



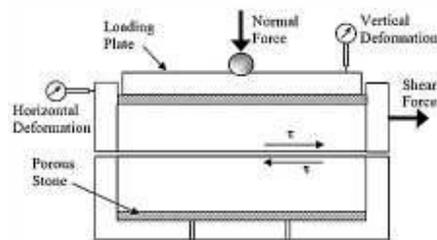
**INDIAN INSTITUTE OF TECHNOLOGY GANDHINAGAR**  
**Department of Civil Engineering**  
**Soil Mechanics Laboratory**

**DIRECT SHEAR TEST**

**(IS-2720-PART-13-1986) Reaffirmed-2002**

**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 assumed to be drained. A schematic diagram of 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. The relationship of Normal stress and Shear stress at failure gives the failure envelope of the soil and provide the shear strength parameters (cohesion and internal friction angle).



**NEED AND SCOPE:**

The value of internal friction angle and cohesion of the soil are required for design of many engineering problems such as foundations, retaining walls, bridges, sheet piling. Direct shear test can predict these parameters quickly.

**APPARATUS REQUIRED:**

- 1) Direct shear box apparatus and Loading frame (motor attached).
- 2) Two Dial gauges, Proving ring, Weighing Balance with accuracy of 0.01g.
- 3) Sample Extractor (Undisturbed sample) / Sampler for preparation of 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 shear box, soil container, loading unit, proving ring, 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.



**INDIAN INSTITUTE OF TECHNOLOGY GANDHINAGAR**  
**Department of Civil Engineering**  
**Soil Mechanics Laboratory**

**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 layers (approximately 10 mm thick each before tamping). If 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 the obtainment of required density.
5. Place the soil specimen inside the direct shear apparatus and put the upper porous stone, pressure pad and loading block on top of soil.
6. Adjust the dial gauges and proving ring to zero position after setting up the specimen set up. Apply the desired normal stress say  $0.5 \text{ kg/cm}^2$ , add water at the top of direct shear box set up and wait for at least 20 minutes to ensure saturation and Remove the shear pin.
7. Measure the final vertical dial gauge reading which measures the deformation in vertical direction due to saturation.
8. Record the initial reading of the dial gauge and proving ring values before starting the shearing.
9. Check all adjustments to see that there is no connection between two parts except sand/soil.
10. Fix the strain controlled frame to the required strain rate. Start the motor. Take the reading of the shear force in proving ring with respect to the change in horizontal dial gauge reading and vertical deformation in vertical dial gauge till failure.
11. The steps from 1 to 10 has to be repeated for another two normal stresses ( $1.0 \text{ kg/cm}^2$  and  $1.5 \text{ kg/cm}^2$ ).



**INDIAN INSTITUTE OF TECHNOLOGY GANDHINAGAR**  
**Department of Civil Engineering**  
**Soil Mechanics Laboratory**

**DATA CALCULATION SHEET FOR DIRECT SHEAR TEST:**

Normal stress = **0.5 kg/cm<sup>2</sup>**

Size of the sample = 60 mm x 60 mm x 25 mm                      Least count of dial gauge (Horizontal) = \_\_\_\_\_  
 Area of the sample (Cross Sectional ) = 36 sq.cm                      Least count of dial gauge (Vertical) = \_\_\_\_\_  
 Volume of the sample = 90 cm<sup>3</sup>                      Proving Ring No. = \_\_\_\_\_  
 Weight of the sample (gm) = \_\_\_\_\_                      Proving ring constant = \_\_\_\_\_  
 Density of the sample (gm/cc) = \_\_\_\_\_                      Normal stress (Kg/ sq.cm) = \_\_\_\_\_  
 Water content (%) = \_\_\_\_\_

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, w1 = \_\_\_\_\_  
 Weight of container and wet soil, w2 = \_\_\_\_\_  
 Weight of container and dry soil, w3 = \_\_\_\_\_  
 Water content, (%) =  $(w2-w3)/(w3-w1)*100$   
 = \_\_\_\_\_



**INDIAN INSTITUTE OF TECHNOLOGY GANDHINAGAR**  
**Department of Civil Engineering**  
**Soil Mechanics Laboratory**

Normal stress = **1.0 kg/cm<sup>2</sup>**

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

Least count of dial gauge (Horizontal) = \_\_\_\_\_

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

Least count of dial gauge (Vertical) = \_\_\_\_\_

Volume of the sample = 90 cm<sup>3</sup>

Proving Ring No. = \_\_\_\_\_

Weight of the sample (gm) = \_\_\_\_\_

Proving ring constant = \_\_\_\_\_

Density of the sample (gm/cc) = \_\_\_\_\_

Normal stress (Kg/ sq.cm) = \_\_\_\_\_

Water content (%) = \_\_\_\_\_

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)									

**Water content calculation:**

Name of container = \_\_\_\_\_  
 Weight of container, w1 = \_\_\_\_\_  
 Weight of container and wet soil, w2 = \_\_\_\_\_  
 Weight of container and dry soil, w3 = \_\_\_\_\_  
 Water content, (%) =  $(w2-w3)/(w3-w1)*100$   
 = \_\_\_\_\_



**INDIAN INSTITUTE OF TECHNOLOGY GANDHINAGAR**  
**Department of Civil Engineering**  
**Soil Mechanics Laboratory**

Normal stress = **1.5 kg/cm<sup>2</sup>**

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

Least count of dial gauge (Horizontal) = \_\_\_\_\_

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

Least count of dial gauge (Vertical) = \_\_\_\_\_

Volume of the sample = 90 cm<sup>3</sup>

Proving Ring No. = \_\_\_\_\_

Weight of the sample (gm) = \_\_\_\_\_

Proving ring constant = \_\_\_\_\_

Density of the sample (gm/cc) = \_\_\_\_\_

Normal stress (Kg/ sq.cm) = \_\_\_\_\_

Water content (%) = \_\_\_\_\_

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)									

**Water content calculation:**

Name of container = \_\_\_\_\_  
 Weight of container, w1 = \_\_\_\_\_  
 Weight of container and wet soil, w2 = \_\_\_\_\_  
 Weight of container and dry soil, w3 = \_\_\_\_\_  
 Water content, (%) =  $(w2-w3)/(w3-w1)*100$   
 = \_\_\_\_\_



**INDIAN INSTITUTE OF TECHNOLOGY GANDHINAGAR**  
**Department of Civil Engineering**  
**Soil Mechanics Laboratory**

**CALCULATIONS:**

1. Shear stress ( $\tau$ ) on the horizontal failure plane are calculated as  $\tau = S/A$ ; Where S is shear force. A is the 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.  $A_{corr} = A_0 - (6 \cdot \delta)$ , where  $\delta$  is horizontal displacement due to shear force applied on specimen.  $A_0$  is the initial area of the soil specimen.  $A_0$  and  $\delta$  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 state of compaction, coarseness of grains, particle shape and roughness of grain surface and grading. It varies between  $28^\circ$  (uniformly graded sands with round grains in very loose state) to  $46^\circ$  (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 expand and dense sands contract in volume on shearing. There is a void ratio at which either expansion contraction in volume takes place. This void ratio is called critical void ratio. 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.