DIRECT SHEAR TEST

SOIL MECHANICS

SOIL MECHANICS LABORATORY
DEPARTMENT OF CIVIL
ENGINEERING
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DIRECT SHEAR TEST

OBJEVTIVES

To determine the shear strength parameters for a given soil using the direct shear test.

INTRODUCTION

The test is carried out on either undisturbed samples or remoulded samples. To facilitate the remoulding purpose, a soil sample may be compacted at optimum moisture content in a compaction mould. Then specimen for the direct shear test could be obtained using the correct cutter provided. Alternatively, sand sample can be placed in a dry state at a required density, in the assembled shear box.

A normal load is applied to the specimen and the specimen is sheared across the pre-determined horizontal plane between the two halves of the shear box. Measurements of shear load, shear displacement and normal displacement are recorded. The test is repeated foe two or more identical specimens under different normal loads. From the results, the shear strength parameters can be determined.

THEORY

The strength of a soil depends of its resistance to shearing stresses. It is made up of basically the components;

1. Frictional – due to friction between individual particles.
2. Cohesive - due to adhesion between the soil particles

The two components are combined in Colulomb's shear strength equation,

$$\tau_f = c + \sigma_f \tan \varnothing$$

Where τ_f = shearing resistance of soil at failure

c = apparent cohesion of soil

σ_f = total normal stress on failure plane

$\varnothing$ = angle of shearing resistance of soil (angle of internal friction)

This equation can also be written in terms of effective stresses.

$$\tau_f = c' + \sigma'_f \tan \phi'$$

Where c' = apparent cohesion of soil in terms of effective stresses

σ'_f = effective normal stress on failure plane

ϕ' = angle of shearing resistance of soil in terms of effective stresses

$\sigma'_f = \sigma_f - u_f$

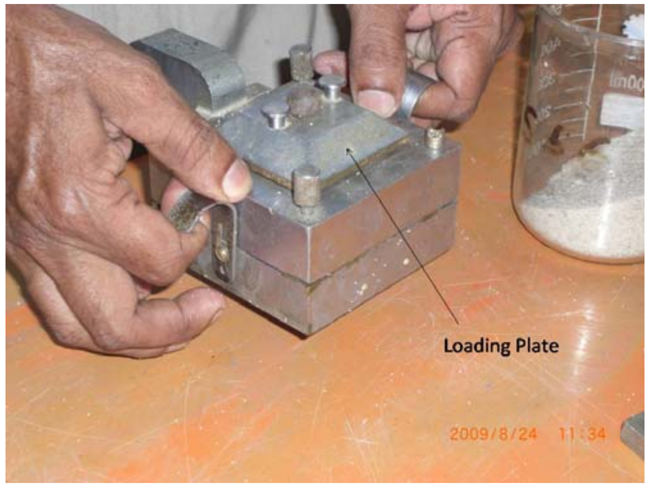
u_f = pore water pressure on failure plane

PROCEDURE

1. Assemble the shear box

2. Compact the soil sample in mould after bringing it to optimum moisture condition
3. Carefully transfer the sample into shear box

4. Place the loading plate on top of the upper porous plate. After recording the weight of the loading carrier place it is on the loading cap.



5. Position all dial gauges and set the readings to zero. Remove the alignment screws which hold two halves of the shear box together
6. Tighten the remaining, two diagonally opposite screws, until there is a small gap between upper and lower boxes to reduce the frictional force
7. Apply the desired normal load. If there is any vertical displacement, wait till the dial gauges indicate a constant reading and then reset the dial gauge to zero
8. Check that screws have been removed and then start the motor to produce the desired constant rate of shearing

9. Take readings of,
    a) Shear load from the proving ring
    b) Shear displacement (i.e. Horizontal displacement)
    c) Vertical displacement at every 10 division increment in horizontal dial gauge
10. Stop the test when the shear load starts to reduce or remains constant for at least three readings
11. Remove the soil and repeat the procedure with different normal loads at least for another two samples

COMPUTATION

1. For each specimen plot the following;
    a. Shear stress Vs shear displacement
    b. Normal displacement Vs shear displacement
    c. Void ratio Vs shear displacement

2. Plot the graph of shear strength Vs normal stress for the three specimens and calculate the shear strength parameters for the soil.

REPORT

Your report should include a brief but accurate description of the test procedure and all the above mentioned graphs. Also it should include a discussion of the followings;

a) Importance of the shear strength in soil
b) The normal displacement behavior of the specimen during shearing
c) Different types of shear tests
d) The main advantages and disadvantages of shear box test
e) Reliability of the results and the factors most likely to influence the reliability

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Direct Shear Test Results	
Load Deformation Readings	
Project :	
Sample No. :	
Type of Test :	
Proving reading Constant = Normal Load Applied =	Vertical Dial Gauge Constant : Horizontal Dial Gauge Constant :
Moisture Content Determination	Mass of Wet sample + Can (g) = Mass of Dry sample + Can (g) = Mass of Can (g) = Moisture Content (%) =

Shear Disp. div.	Proving Ring reading	Vertical Dis. (mm)	Change in Void Ratio	Void Ratio	Shear force (kg)	Shear Stress (kN/m^2)
0						
10						
20						
30						
40						
50						
75						
100						
125						
150						
175						
200						
225						
250						
275						
300						
325						
350						
375						
400						
425						
450						
475						
500						

TEST :3

Normal Stress = 150 kN/m^2

Observations :

Weight of shear box without sand	W_1	=
Weight of shear box with sand	W_2	=
Top plate dimensions	H_{t1},H_{t2}	=
Bottom plate dimensions	H_{b1},H_{b2}	=
Shear box dimensions		= 60mm X 60 mm
Internal height of the shear box (without sand)	H_1	=
Internal height of the shear box (with sand)	H_2	=

Calculations:

Thickness of the soil sample, H	$= H_1-H_2-(H_{b2}-H_{b1})/2-H_{t2}+(H_{t2}-H_{t1})/2$
	=
	=
Volume of the soil, V	=
Weight of the soil sample, W	$= W_1-W_2$
Dry Density of Soil sample, γ_d	= W/V =
Initial Void ratio, e_0	$= G_S\gamma_w/\gamma_d - 1$; $G_S = 2.65$
	=
	=

Specimen calculation for Vertical displacement/ Void ratio

01 div. of vertical dial gauge reading	= 0.001x25.4mm
	= 0.0254mm
Corresponding Void ratio change, Δe	$= \Delta H\,(1+e_0)/H$
	=
Corresponding Void ratio $e = e_0 - \Delta e$	=
	=

Specimen calculation for Shear displacement

01 div. of horizontal dial gauge reading	= 0.01mm

Specimen calculation for Shear Force/ Shear stress

01 div. of Proving ring reading	=
	=
Area correction for shear displacement	=
Eg. For shear displacement …… div =	area =
Corresponding proving ring reading is	=
Shear stress	=

TEST :1

Normal Stress = 50 kN/mm^2

Observations :

Weight of shear box without sand	W_1	=	2.665
Weight of shear box with sand	W_2	=	2.910
Top plate dimensions	H_{t1},H_{t2}	=	1.70mm, 3.44mm
Bottom plate dimensions	H_{b1},H_{b2}	=	1.74mm, 3.26mm
Shear box dimensions		=	60mm X 60 mm
Internal height of the shear box (without sand)	H_1	=	43.60 mm
Internal height of the shear box (with sand)	H_2	=	0mm

Calculations:

Thickness of the soil sample, H	=	H_1-H_2-(H_{b2}- H_{b1})/2- H_{t2}+(H_{t2}- H_{t1})/2
	=	43.60-(3.26-1.74)/2-3.44+(3.44-1.70)/2
	=	40.27mm
Volume of the soil, V	=	60x60x40.27 mm^3
	=	$1.45x10^{-4}$ m^3
Weight of the soil sample, W	=	W_1-W_2
	=	2.910-2.665 kg = 0.245 kg
Dry Density of Soil sample, γ_d	=	W/V = 0.245 /$1.45x10^{-4}$ kg/ m^3
Initial Void ratio, e_0	=	$G_S\gamma_w/ \gamma_d - 1$; $G_S = 2.65$
	=	$2.65x10^3$/1689.66 - 1
	=	0.568

Specimen calculation for Vertical displacement/ Void ratio

01 div. of vertical dial gauge reading	=	0.001x25.4mm
	=	0.0254mm
Corresponding Void ratio change, Δe	=	ΔH (1+ e_0)/H
	=	0.0254(1+0.568)/40.27
	=	$0.989x10^{-3}$
Corresponding Void ratio $e = e_0 - \Delta e$	=	0.568 - $0.989x10^{-3}$
	=	0.567

01 div. of horizontal dial gauge reading	= 0.01mm

Specimen calculation for Shear Force/ Shear stress

01 div. of Proving ring reading	=	0.6lbs
	=	0.6/2.206 kg
	=	0.272 kg
Area correction for shear displacement		
Eg. For shear displacement 200 div = 2mm		area = 60 x (60-2) = 3480 mm^2
Corresponding proving ring reading is	=	6 div = 6 x 0.272 kg = 1.632 kg
Shear stress	=	1.632/3480 kg/mm^2
	=	4.60 kN/m^2

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Direct Shear Test Results							
Load Deformation Readings							
Project :							
Sample No. :							
Type of Test :							
Proving reading Constant = 0.6lbs/div. Normal Load Applied = 18.34 kg (50 kN/m^2)				Vertical Dial Gauge Constant = 0.001" Horizontal Dial Gauge Constant = 0.01mm			
Moisture Content Determination				Mass of Wet sample + Can (g) = Mass of Dry sample + Can (g) = Mass of Can (g) = Moisture Content (%) =			
Shear Disp. div.	Proving Ring reading	Vertical Gauge Reading	Vertical Dis. (mm)	Change in Void Ratio	Void Ratio	Shear force (kg)	Shear Stress (kN/m^2)
0	0	0	0	0.00000	0.56800	0.00000	0
10	1	-0.5	-0.0127	-0.00049	0.56849	0.27199	0.756777
20	2	-1	-0.0254	-0.00099	0.56899	0.54397	1.516084
30	2.5	-2	-0.0508	-0.00198	0.56998	0.67996	1.89828
40	3	-2	-0.0508	-0.00198	0.56998	0.81596	2.281758
50	3.5	-2	-0.0508	-0.00198	0.56998	0.95195	2.666524
75	4	-2.5	-0.0635	-0.00247	0.57047	1.08794	3.060315
100	4.5	-3.5	-0.0889	-0.00346	0.57146	1.22393	3.457443
125	5	-4.5	-0.1143	-0.00445	0.57245	1.35993	3.85795
150	5.5	-5.5	-0.1397	-0.00544	0.57344	1.49592	4.261881
175	6	-6.5	-0.1651	-0.00643	0.57443	1.63191	4.669279
200	6	-7.5	-0.1905	-0.00742	0.57542	1.63191	4.689405
225	6	-8.5	-0.2159	-0.00841	0.57641	1.63191	4.709706
250	6	-9.5	-0.2413	-0.00940	0.57740	1.63191	4.730183
275	6	-10.5	-0.2667	-0.01038	0.57838	1.63191	4.750838
300	6	-11.5	-0.2921	-0.01137	0.57937	1.63191	4.771675
325	6	-12	-0.3048	-0.01187	0.57987	1.63191	4.792696
350	6	-12	-0.3048	-0.01187	0.57987	1.63191	4.813903
375	6	-12	-0.3048	-0.01187	0.57987	1.63191	4.835298
400	6	-12	-0.3048	-0.01187	0.57987	1.63191	4.856884
425							
450							
475							
500							

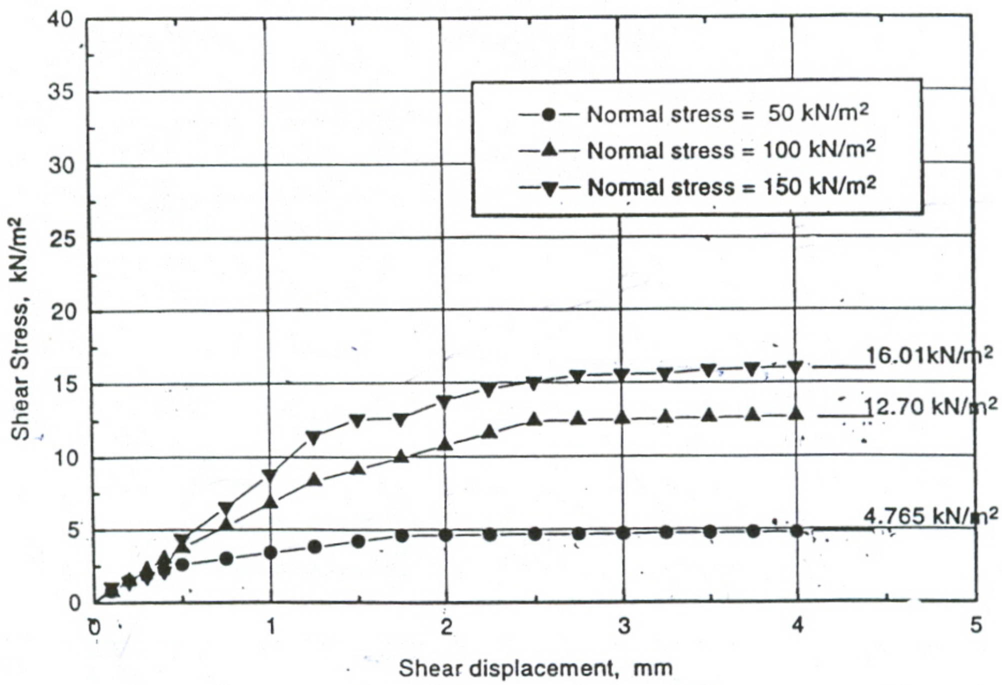

Figure 1. Shear stress vs Shear Displacement

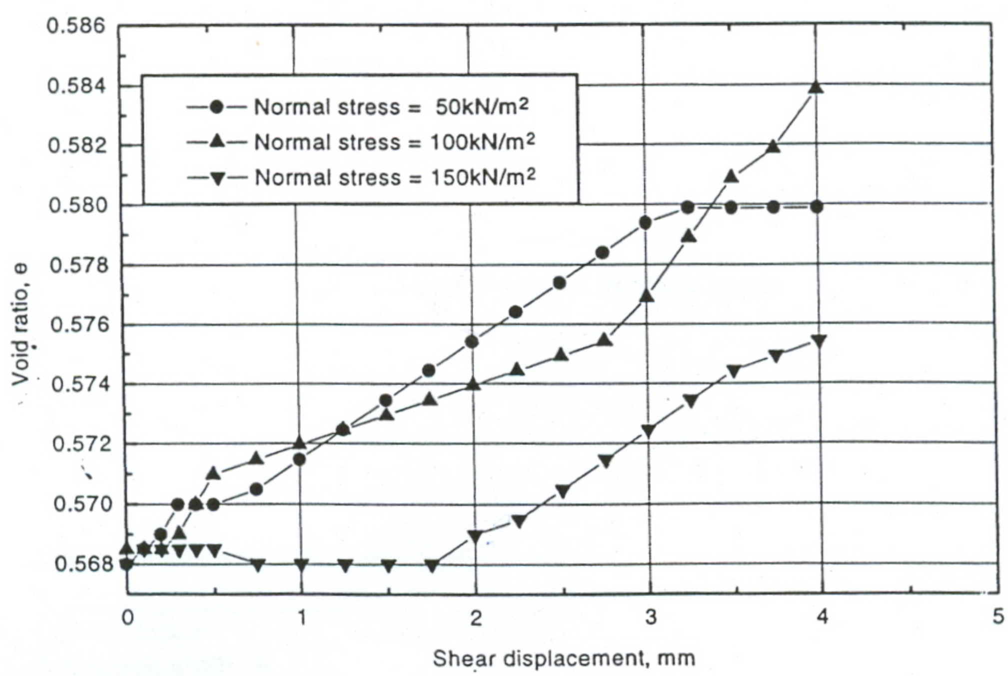

Figure 2. Void ratio vs Shear Displacement

From Figure. 1; Variation of Shear strength of sand with Normal Shear Stress can be obtained as follows.

Normal Stress, σ kN/m²	Shear stress at failure, τ kN/m²
50	4.765
100	12.70
150	16.01

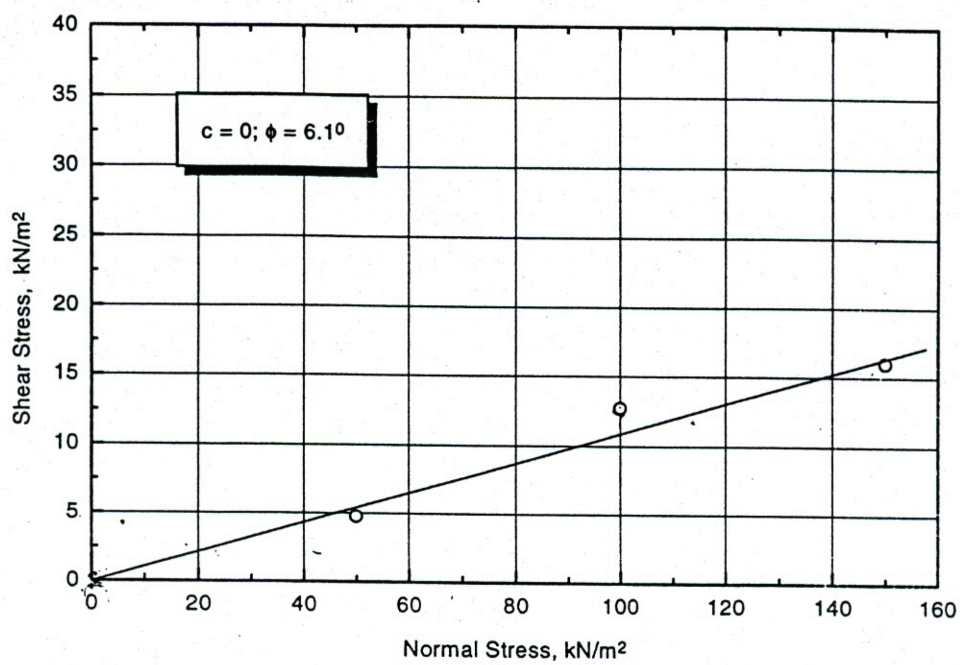

Figure 3. Shear Stress vs. Normal Stress

Results

Shear Strength parameters for Soil used in this test

Cohesion, c	**= 0 kN/m²**
Friction angle, ϕ	**= 6.1⁰**