1.7 Direct Shear Test

- A test to determine the shearing characteristics of soils. (Based on stress states on failure plane)
- The shear strength parameters, *c'* and ϕ' (based on Mohr-Coulomb failure criteria $(s = c' + (\sigma - \Delta u)\tan\phi')$) can be easily determined.

1) Test conditions and procedures

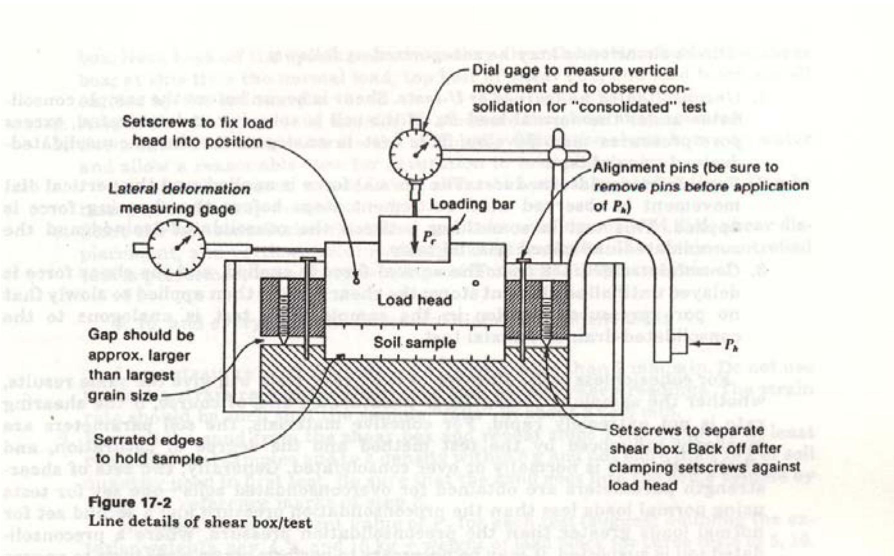


Figure 17-2
Line details of shear box/test

Fig. 17-2

i) Apply the desired vertical load (normal force) P_v and measure the vertical displacements (with time).

ii) Start horizontal loading at a constant displacement rate and measure horizontal load (shearing force) P_h, horizontal displacement (shear displacement), and vertical (volume change) displacement.

iii) Repeat i) – ii) for additional samples of identical condition at different values of P_v. (At least, 3 tests are required to compute *c'* and ϕ')

<u>2) Categorization of shear test based on drained condition.</u>

i) Unconsolidated – Undrained test (UU test) ⇒ Undrained strength for saturated cohesive soils. ⇒ Shearing process is begun as soon as the sample is put in the machine.

ii) Consolidated – Undrained test (CU test) ⇒ Undrained strength for saturated cohesive soils ⇒ Soil sample is sheared at high strain rate after completion of consolidation under applied vertical load.

iii) Consolidated – Drained test (CD test) ⇒ Effective (Drained) Strength parameters, c' and ϕ' ⇒ The shear force is applied so slowly that the small pore pressure cannot be developed after completion of consolidation.

- For cohesionless soils, it is reasonable to assume "drained" condition, due to short drainage path of sample (thickness of sample = 20 to 25 mm) and its high permeability.

- For cohesive soils, drained condition can be simulated with low strain rate while undrained condition can be simulated with high strain rate.

- Undrained and Drained Strength

For cohesionless soils ⇒ drained strength

For cohesive soils ⇒ drained strength and undrained strength

3) Typical test results

$$\sigma_n = P_v/A \text{ and } s = P_h/A$$

where A is the nominal area of the sample (or of the shear box).

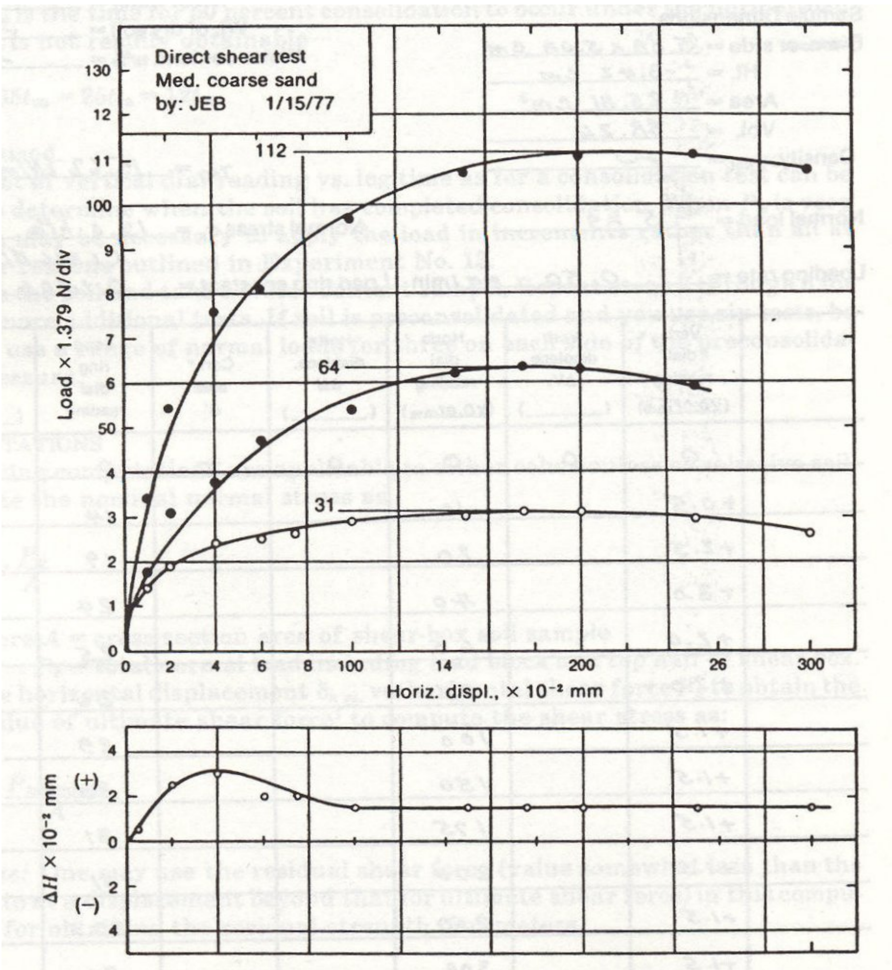


Figure 17-4

- Graphical determination of shear strength parameters

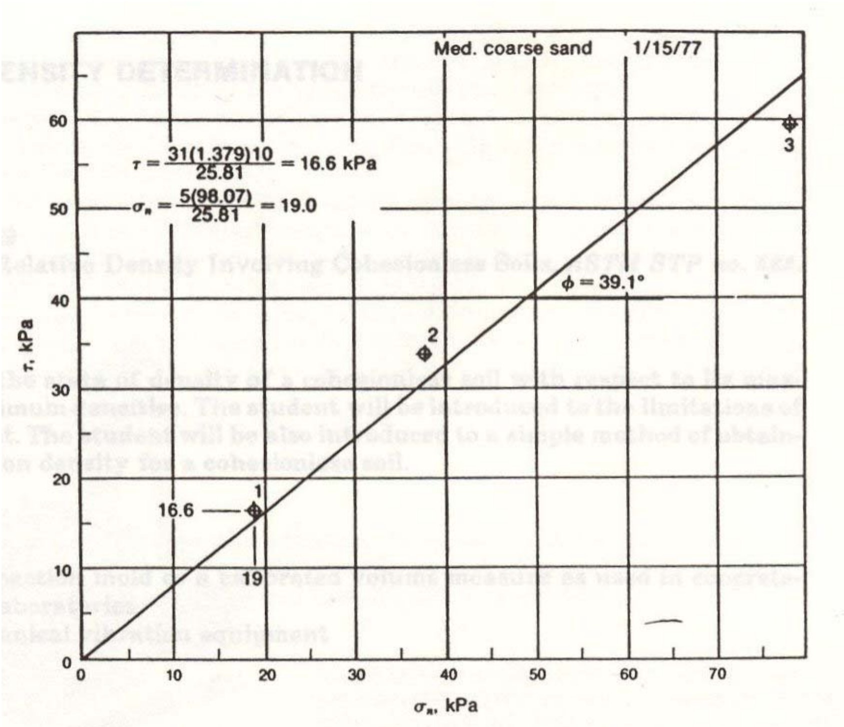


Figure 17-5

- A small "apparent cohesion" (less than 10 – 15 kPa) should be neglected.

4) Advantages

i) It is easy and simple to perform the tests and interpret test results.

ii) Drainage path is short. The time for consolidation is relatively short.

iii) The direct-shear machine is quite adaptable to electronic readout equipment.

5) Disadvantages and limitations

i) Cannot control drainage and thus cannot measure volume change or pore pressure.

ii) The area of sample changes as the test progresses.

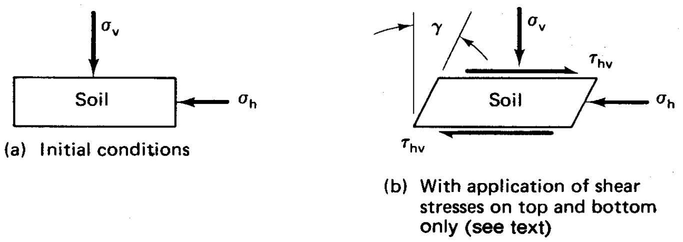
iii) The failure surface is predetermined as a plane.

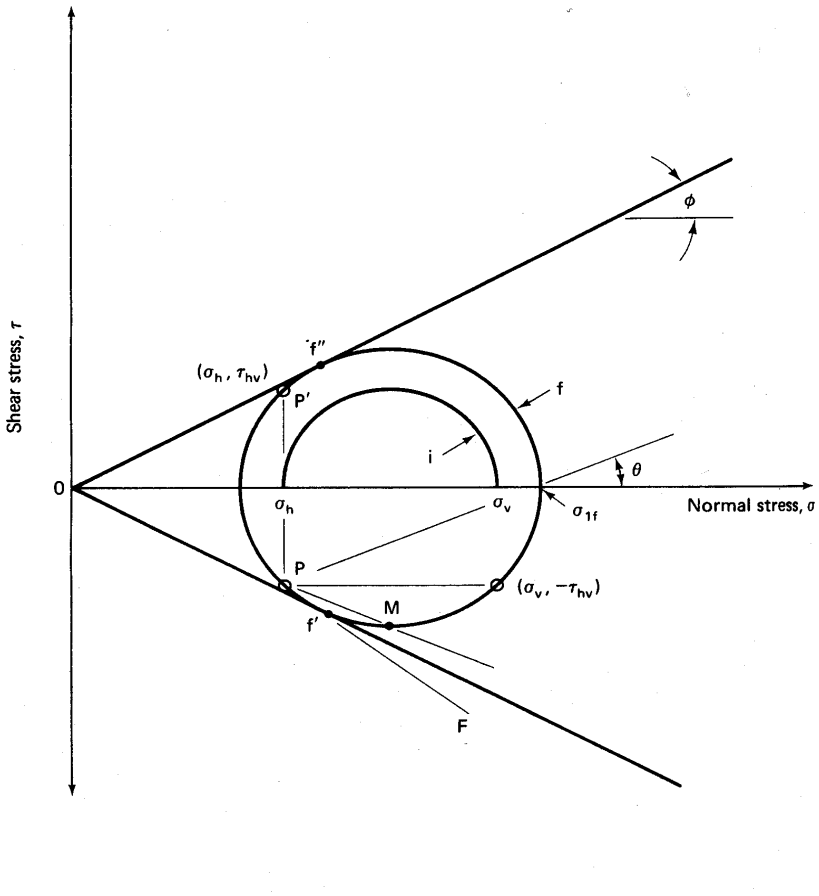
iv) The shearing stress is not uniformly distributed over the failure plane.

v) The test uses a small sample with the result so that preparation errors can become relatively important.

vi) Values of deformation modulus (E_s or G_s) cannot be determined.

6) Direct Simple Shear Test





i) The Direct simple shear uses a closed shear box fixed at the base with the top free to translate under a horizontal force. The shear box may

   a) Use hinged sides.

   b) Use a wire-reinforced rubber membrane for the sides.

ii) Direct simple shear test simulates the pure shear condition.

iii) Drainage condition can be controlled (partly).

iv) Cyclic stresses can be applied. ⇒ Particular application in liquefaction studies.

<u>Advantages</u>

1. Use in special design practice.
   s_u of soft clays for use in slope stability calculations.
2. K_0 consolidation.
3. Can be used for cyclic behaviors of soils.

$\phi'_{DSS} \approx \phi'_{TX}$ (sands)

$s_{u(TXE)} \leq s_{u(DSS)} \leq s_{u(TXC)}$ for NC to lightly OC clays

∗ Undrained Strength vs. Drained Strength

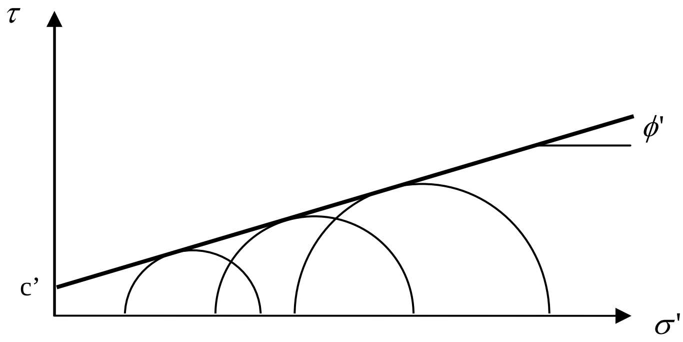
- drained strength : no u_e during loading. (volume change)

  ⬅ sands and clays for long-term stability

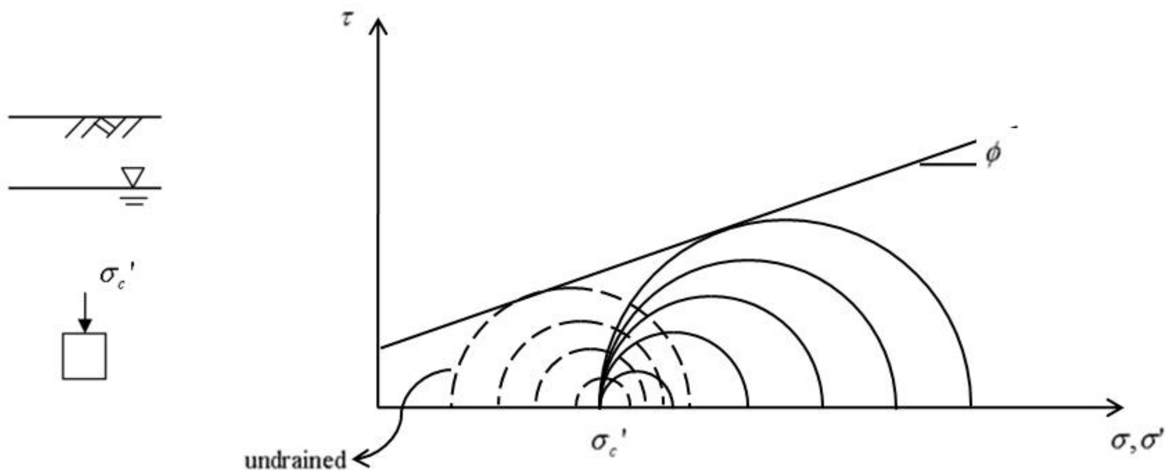
- undrained strength : no volume change during loading (➔ u_e)

  ⬅ clays at the end of construction

- Whatever drainage condition is, failure is governed by effective stress.

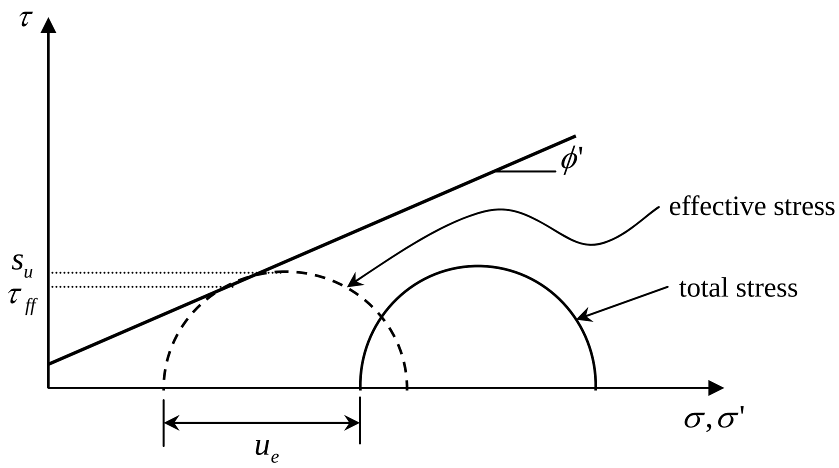


For TX condition,



drained strength parameter : c', ϕ'

undrained strength parameter : c_u or s_u



for τ_{ff} ➡ we must know ϕ' (and c') and we need to find out u_e.

But u_e cannot be determined from simple test.

(unconfined test or unconsolidated-undrained test).

⬇

use s_u