جامعة بيرزيت

BIRZEIT UNIVERSITY

Faulty of Engineering and Technology

Civil Engineering Department

Soil Lab

ENCE311

Experiment #7 :

" Direct Shear Test "

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Contents :

Introduction :

Shear strength is defined as the resistance of a soil to the induced shear strain. Shear strength is not a fundamental property in soils as it depends on the in-situ conditions, such as density, moisture, stress state etc. The value measured in the laboratory is likewise dependent upon the conditions imposed during the test and in some instances upon the duration of the test. Therefore, it is important to apply similar conditions in the laboratory as in the field.

Failure in soils usually occurs on a specific surface (shear plane) in opposition to other material, like concrete or metals. The failure occurs when the shear stress, acting parallel to that surface, exceeds the shear strength. In the case of shear stress acting on a body, the deformation which is produced is called shear strain. In direct shear tests, shear strain is measured as the displacement between the two portions of the soil specimen.

$$S = \sigma' \times \tan \phi$$

Where:

S: is the shear stress of a given soil.

σ': is the effective normal stress.

ϕ: is the angle of friction of the soil.

The angle of friction, ϕ , is a function of the relative density, of compaction of sand, grain size, shape and distribution in a given soil mass, For a given sand, an increase in the void ratio (i.e., a decrease in the relative density of compaction) will result in a decrease of the magnitude of ϕ. However, for a given void ratio, an increase in the angularity of the soil particles will give a higher value of the soil friction angle. The general range of the angle of friction of sand with relative density Classification of the soil according to (ϕ) .

Round-grained sand	ϕ (degree)	Angular-grained sand	ϕ (degree)2
Loose	28-32	Loose	30-36
Medium	30-35	Medium	34-40
Dense	34-38	Dense	40-45

Purpose:

To determine the shear strength parameters for a given soil sample using the direct shear apparatus in the laboratory

Some of the advantages of the direct shear tests are :

• Direct measurement of shear strength

• Basic principles are easily understood

• Relatively easy testing procedure

• Almost all soil types can be tested

• Partially saturated soil specimens can be tested with the appropriate equipment

Materials and Equipment's :

Look at the **" Table 1 "** that show the equipment we used in this experiment :

Equipment	The name of it :	Equipment	The name of it :
 Figure 1	**A sample of sand**	 Figure 2	**Direct shear test machine**
 Figure 3	**Brush for cleaning**	 Figure 4	**Mold**
 Figure 5	**Aluminium Mold**	 Figure 6	**Tamper**
 Figure 7	**Balance**	 Figure 8	**Stop Watch**

Table 1

Procedure :

- A sample of sand was taken and weighted.
- A little of water was added to the sand to give it a cohesion because it's cohesionless
- The sand sample was put in shear box as a layers, and after every layer, the sand was compacted.
- The shear box was put in the shear machine.
- The normal load was applied on the specimen.
- The two vertical pines holding at the end of the mold was removed.
- The horizontal and vertical gauge was used to measure the displacement during the test.
- The horizontal load was applied to the shear box.
- The data still taken until the failure happened, and the failure was happened when the gauge stopped.

Data and Calculations :

Data :

Trial 1				Trial 2				Trial 3			
hor. Disp.	**Load ring**	**Shear force**	**Shear stress**	**hor. Disp.**	**Load ring**	**Shear force**	**Shear stress**	**hor. Disp.**	**Load ring**	**Shear force**	**Shear stress**
Divs	**Divs.**	**N**	**KPa**	**Divs**	**Divs.**	**N**	**KPa**	**Divs**	**Divs.**	**N**	**KPa**
0	0	0	0	0	0	0	0	0	0	0	0
10	1	20	5.56	10	3	50	13.89	10	11	180	50
20	1.1	21	5.83	20	4	70	19.44	20	13	220	61.1
30	1.8	28	7.78	30	4.8	78	21.67	30	14	230	63.9
40	2	30	8.33	40	5	80	22.22	40	15	250	69.4
50	2	30	8.33	50	5.3	86	23.89	50	16	270	75
60	2.1	32	8.89	60	5.8	96	26.67	60	17	280	77.8
70	2.3	36	10	70	6	100	27.78	70	19	320	88.9
80	2.3	36	10	80	6.4	108	30	80	19	320	88.9
90	2.5	40	11.11	90	7.4	124	34.44	90	19	320	88.9
100	2.5	40	11.11	100	9.5	160	44.44	100	20	330	91.7
110	2.5	40	11.11	110	13	220	61.11	120	20	330	91.7
120	2.5	40	11.11	120	15.8	266	73.89	140	21	350	97.2
130	2.5	40	11.11	130	17.9	298	82.78	160	22	370	102.78
--	--	--	--	--	--	--	--	180	23	380	105.56
--	--	--	--	--	--	--	--	200	24	400	111.11

Trial 4			
hor. Disp.	**Load ring**	**Shear force**	**Shear stress**
Divs	**Divs.**	**N**	**KPa**
10	13	220	61.1
20	14	230	63.9
30	17	280	77.8
40	25	420	116.7
50	36	600	166.7
60	48	800	222.2
70	61	1020	283.3
80	77	1290	358.3
90	93	1560	433.3
100	109	1830	508.3
120	147	2470	686.1

	Trial 1	**Trial 2**	**Trial 3**	**Trial 4**
L(cm)	6	6	6	6
H(cm)	2	2	2	2
W(cm)	6	6	6	6
W_1 (gm)	146.5	146.5	145	145
W_2 (gm)	273	274.5	274.1	275
$W_2 - W_1$ (gm)	126.5	128	129.1	130
γ_d ($\frac{KN}{m^3}$)	17.24	17.44	17.59	17.71

Calculations :

Normal Stress :

For Trial 1 : $\sigma = \frac{10\ N}{36*10^{-4}\ mm^2}$ = 2.77 KPa

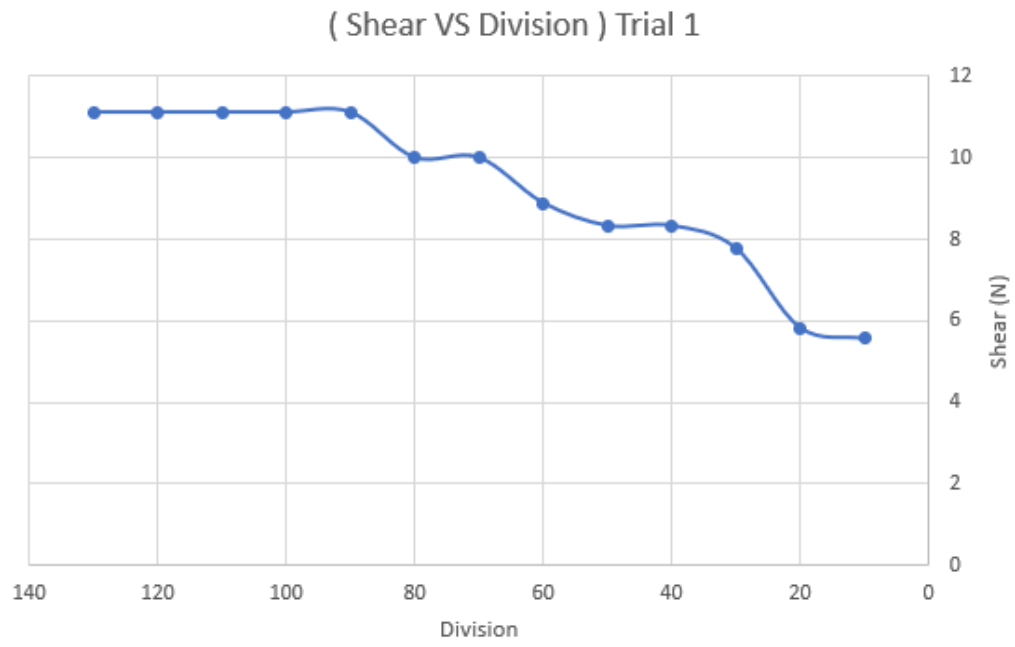
For Trial 2 : $\sigma = \frac{30\ N}{36*10^{-4}\ mm^2}$ = 8.33 KPa

For Trial 3 : $\sigma = \frac{60\ N}{36*10^{-4}\ mm^2}$ = 16.67 KPa

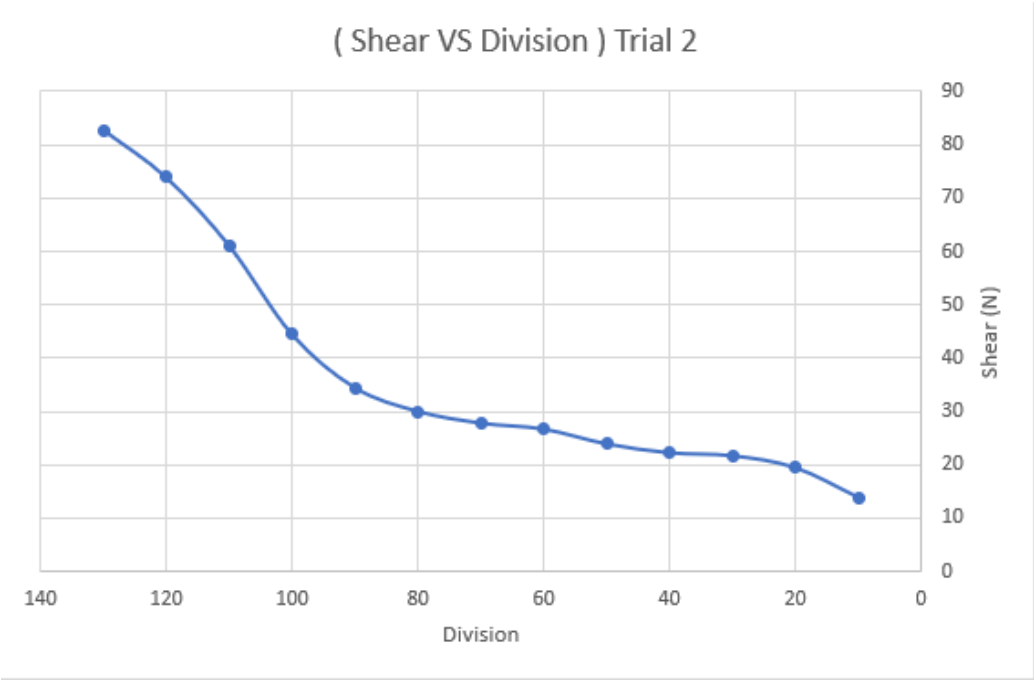
For Trial 4 : $\sigma = \frac{90\ N}{36*10^{-4}\ mm^2}$ = 25 KPa

Figures of (Shear VS Division) For All Trials :

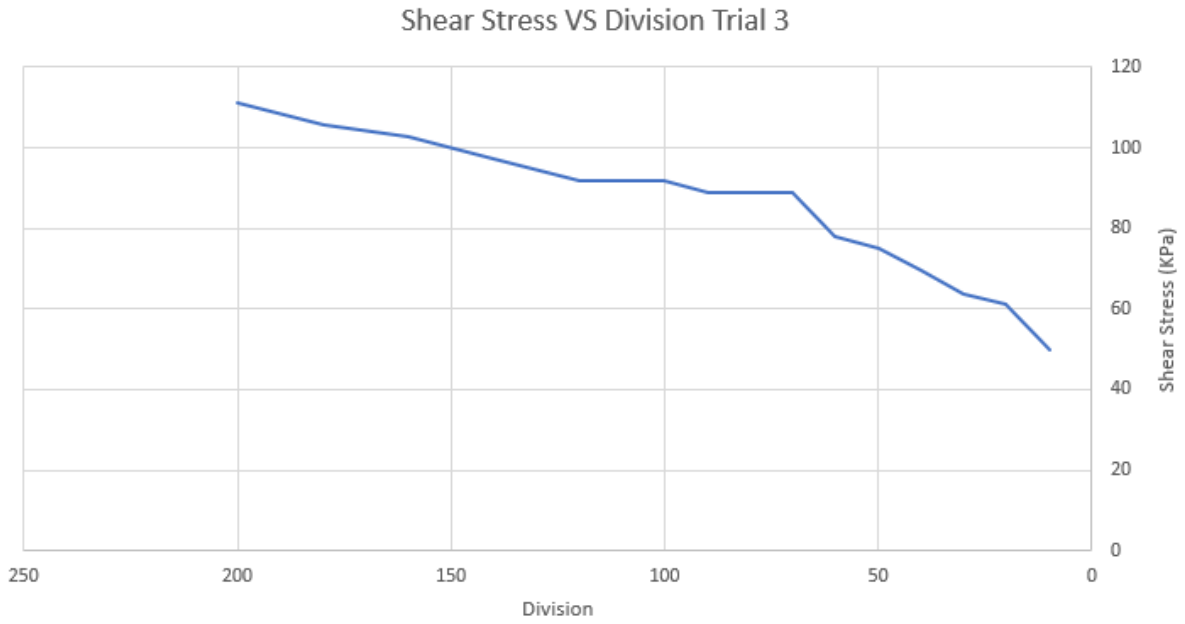
Trial 1 : τ_{max} = 11.1 KPa



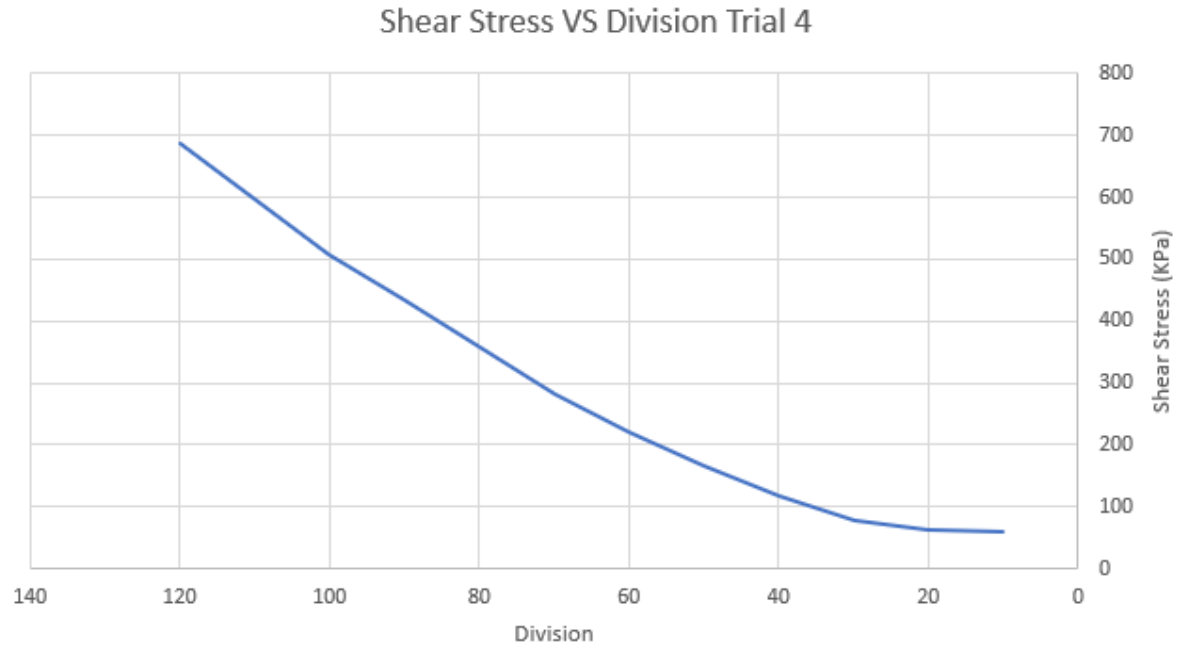
Trial 2 : τ_{max} = 82.78 KPa



Trial 3 : τ_{max} = 111.11 KPa

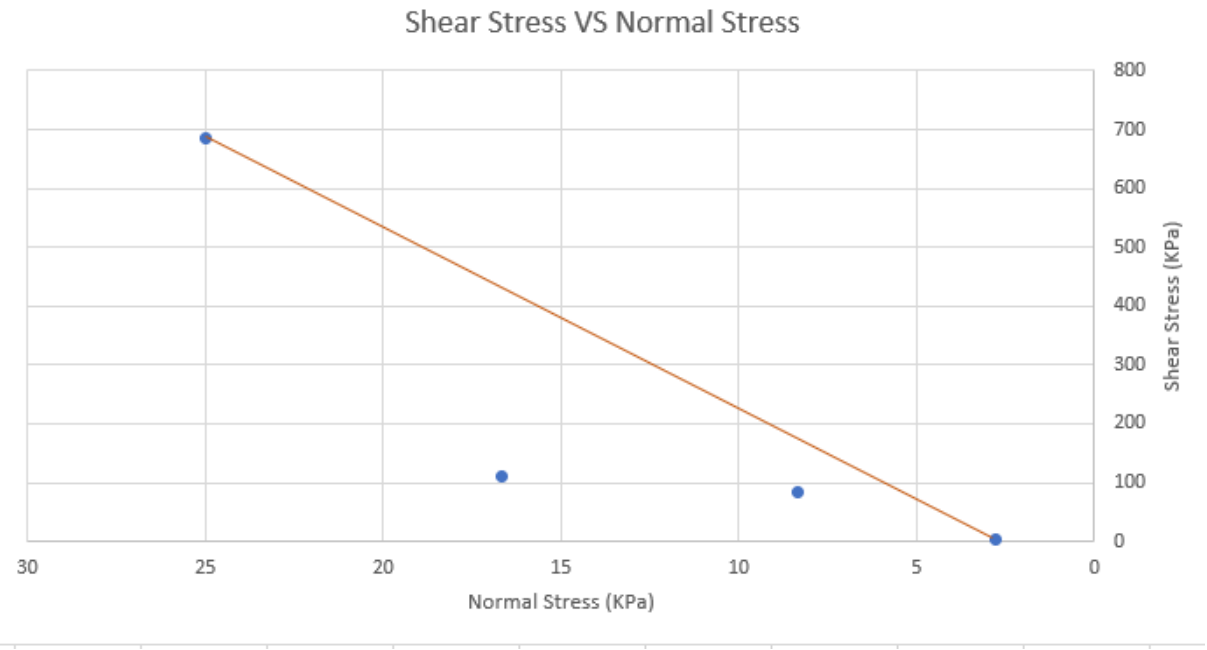


Trial 4 : τ_{max} = 686.1 KPa



	Trial 1	Trial 2	Trial 3	Trial 4
Normal Stress (KPa)	2.77	8.33	16.67	25
Shear Stress (KPa)	11.1	82.78	111.11	686.1

Figure of (Shear Stress VS Normal Stress) :



- Slope = $\frac{686.1-500}{25-18}$ = 26.6
- $Y - y_1 = m (X - x_1)$

  $Y = 26.6 X + 21.2$

  $\Phi = \tan^{-1}(\frac{500}{18}) = 87.94°$

Results and Conclusion :

Results :

Slope = 26.6

Φ = 87.94°

Conclusion :

From the results, it can be observed that the shear stress increase with the increase the applied normal stress, and for the same normal stress the shear stress varied highly with respect to strain rate.

The direct shear test results basically shows the variation of the angle of internal friction with respect to both strain rate and density. This effect of strain rate to be decreasing with a corresponding increase in the density of the sand.

In general, the angle of internal friction is found to increase with increasing strain rate at which the direct shear test is performed. In comparison to the sand with higher relative density, this effect is observed to be more on sand with lower relative density.

Sources of errors :

- The sample is not placed on the device in the correct way .
- The two vertical pines wasn't be removed .
- The time calculated when the sample reaches failure is not accurate .

References :

- Soil lab manual