DIRECT SHEAR TEST

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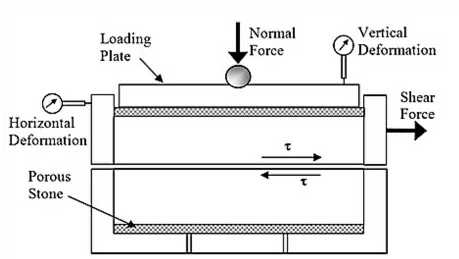
THEORY- CONCEPT:

The concept of direct shear is simple and mostly recommended for granular soils, sometimes on soils containing some cohesive soil content. The cohesive soils have issues regarding controlling the strain rates to drained or undrained loading. In granular soils, loading can always be assumed to be drained. A schematic diagram of the shear box shows that soil sample is placed in a square box which is split into upper and lower halves. Lower section is fixed and upper section is pushed or pulled horizontally relative to other section; thus, forcing the soil sample to shear/fail along the horizontal plane separating two halves. Under a specific Normal force, the Shear force is increased from zero until the sample is fully sheared (failed). The relationship between Normal stress and Shear stress at failure gives the failure envelope of the soil and provides the shear strength parameters (cohesion and internal friction angle).



NEED AND SCOPE:

The value of internal friction angle and cohesion of the soil is required for the design of many engineering structures such as foundations, retaining walls, bridges, and sheet piling. The direct shear test can provide these parameters quickly.

APPARATUS REQUIRED:

1) Direct shear box apparatus and Loading frame (motor attached).
2) Two Dial gauges, proving ring, Weighing Balance with an accuracy of 0.01g.
3) Sample Extractor (Undisturbed sample) / Sampler for preparation of a remolded sample of dimension (60mm*60mm*25mm).
4) Tamper, Straight edge, Spatula.
5) Filter paper
6) Two porous stones
7) Two corrugated metallic plates with perforation (drained) / metallic imperforated plates with corrugation (undrained)
8) Metallic Pressure pad

KNOWLEDGE OF EQUIPMENT:

Strain-controlled direct shear machine consists of a shear box, soil container, loading unit, proving ring, and dial gauge to measure shear deformation and vertical deformation. A proving ring is used to indicate the shear load taken by the soil along the shearing plane.

PROCEDURE:

1. Check the inner dimension of the soil sampler, and put the parts of the direct shear apparatus together.
2. Calculate the volume of the sampler. Weigh the sampler.
3. Place the soil inside the sampler in three smooth and equal layers. If the dense sample is desired, tamp the soil with appropriate equal number of blows in each layer for the required density.
4. After completing three layers, level the top layer and weigh the soil sampler with soil. Find the weight of wet soil and calculate the density of soil to confirm whether the required density is achieved.
5. Place the base plate in the shear box and perforated grid plate (for submerged condition) over it in such a way that the serrations of the grid plate are perpendicular to the direction of shear. Then, put the filter paper and place the soil specimen over it.
6. Lock the upper and lower half of the shear box with locking screws. After locking, place the upper filter paper, perforated grid plate, porous stone, and loading pad sequentially on the top of soil.
7. Create a small gap of approximately 1 mm between two parts of the shear box using spacing screws.
8. Place the whole assembly in the box of the loading frame and put the loading yoke on top of the loading pad.
9. Adjust the dial gauges and proving ring to zero position after setting up the specimen set up. Apply the desired normal stress say, 0.5 kg/cm^2, add water (if soaked condition) at the top of the direct shear box set up, and wait for at least 20 minutes to ensure saturation (until the reading in vertical dial gauge becomes constant) and then remove the locking screws.
10. Measure the final vertical dial gauge reading which measures the deformation in the vertical direction due to saturation.
11. Record the initial reading of the horizontal dial gauge and proving ring values before starting the shearing.
12. Check all adjustments to see that there is no connection between two parts except soil.
13. Set the strain-controlled frame to the required strain rate. Start the motor. Take the reading of the shear force in the proving ring with respect to the change in horizontal dial gauge reading and vertical deformation in vertical dial gauge till failure.
14. The steps from 1 to 13 have to be repeated for another two normal stresses (1.0 kg/cm^2 and 1.5 kg/cm^2).

DATA CALCULATION SHEET FOR DIRECT SHEAR TEST:

Normal stress =**0.5 kg/cm^2**

Size of the sample = 60 mm x 60 mm x 25 mm

Area of the sample (Cross Sectional) = 36 sq.cm

Volume of the sample = 90 cm^3

Weight of the sample (gm) = _________

Density of the sample (gm/cc) = _________

Water content (%) = _________

Least count of dial gauge (Horizontal) = _________

Least count of dial gauge (Vertical) = _________

Proving Ring No. = _________

Proving ring constant = _________

Normal stress (Kg/ sq.cm) = _________

Time (min)	1	2	3	4	5	6	10	15	20	25	30	35	40	45	50	55	60	90	120
Vertical Dial Reading																			

Horizontal Dial reading	20	40	60	80	100	120	140	160	180
Proving Ring Reading									
Shear Stress (Kg/sq.cm)									
Horizontal Dial reading	200	220	240	260	280	300	320	340	360
Proving Ring Reading									
Shear Stress (Kg/sq.cm)									
Horizontal Dial reading	380	400	420	440	460	480	500	520	540
Proving Ring Reading									
Shear Stress (Kg/sq.cm)									
Horizontal Dial reading	560	580	600	620	640	660	680	700	720
Proving Ring Reading									
Shear Stress (Kg/sq.cm)									
Horizontal Dial reading	740	760	780	800	820	840	860	880	900
Proving Ring Reading									
Shear Stress (Kg/sq.cm)									

**L.C – Least Count, P.R.C – Proving Ring Constant*

Water content calculation:

Name of container =
Weight of container, w_1=
Weight of container and wet soil, w_2 =
Weight of container and dry soil, w_3 =
Water content, (%) = $(w_2-w_3)/(w_3-w_1)*100$
=

Normal stress =**1.0 kg/cm²**

Size of the sample = 60 mm x 60 mm x 25 mm

Area of the sample (Cross Sectional) = 36 sq.cm

Volume of the sample = 90 cm^3

Weight of the sample (gm) = _________

Density of the sample (gm/cc) = _________

Water content (%) = _________

Least count of dial gauge (Horizontal) = _________

Least count of dial gauge (Vertical) = _________

Proving Ring No. = _________

Proving ring constant = _________

Normal stress (Kg/ sq.cm) = _________

Time (min)	1	2	3	4	5	6	10	15	20	25	30	35	40	45	50	55	60	90	120
Vertical Dial Reading																			

Horizontal Dial reading	20	40	60	80	100	120	140	160	180
Proving Ring Reading									
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Proving Ring Reading									
Shear Stress (Kg/sq.cm)									

Water content calculation:

Name of container =
Weight of container, w_1=
Weight of container and wet soil, w_2 =
Weight of container and dry soil, w_3 =
Water content, (%) = $(w_2-w_3)/(w_3-w_1)*100$
=

Normal stress =**1.5 kg/cm²**

Size of the sample = 60 mm x 60 mm x 25 mm

Area of the sample (Cross Sectional) = 36 sq.cm

Volume of the sample = 90 cm^3

Weight of the sample (gm) = _________

Density of the sample (gm/cc) = _________

Water content (%) = _________

Least count of dial gauge (Horizontal) = _________

Least count of dial gauge (Vertical) = _________

Proving Ring No. = _________

Proving ring constant = _________

Normal stress (Kg/ sq.cm) = _________

Time (min)	1	2	3	4	5	6	10	15	20	25	30	35	40	45	50	55	60	90	120
Vertical Dial Reading																			

Horizontal Dial reading	20	40	60	80	100	120	140	160	180
Proving Ring Reading									
Shear Stress (Kg/sq.cm)									
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Water content calculation:

Name of container =
Weight of container, w_1=
Weight of container and wet soil, w_2 =
Weight of container and dry soil, w_3 =
Water content, (%) = $(w_2-w_3)/(w_3-w_1)*100$
=

CALCULATIONS:

1. Shear stress (τ) on the horizontal failure plane is calculated as $\tau = S/A$; Where S is shear force. A is the horizontal cross-sectional area of the sample, which decreases slightly with the horizontal deformations.

2. Corrected area (A_{corr}) needs to be calculated for calculating the shear stress at failure. $A_{corr} = A_0 * (1-\delta/6)$, where δ is horizontal displacement due to the shear force applied to the specimen. A_0 is the initial area of the soil specimen. A_0 and δ are in cm.

3. i. Shear Stress = (Proving ring reading x Proving ring constant)/A_{corr}
   ii. Horizontal displacement = Horizontal dial gauge reading x Least count of horizontal dial gauge
   iii. Vertical displacement = Vertical dial gauge reading x Least count of vertical dial gauge

4. Shear stress at failure needs to be calculated for all three tests performed at three different normal stresses to plot the failure envelope.

GENERAL REMARKS:

1. In the shear box test, the specimen is not failing along its weakest plane but along a predetermined or induced failure plane i.e., horizontal plane separating the two halves of the shear box. This is the main drawback of this test. Moreover, during loading, the state of stress cannot be evaluated. It can be evaluated only at failure condition i.e.; Mohr’s circle can be drawn at the failure condition only. Also, failure is progressive.
2. Direct shear test is simple and faster to operate. As thinner specimens are used in shear box, they facilitate drainage of pore water from a saturated sample in less time. This test is also useful to study friction between two materials – one material in lower half of box and another material in the upper half of box.
3. The angle of shearing resistance of sands depends on the state of compaction, coarseness of grains, particles, shape, roughness of grain surface, and grading. It varies between 28^o (uniformly graded sands with round grains in very loose state) to 46^o (well-graded sand with angular grains in dense state).
4. The volume change in sandy soil is a complex phenomenon depending on gradation, particle shape, state and type of packing, orientation of principal planes, principal stress ratio, stress history, magnitude of minor principal stress, type of apparatus, test procedure, method of preparing specimen, etc. In general, loose sands contract and dense sands expand in volume on shearing. Expansion or contraction can be inferred from the movement of vertical dial gauge during shearing.
5. The friction between sand particles is due to sliding and rolling friction and interlocking action.

The ultimate values of shear parameter for both loose sand and dense sand approximately attain the same value so, if angle of friction value is calculated at ultimate stage, slight disturbance in density during sampling and preparation of test specimens will not have much effect.