Lecture 10
14/11/19

Note ② If Mohr's circle are Plotted for total stress then undrained / total shear Parameter can be obtained.

If we use effective stress to draw the Mohr's circle then effectiv / drained shear Parameter can be obtained

CD Test — $\left| \begin{array}{l} \sigma_1 = \bar{\sigma}_1 + u \\ \sigma_3 = \bar{\sigma}_3 + u \end{array} \right. \mapsto$ 5* eqn $\boxed{C_d, \phi_d \quad C', \phi'}$

UU test = $\left| \begin{array}{l} \sigma_1 = \bar{\sigma}_1 + u \\ \sigma_3 = \bar{\sigma}_3 + u \end{array} \right. \mapsto$ 5* eqn $\begin{bmatrix} C_u, \phi_u \\ \text{or} \\ C, \phi \end{bmatrix}$

CU test = $\left| \begin{array}{l} \bar{\sigma}_1 = \sigma_1 - u \\ \bar{\sigma}_3 = \sigma_3 - u \end{array} \right. \mapsto$ 5* eqn $\begin{bmatrix} C_d, \phi_d \\ \text{or} \\ C', \phi' \end{bmatrix}$

Note ③ Area of C/S at failure (A_f)

let A_0 = initial C/S Area = $\frac{\pi}{4} d^2 = \frac{V_0}{L_0}$

$$\text{Area})_f = \left[\frac{V_0 \pm \Delta V}{L_0 - \Delta L}\right] = \frac{V_0\left[1 \pm \frac{\Delta V}{V_0}\right]}{L_0\left[1 - \frac{\Delta L}{L_0}\right]} = \frac{A_0\left[1 \pm \varepsilon_v\right]}{\left[1 - \varepsilon_L\right]}$$

$$\boxed{A_f = \frac{A_0\left[1 \pm \varepsilon_v\right]}{\left[1 - \varepsilon_L\right]}} \text{***}$$

$\varepsilon_v = \frac{\Delta V}{V_0}$ = Volumetric strain

$\varepsilon_L = \frac{\Delta L}{L_0}$ = Axial strain

- If UU test will take Place then ($\varepsilon_v = 0$) due to unconsolidated undrained cond

Hence

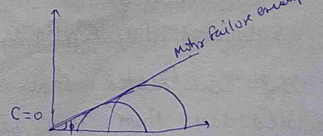
$A_f = \frac{A_0[1]}{[1 - \varepsilon_L]}$ then $\boxed{A_f = \frac{A_0}{[1 - \varepsilon_L]}}$ *

Note ④

Type of Mohr's failure envelope

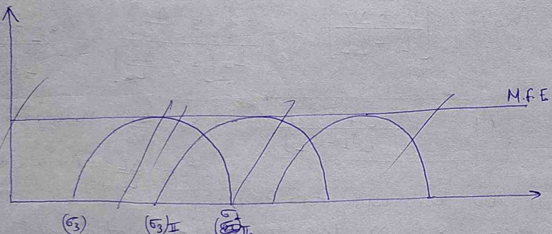
1) Depending upon type of soil, drainage cond following types of Mohr's failure envelope can be obtained

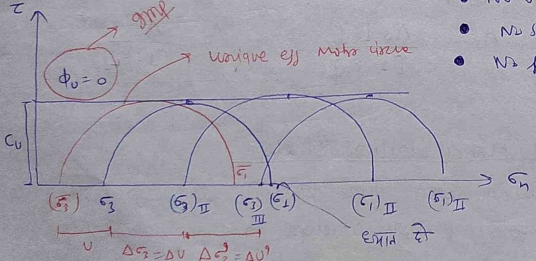
A) for sand



② for saturated clay under undrained cond.

if unconsolidated undrained test is conducted on saturated clay then the behaviour of clay is cohesive and no friction is observed when test result are plotted then radius of all the Mohrs circle is found to be equal and if Mohr's circles are plotted in effective stress then unique effective Mohr's circle are obtained



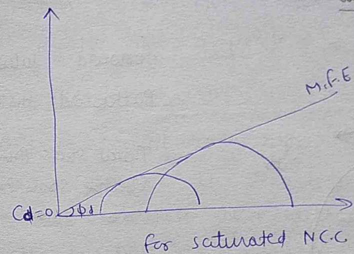


- No volm change
- No sliding
- No friction

③ Saturated clay under drained cond :-

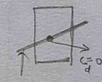
① If consolidated drain test (CD) test is conducted on saturated clay then ~~the~~ behavior of N.C. clay is similar to that of sand.

(exception case for F.O.S we will take saturated case for long period of time)



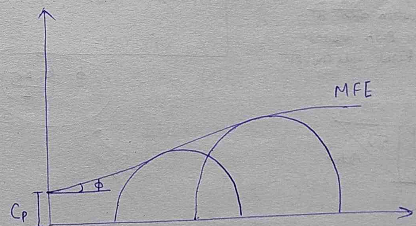
for saturated N.C.C

- Volm change
- Sliding
- friction



(failure point में cohesion 0 हो जायेगा)

Case -④ for Partially saturated clay → Partially saturated clay under drained and undrained cond similar to that of silt.



Pore Air will also take the Pressure

M.F.E → slightly curve

After some loading soil becomes saturated

Case ⑤ Saturated clay in CU test behave like silt ($C-\phi$)

OC soil in CD test behave like silt ($C-\phi$)

Note-⑤ Stress path

1) Stress path is a curve which shows change in stresses as the load acting on the soil specimen changes.

2) In another words It is the locus of points of Maxm shear stress expressed by a ~~specific~~ specimen as the load change takes place.

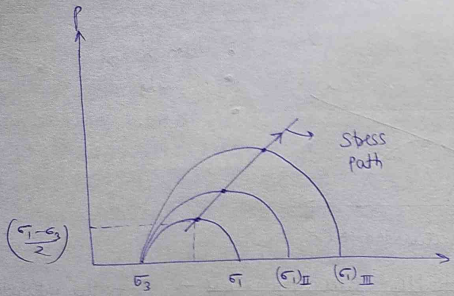
3) Stress path can also be represented in (P-Q) plot

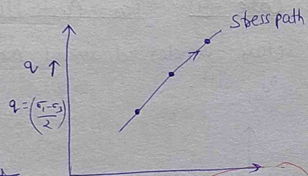
forward = future

Backward = History

Total stress ~~Point~~ Pressure

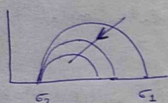
Effective stress Pressure

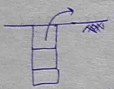




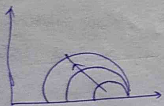
$p = \left(\frac{\sigma_1+\sigma_3}{2}\right)$

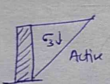
Imp

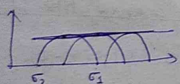
① 

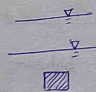


Excavation करेंगे तो stress path decrease (या) Right side shift होगा

② 



③ 



(अगर water level increase हो रहा तो stress path Horizontal हो जायेगा क्योंकि Pascal law की तरह से)

Merits of triaxial test

1) Failure Plane is not Pre-determined. it is the weakest Plane.

2) there is mechanism to measure Pore Pressure

3) Drainage is controlled.

4) Suitable for all types of soil

⑤ Stress distribution is uniform

⑥ Results are accurate

② Unconfined compressive test

1) It is special case of triaxial test in which confining pressure is zero ($\sigma_3 = 0$) it means there is no 1st stage therefore no - Rubber membrain is required.

2) Without Rubber membrane, dry soil and sand can't be held in Position, Hence this test can be conducted in saturated silt and clay.

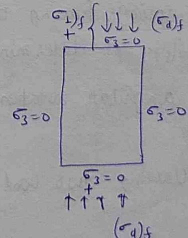
3) These saturated sample is subjected to axial loading and load deviator stress at failure is (σ_d).

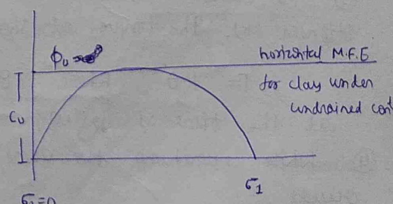
Note deviator stress at failure is termed as unconfined compressive stress (UCS) (q_u)

$$\boxed{UCS = (\sigma_d)_f = (\sigma_1 - \overset{0}{\sigma_3})_f = \frac{P}{A_f}}$$ ★★

A_f = Area of c/s at failure

① becoz ($\sigma_3 = 0$) Hence, σ_1 at failure will obtained same for each sample of same size soil, Hence unique Mohr's circle will obtained which passes from origin





1) this test is suitable for clay under-undrained cond for which Mohr's failure envelope is a Horizontal line.

Unconfined compressive strength

$$UCS = (\sigma_d)_f = (\sigma_1 - \cancel{\sigma_3}^{\,0})_f$$

$$\sigma_1 = \sigma_3 \tan^2\left(45 + \frac{\phi}{2}\right) + 2c\tan\left(45 + \frac{\phi}{2}\right)$$

$$\sigma_1 = 2c\tan\left(45 + \frac{\phi}{2}\right)$$

$$\boxed{UCS = 2c\tan\left(45 + \frac{\phi}{2}\right)}$$

If soil is clay under undrained cond ($\phi = 0$)

$$UCS = 2c\tan 45°$$

$$UCS = 2c$$

$$\boxed{c = \frac{U.C.S}{2}} \;**$$

③ Vane shear test

this test is suitable for soft saturated clay (like Marine clay) to find undrained shear strength. It can also be used to determine senstivity of clay and liquid limit

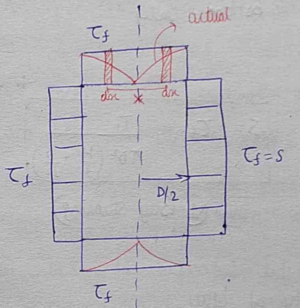
② the vane is punched into the soil and Torque is applied

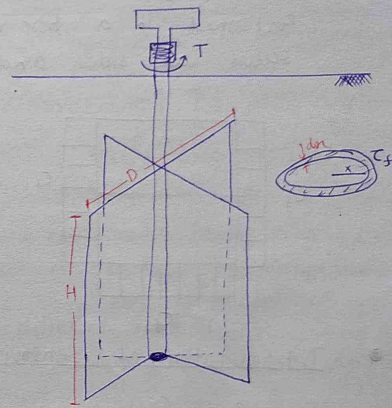
③ The vane is calibrated to a spring having torsional stiffness (K). the torque at shear failure is determined as

$T = K\theta$ where θ is angular rotation of vane at the time of failure

④ While punching the vane following two cond. may occurs

A) Two way shearing → the vane is punched in the ground such that top of vane is at some depth below the ground level then shearing occurs at sides and top and bottom both.





$\Rightarrow T = (T_1)_{sides} + (T_2)_{\text{Top and bottom}}$

$$T_1 = (\text{force} \times \text{distance}) = (\tau_f \times \pi D H) \times \frac{D}{2} = \tau_f \times \pi D^2 \frac{H}{2}$$

$$T_2 = 2 \times [\tau_f \times 2\pi x\, dx] . x$$

$$T_2 = 4\pi\tau_f \int_0^{D/2} x^2 . dx = 4\pi\, \tau_f . \frac{x^3}{3}\Big|_0^{D/2}$$

$$= \frac{4}{3}\pi \tau_f . \frac{D^3}{8} = \tau_f . \frac{\pi D^3}{6}$$

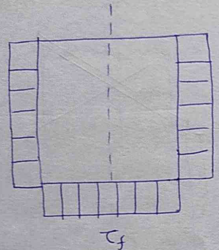
$$\Rightarrow T = T_1 + T_2 = \tau_f . \pi . D^2 . \frac{H}{2} + \tau_f . \frac{\pi D^3}{6}$$

$$\boxed{S = \tau_f = \frac{T}{\pi D^2\left(\frac{H}{2} + \frac{D}{6}\right)}} \;** \rightarrow \text{2 way shearing}$$

Important derivation also

Ⓑ one-way Shearing

If top of the vane is at G.L. or test is performed in a box-hole, then shearing will occurs at sides and bottom Only



** $\boxed{S = \tau_f = \dfrac{T}{\pi D^2\left(\frac{H}{2}+\frac{D}{12}\right)}}$

(1-way shearing)

- **Determination of senstivity of clay**

$$S_t = \frac{(UCS)\ \text{undisturbed}}{(UCS)\ \text{remoulded}} = \frac{(2C)\ \text{undisturbed}}{(2C)\ \text{remoulded}}$$

or

$$S_t = \frac{\text{undisturbed shear strength}}{\text{Remoulded shear strength}} = \frac{\dfrac{(T)\ \text{undisturbed}}{\pi D^2\left(\frac{H}{2}+\frac{D}{6}\right)}}{\dfrac{(T)\ \text{Remoulded}}{\pi D^2\left(\frac{H}{2}+\frac{D}{6}\right)}}$$

$$S_t = \frac{(T)\ \text{undisturbed}}{(T)\ \text{Remoulded}}$$

④ Direct Shear test

① Shear box is either square or circular having size 60-90mm

② In this stress drainage is not control Hence it is preferred under drained cond However it can be conducted under undrained cond also.

③ There are two mechanism to conduct this test

① Straine control (motor and screw)

② Stress control (with the help of pully and weight)

→ Strained controlled is better ✓

④ Saturated sample is placed in Shear box and normal force (P) is applied from top and when expulsion of pore water stop shearing is introduced on a predetermined Horizontal plane.

⑤ ~~And~~ At Constant normal stess ($\sigma_n = \frac{P}{A}$), shear displacement is given and when failure occurs shear stess at failure can be determined as

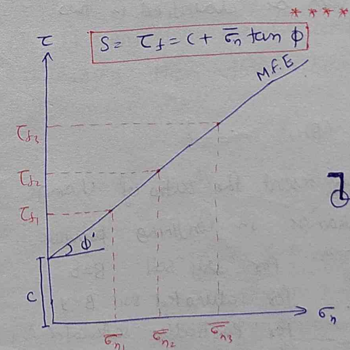
$$\tau_f = \frac{\text{Shear force}}{\text{Area}} = \frac{KN}{A}$$

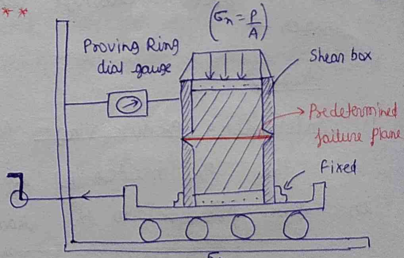
K = Proving Ring Constant
N = dial gauge reading at failure

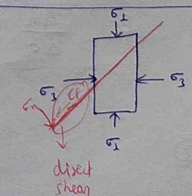
⑥ Test is repeated at different normal stess and corresponding shear stess at failure (τ_f) is noted and drawn on the graph paper.

⑦ If test is drained then $\sigma_n = \bar{\sigma}_n + \cancel{u}^{0}$ ($\sigma_n = \bar{\sigma}_n$)

*** $\boxed{S = \tau_f = c + \bar{\sigma}_n \tan\phi}$







Limitations

1) Failure Plane is predetermined which may not be the weakest Plane.
2) There is no mechanism to measure pore pressure.
3) Drainage is not controlled
4) stressed distribution is not uniform

Pore Pressure Parameter

1) If it is not Possible to measure pore pressure by Practical means then theortical approach given by Skempton can be adopted.
2) The Parameter B and A represent the response of change in Pore pressure due to change in vertical pressure under Undrained cond.
3) The pore pressure change can be classified in two stages →

Stage ①

1) Confining Pressure stage (B)

⇒ the Parameter (B) represent the ratio of change in Pore pressure to the change in confining pressure

$$\boxed{B = \frac{\Delta U_c}{\Delta \sigma_c} = \frac{\Delta U_c}{\Delta \sigma_3}}$$ *

For dry soil $B=0$
For saturated soil $B=1$
For partially saturated soil
~~B = (0 to 1)~~

$(0 < B < 1)$

Stage ②

Deviator stage / Shear stage

① The Parameter A is defined in termes of another Parameter $\bar{A}$ such that $\boxed{\bar{A} = A.B}$

② The Parameter $\bar{A}$ represent the ratio of change in Pore pressure to the change in deviator stress in Shear stage under undrained cond

$\bar{A} = A.B$

$$\boxed{\frac{\Delta U_d}{\Delta \sigma_d} = \frac{\Delta U_d}{\Delta \sigma_1 - \Delta \sigma_3}}$$ *

Note ① Parameter A depends upon degree of saturation (OCR), Strain in soil and stratification of soil

Note ② It value may be as low as (−0.5 for highly O.C.C over consol. clay) and dense sand and may be as high as (+3) for loose sand.

③ If confining pressure and deviator stress both are changing then total change in pore pressure can be determine as.

$$\Delta U = \Delta U_c + \Delta U_d$$
$$\Delta U = B.\Delta \sigma_3 + \bar{A}(\Delta \sigma_1 - \Delta \sigma_3)$$
$$\Delta U = B.\Delta \sigma_3 + A.B(\Delta \sigma_1 - \Delta \sigma_3)$$
$$\boxed{\Delta U = B[\Delta \sigma_3 + A(\Delta \sigma_1 - \Delta \sigma_3)]}$$