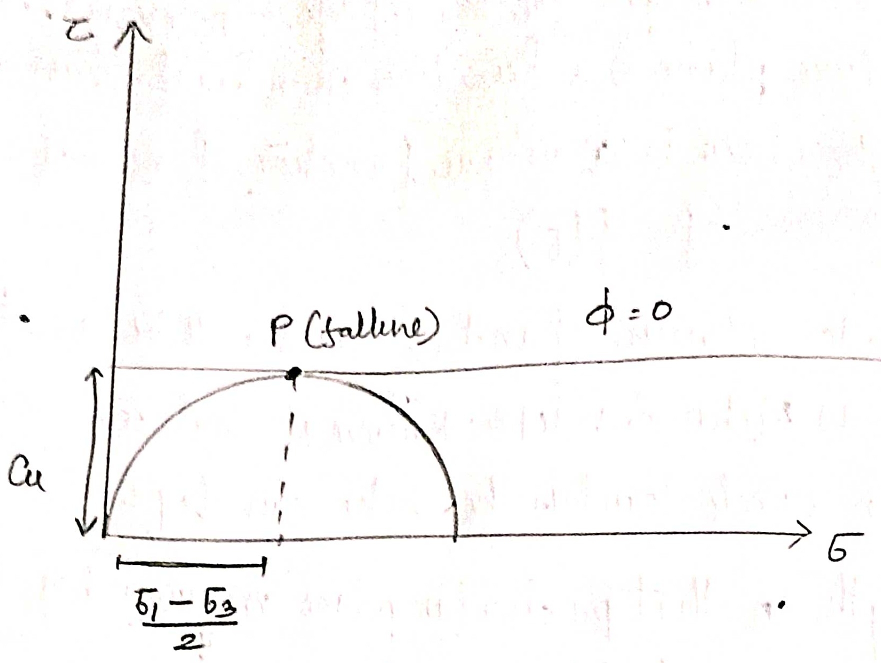
$$S = C + \sigma_n \tan\phi.$$



Failure envelopes.

(4) This is a special form of triaxial test in which confining pressure is 0. The tests can be conducted on clayey soil. The major principle stress $(\sigma_1) = \sigma_d$, deviator stress. The axial stress at which the specimen fails is known as unconfined compressive strength (q_u). The failure envelope is horizontal ($\phi_u = 0$).

$$S = C_u = \frac{q_u}{2} = \frac{\sigma_1}{2}$$



(5) The undrained shear test can be determined by vane shear test. It can also be conducted in a field by drilling bore hole by direct penetration of the vane on the ground surface. For conducting a test 38mm and 75mm H sample is taken an torque is applied about 6° per minute. The shear strength is determined using -

$$\frac{2T}{\pi D^2\left(\frac{D}{3}+H\right)}$$

Question No: 06 :

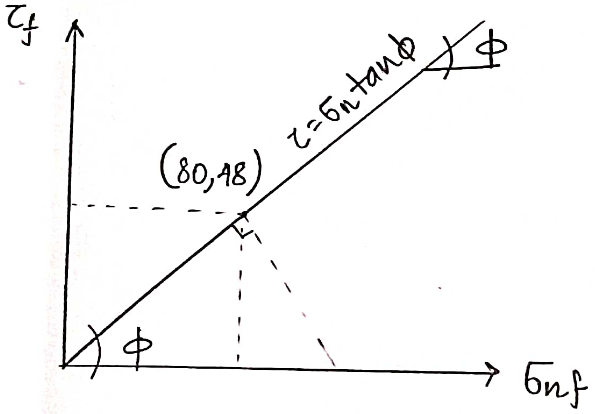
Given: Normal Load : 288 N
Shear Load : 173 N
cross section area : 36 cm² = ~~36mm²~~ = 3600 mm²

To find: 1) angle of internal friction, ϕ
2) Magnitude of principle stresses and orientation of planes
3) Orientation of plane of maximum shear stress at failure.

remoulded sand sample is given, hence c = 0.

$\rightarrow$ Normal stress $(\sigma_n)_f = \frac{288}{3600} = 80$ KN/mm²

$\rightarrow$ Shear stress $(\tau_f) = \frac{173}{3600} = 48.05$ kn/mm²



$\tan\phi = \frac{\tau_f}{\sigma_{nf}}$

$\phi = \tan^{-1}\left(\frac{48.05}{80}\right)$

$= 31^\circ$ (Ans) — 1

from the mohr circle (graphical approach):

$\rightarrow \sigma_1$ (major principle stress) = 165 KN/mm²

$\rightarrow \sigma_3$ (minor principle stress) = 53 KN/mm²

$\rightarrow$ Orientation of major principle plane = 60° clockwise from horizontal

$\rightarrow$ orientation of minor principle plane = 30° anticlockwise from horizontal

orientation of plane of maximum shear stress at failure = 45°

Question No: 06 :

Given: Normal Load : 288 N

Shear Load : 173 N

cross section area : 36 cm^2 = ~~36 mm^2~~ = 3600 mm^2

To find: 1) angle of internal friction, ϕ

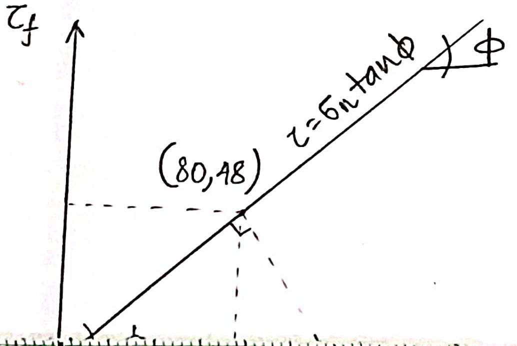
2) Magnitude of principle stresses and orientation of planes

3) Orientation of plane of maximum shear stress at failure.

remoulded sand sample is given, hence c = 0.

$\rightarrow$ Normal stress $(\sigma_n)_f = \frac{288}{3600} = 80\ KN/mm^2$

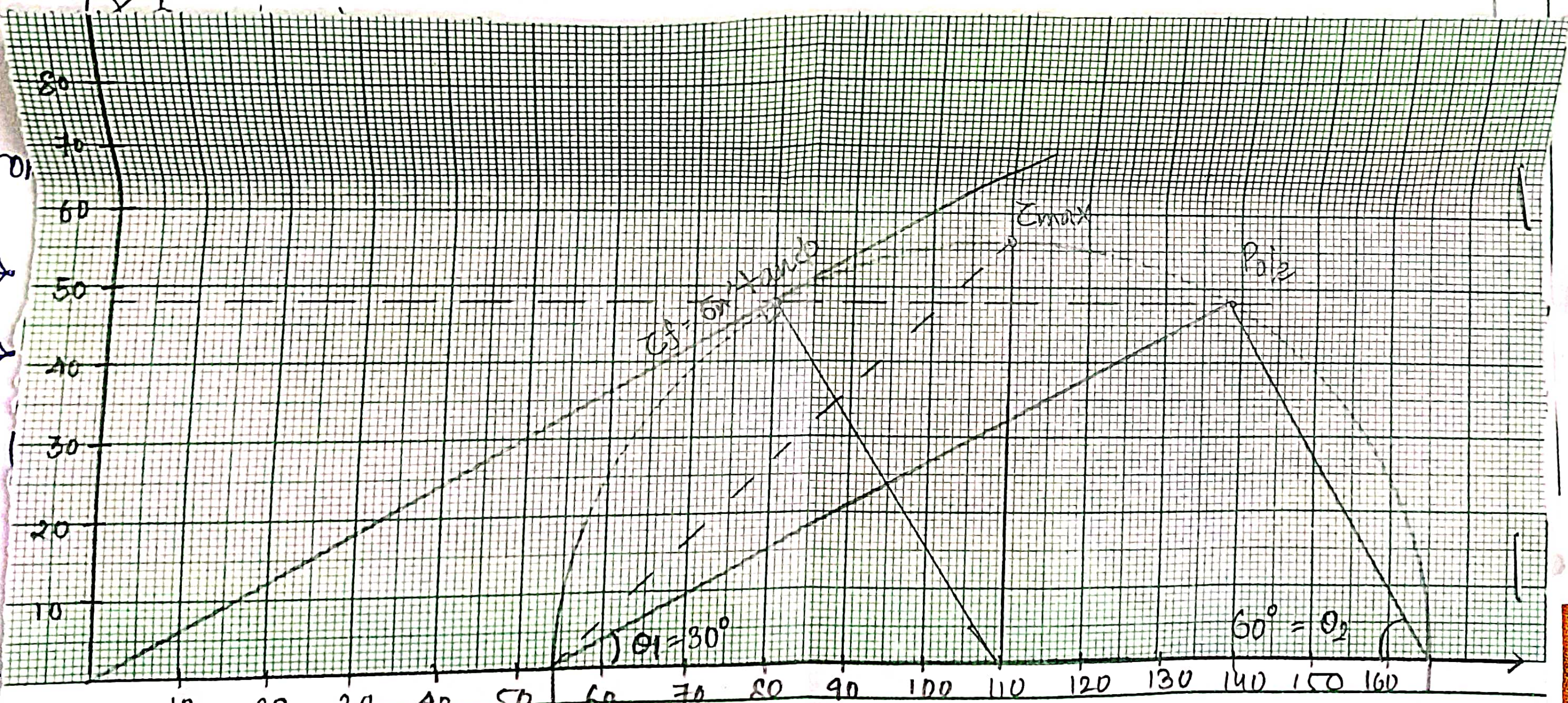
$\rightarrow$ Shear stress $(\tau_f) = \frac{173}{3600} = 48.05\ kn/mm^2$



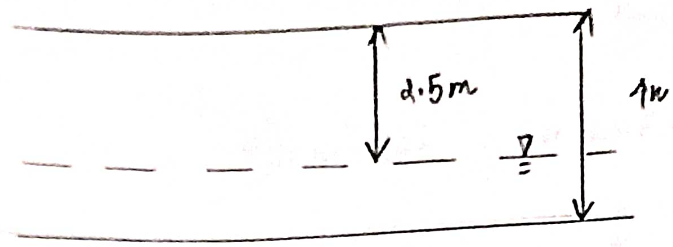
$\tan\phi = \frac{\tau_f}{\sigma_{nf}}$

$\phi = \tan^{-1}\left(\frac{48.05}{80}\right)$

$= 31^\circ$ (Ans) — 1



Question No: 07



Compression test:

$\sigma_1 = 2c\tan\alpha$

$1.2 = 2c\tan\alpha$ —(i)

Triaxial test

$\sigma_3 = 0.4\ kg/cm^3$

$\sigma_d = 1.6\ kg/cm^2$

$\sigma_1 = 2\ kg/cm^2$

$\sigma_1 = \sigma_3 \tan^2\alpha + 2c\tan\alpha$

$\cancel{\sigma_1}\ 2 = 0.4\tan^2\alpha + 1.2$

$\tan\alpha = 1.4142$

$\phi = 19.47$

$$e = \frac{G\gamma_w}{\gamma_d} = 0.588$$

$$\gamma_{sub} = \frac{G-1}{1+e}\gamma_w = 1.07\ g/cm^3$$

$\therefore\ \sigma' = 2.5 \times 1.7 + 1.07 \times 1.5 = 5.855$

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

$= 4.24 + 5.855 \tan 19.47$

$= 6.31\ t/m^3$.

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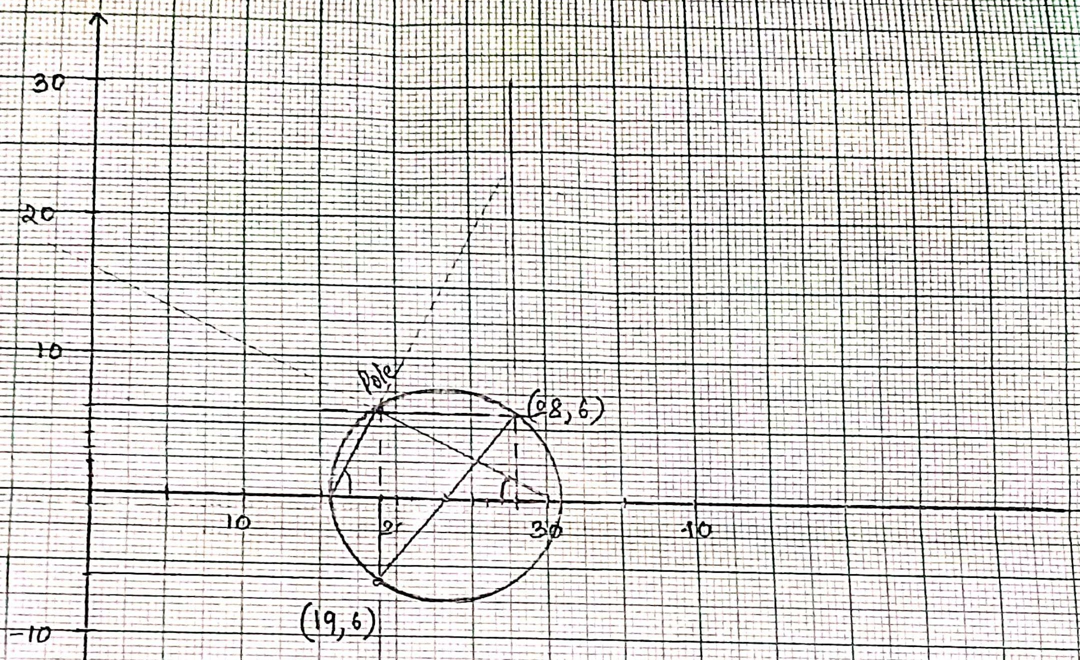
Question No: 09

x: and y axis
Scale: 20 small div = 10 N/cm^2
1 small div = $\frac{10}{20}$ = 0.5 N/cm^2



Question No: 08

Given, Torque = 6040 N-cm

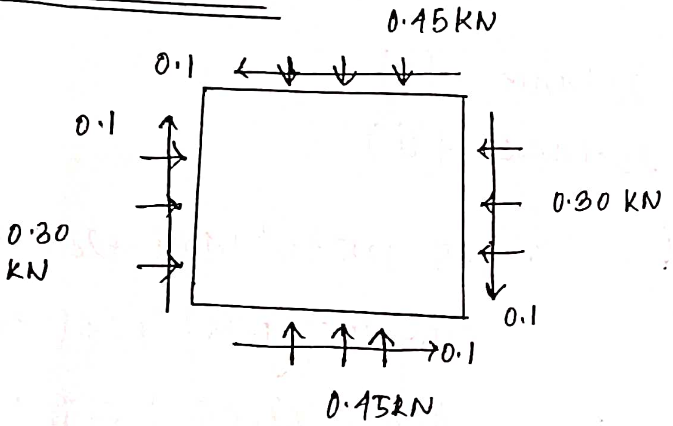
H = 10 cm

D = 7 cm

To find, undrained shear Test = $\frac{2T}{\pi D^2\left(\frac{D}{3}+H\right)} = \frac{2 \times 6040}{\pi (7)^2 \left(\frac{7}{3}+10\right)}$

$= 6.36 \ N/cm^2$

Question No: 09



Area = $(40mm)^2$

$= 1600 \ mm^2$

$= 1600 \times 10^{-2} \ cm^2$

$= 16 \ cm^2$

stress $(\sigma_1) = \frac{F_1}{A} = \frac{0.45 \times 10^3}{16\cancel{00}}$

$= \frac{450}{16} = 28.1$

$= 28.1 \ N/cm^2$

$(\sigma_2) = \frac{F_2}{A} = \frac{0.30 \times 10^3}{16}$

$= 19 \ N/cm^2$

$\tau = \frac{0.1 \times 10^3}{16} = 6.25 \ N/cm^2$

Sign convention:

anticlock: (+) = (28.1, 6.25)

clock (-ve) = (19, -6)

$\sigma_1 = 32 \ N/cm^2$

$\sigma_3 = 15.5 \ N/cm^2$

θ_1 (from major principle plane) = 28° clock.

θ_2 (from minor principle plane) = 64° anti

Solution No. 10

			$(\sigma_3+\sigma_d)$		(σ_3-u)	(σ_1-u)
Sl	σ_3 (σ_3)	σ_d	σ_1	u	σ_3'	σ_1'
1	125	510	635	−70	195	705
2	250	620	870	−10	260	580
3	500	850	1350	+120	380	1230

(i) Total strength parameter

$635 = 125 \tan^2(\alpha) + 2c \tan\alpha$ — (i)

$1350 = 500 \tan^2\alpha + 2c \tan\alpha$ — (ii)

Subtracting (ii)−(i)

$715 = 375 \tan^2\alpha$

$1.91 = \tan^2\alpha$

$1.38 = \tan\alpha$

$\alpha = 54.07$

$45 + \frac{\phi}{2} = 54.07$

$\phi = 18.14°$

$\therefore 635 = 125 \tan^2 54.07 + 2c \tan$

$635 = 125(1.38)^2 + 2c(1.38)$

$635 = 238.05 + 2.76c$

$c = 143.8$

Effective strength parameter

$705 = 195 \tan^2\alpha + 2c \tan\alpha$ — (i)

$1230 = 380 \tan^2\alpha + 2c \tan\alpha$ — (ii)

$\Rightarrow 525 = 185 \tan^2\alpha$

$\Rightarrow 2.83 = \tan^2\alpha$

$\Rightarrow 1.68 = \tan\alpha$

$\therefore \alpha = 59.3°$

$45 + \frac{\phi}{2} = 59.3°$

$\phi = 28.61$

$705 = 195(1.68)^2 + 2c(1.68)$

$\frac{154.63}{3.36} = c$

$c = 46.02$

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10 small = 100
1 sm = 10

Question No: 10