

**University of Texas at Arlington**  
Geotechnical Engineering Laboratory

## **Direct Shear Test**

Lecture Notes # 11

## Definitions, Objectives and Applications

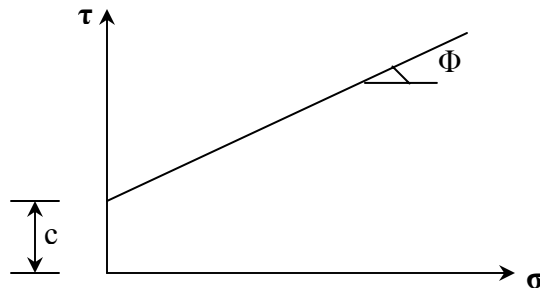
### Objective

Estimate the angle of friction ( $\phi$ ) and cohesion ( $c$ ) of soils. For the current lab, a granular soil is used

### Significance and Applications

- Unlike materials like steel, most of the soils are visco-elastic, meaning the failures are time dependant
- For most of the geotechnical designs concerning foundations, earthworks and slope stability issues the soils are required to *withstand shearing stresses* along with compressive stresses
- Shear stresses tend to displace a part of soil mass relative to rest of the soil mass
- Shear strength is the capacity of the soil to resist shearing stresses
- Relative sliding between soil particles is the major factor contributing to the shear resistance
- If the normal forces increase, the number of contact points also increase thus increasing the resistance
- The reverse may happen if the normal loads decrease (which is the case in *excavations*)
- Hence the shear strength is a function of normal load, angle of friction (amount of interlocking among the soil particles) and cohesion (intrinsic property of clays due to which they stay close to each other even at zero normal load).

### Mohr-Coulomb Failure Criterion



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

Where:

c: cohesion ( $c = 0$  in case of sands)

$\sigma$ : vertical normal stress

$\Phi$ : Angle of friction ( $\Phi = 0$  in case of clays)

## Measurement of Shear Strength

- Direct shear (Shear box test)
- Triaxial tests (including UCS, UU, CU, CD tests)
- Vane shear
- Torsional shear
- In situ tests

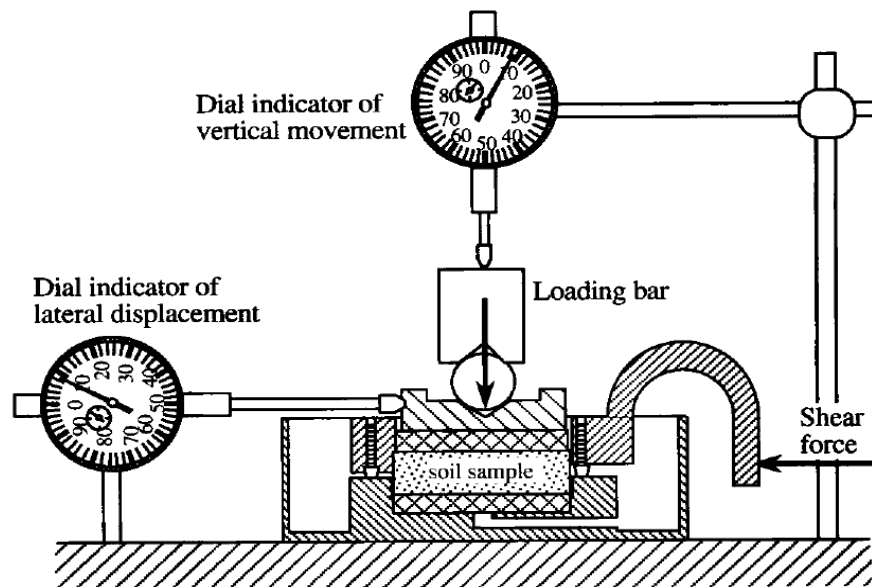
### Direct Shear Test

#### *Pros*

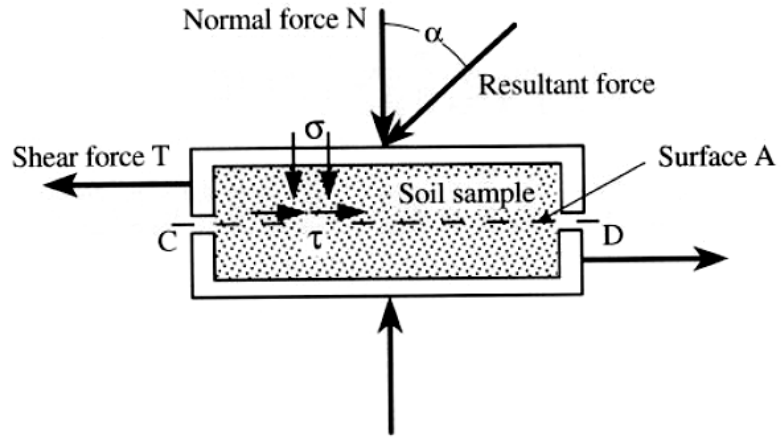
- A quick and inexpensive test to obtain the shear strength parameters of both fine and coarse grained soils either in undisturbed or remolded state
- Ease of sample preparation

#### *Cons*

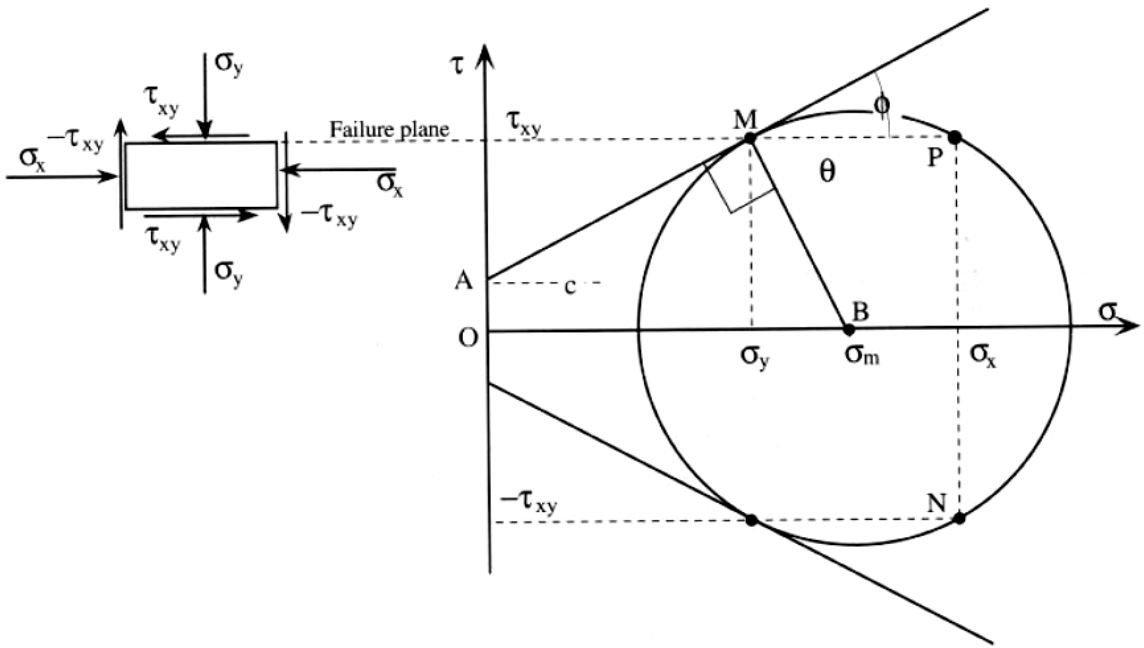
- Drainage cannot be controlled and pore water pressure can not be measured
- Not very much representative of failures in fine grained soils where pore pressure plays a significant role on shear strength. Much recommended for fully drained cases
- The failure plane is always forced horizontal which is not the weakest plane in the case of in situ conditions. This issue can be resolved by using triaxial testing



Schematic showing direct shear equipment



**Figure 1** Soil sample in the direct shear box.



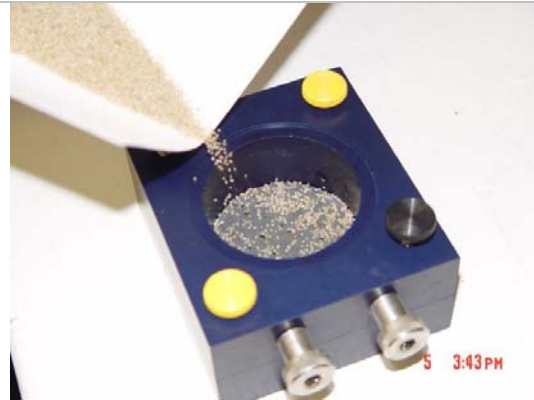
**Figure 2** Stress state at failure in direct shear test and its Mohr representation.

## Performing the test:

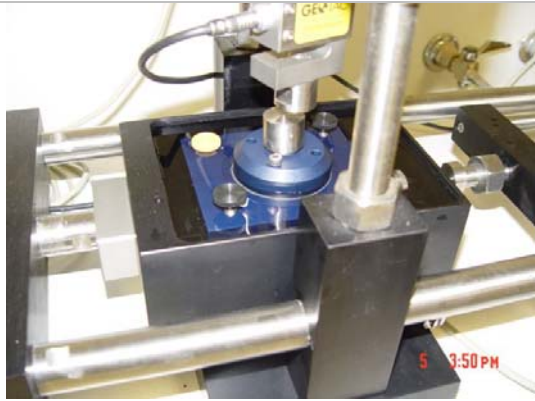
Will be explained in the lab



Direct shear equipment



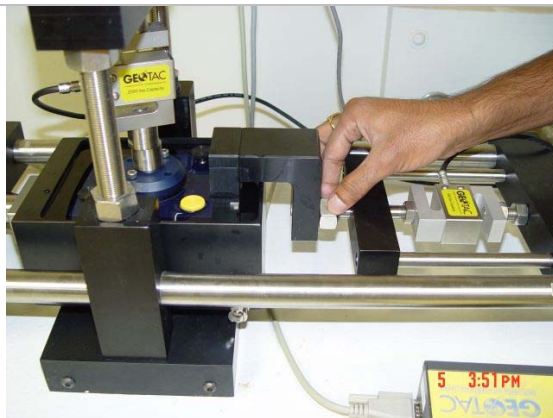
The shear box



Align the box under the normal load cell

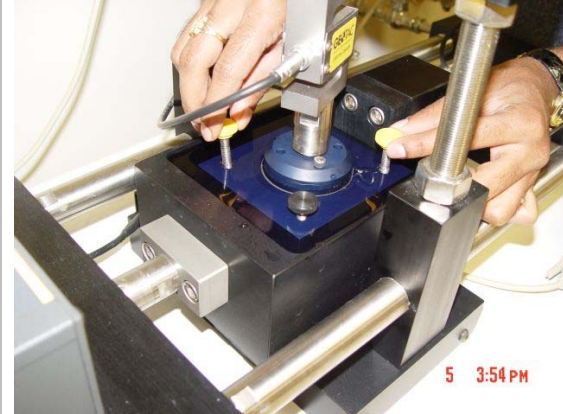


Adjust the displacement LVDT



Secure the shear box

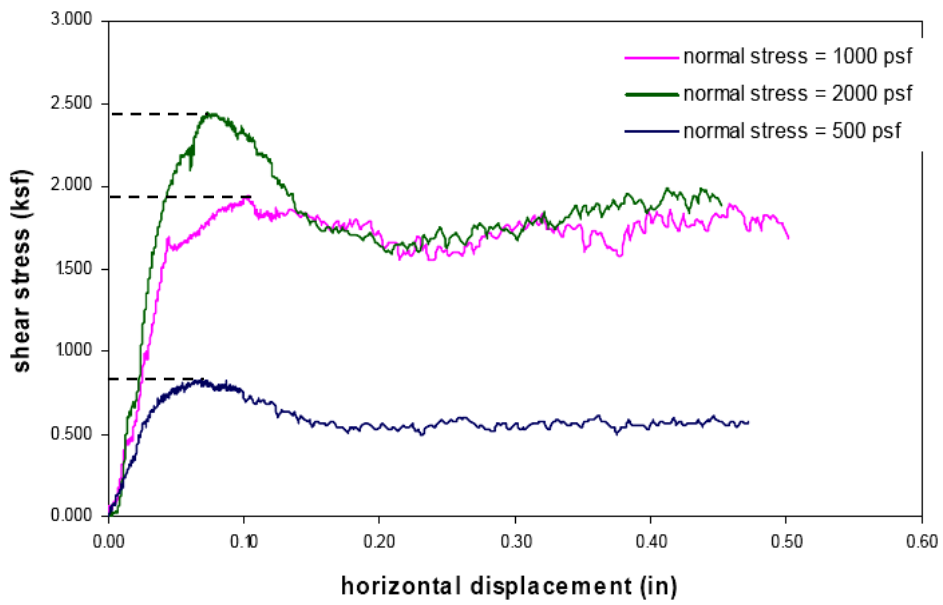
- Apply the normal load in the computer software
- Give the displacement limit to failure
- Specify the rate of horizontal shear application  
(for clays this is important so as to avoid pore pressures to develop which may effect the shear strength)
- Tare all sensors prior to starting the test
- For testing sands or clays, the consolidation phase in the software is usually skipped unless required



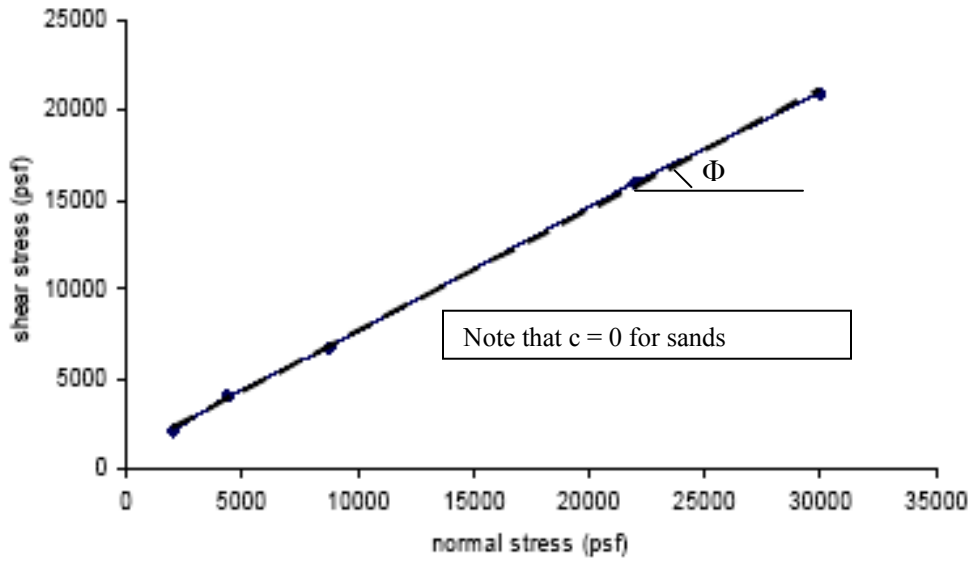
*Remove the fixing screws and loosen the alignment screws.*

This is very important step if not performed, you will measure the shear strength of the fixing screws rather than the soil supplied. More importantly it will damage the whole direct shear setup

- Obtain the EXCEL spreadsheet generated by the software and compute the peak shear load corresponding to the normal load applied
- Repeat the test at three different normal loads and correspondingly obtain three shear loads
- Plot the three coordinates in the  $\sigma$ - $\tau$  plane and obtain a best fit line
- The intercept of the line with the y-axis ( $\tau$ -axis) gives the cohesion (for the present case testing sands, note that  $c = 0$ )
- The slope of the line gives the friction angles
- Report the value of friction angle



*Note: The graph below is not related to the above graph. It only explains how to obtain the angle of friction*



**Graphs explaining the determination of angle of friction of the given sand**