INDIAN INSTITUTE OF TECHNOLOGY, KANPUR
CIVIL ENGINEERING DEPARTMENT
GEOTECHNICAL ENGINEERING LABORATORY

VISUAL SOIL IDENTIFICATION

Sl. No.	Colour	Odour	Texture	Dilatancy	Grain Properties	Volume Change	Type Of Soil
	1	2	3	4	5	6	7
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

- Distinctive dark colour indicates organic matter.
- Fresh wet organic soils usually have a distinctive odour of decomposed organic matter. If odour is faint, heat the sample slightly. This intensifies the odour.
- Describe appearance of fresh fracture of intact sample (granular, dull, smooth, glossy). Rub small quantity of soil between fingers and describe sensation (Floury, smooth, gritty, sharp).
- Take a small representative sample in the form of a soil pat of size of about 5cc and add enough water to nearly saturate it. Place the pat in the open palm of one hand and shake horizontally striking vigorously against the other hand several times. Squeeze the pat between the fingers. The appearance and disappearance of the water with shaking and squeezing is referred to as reaction* intensity of phenomena observed.
- Describe shape (angular, subangular, rounded, well rounded). If mica is present indicate mica content (slightly, moderate or highly micaceous).
- Take a small quantity of soil and add enough water until it has the consistency of a putty. Make a ball out of it and allow it to dry. Note results as severe, mile or none depending on intensity of cracking observed.

* Describe the results as quick, slow or none depending on the case.

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MOISTURE DENSITY RELATIONS OF SOILS (PROCTOR TEST)

SCOPE:
This method covers the determination of the relationship between the moisture content and density of soils when compacted in a mould of a given size with a 2.5 kg rammer dropped from a height of 30cm.

APPARATUS:

1. Proctor mould having a capacity of 1000 cc approx with an internal diameter of 10 cm and a height of 12.73 cm. The mould shall have a detachable collar assembly and a detachable base plate.
2. Rammer: A mechanically operated metal rammer having a 5.0 cm diameter face and weight of 2.6 kg. The rammer shall be equipped with a suitable arrangement to control the height of drop to a free fall of 31cm.
3. Same extruder
4. A balance of 15kg capacity
5. Sensitive balance
6. Straight edge
7. Graduated cylinder
8. Mixing tools such as mixing pan, spoon, trowel, spatula etc.
9. Moisture tins

PROCEDURE:
Take a representative oven dried sample, approximately 5kg in the given pan. Thoroughly mix the sample with sufficient water to dampen it to approximately frur to six percentage points below optimum moisture content.

Weigh the proctor mould without base plate and collar. Fix the collar and base plate .Place the soil in the proctor mould and compact it in 3 layers giving 25 blows per layer with 2.5kg rammer falling through.

Remove the collar, trim the compacted soil even with the top of the mould by means of the straight edge and weigh.

Divide the weight of the compacted specimen by 1000 cc and record the result as the wet unit weight in gram per cubic centimeter of the compacted soil.

Remove the sample from the mould and slice vertically through the center and obtain a small sample for moisture determination.

Thoroughly break up the remainder of the material until it will pass a no.4 sieve as judged by the eye. Add water in sufficient amounts to increase the moisture content of the soil sample by one or two percentage points amd repeat the above procedure for each increment of water added. Continue this series of determinations until there is either a decrease or no change in the wet unit weight in gm/cc of the compacted soil.

CALCULATION:

Wet density in gm/cc = (weight of compacted soil)/1000

Dry density in gm/cc = wet density/(1+ water content)
= wet density X 100 / (100 + moisture content in percentage)

Plot the dry density against moisture content and find out the maximum dry density and optimum moisture content for the soil.

TABULATION

Sample No. :
No. of blows on each layer :
No. of layers:
Cylinder dimensions: Diameter in cm. :
Height in cm :
Volume in cm:
Initial weight of soil in gm:
Final weight of soil in gm:

Weight of cylinder:
Weight of soils:
Weight of water:
Specific gravity of soils:

Note: *Plot dry density vs. moisture content and find out the max dry density and optimum moisture for the soil.*

DENSITY

Determination No.								
Water to be added in percent								
Volume of water to be added in cc								
Weight of Cylinder + Compacted soil in gms.								
Weight of Compacted soil in gms.								
Average moisture content in percent								
Wet density in gm/cc								
Dry density in gm/cc								

WATER CONTENT

Container No.								
Weight of Container + Wet soil in gms.								
Weight of container + Dry soil in gms.								
Weight of container alone in gms.								
Weight of water in gms.								
Weight of Dry soil in gms.								
Water Content %								

PERMEABILITY TEST

TYPES OF TEST

- CONSTANT HEAD METHOD

- FALLING HEAD METHOD

DEFINITION OF COEFFICIENT OF PERMEABILITY

The rate of flow under laminar flow conditions through a unit cross sectional are of porous medium under unit hydraulic gradient is defined as coefficient of permeability.

NEED AND SCOPE

Permeability is useful in solving problems involving yield of water bearing strata, seepage through earthen dams, stability of earthen dams, and embankments of canal bank affected by seepage, settlement etc.

The falling head method of determining permeability is used for soil with low discharge, where as the constant head permeability test is used for coarse-grained soils with a reasonable discharge in a given time. For very fine-grained soil, capillarity permeability test is recommended.

PREPARATION OF THE SPECIMEN

The preparation of the specimen for this test is important. There are two types of specimen, the undisturbed soil sample and the disturbed or made up soil sample.

A. UNDISTURBED SOIL SPECIMEN

1. Note down-sample no., borehole no., depth at which sample is taken.
2. Remove the protective cover (wax) from the sampling tube.
3. Place the sampling tube in the sample extract or and push the plunger to get a cylindrical shaped specimen not larger than 85 mm diameter and height equal to that of the mould.
4. This specimen is placed centrally over the drainage disc of base plate.
5. The annular space in between the mould and specimen is filled with an impervious material like cement slurry to block the side leakage of the specimen. (Protect the porous disc when cement slurry is poured.)
6. Compact the slurry with a small tamper.
7. The drainage cap is also fixed over the top of the mould.
8. The specimen is now ready for test.

B. DISTURBED SPECIMEN

The disturbed specimen can be prepared by static compaction or by dynamic compaction.

(a) Preparation of statically compacted (disturbed) specimen.

1. Take 800 to 1000 gms of representative soil and mix with water to O.M.C determined by I.S Light Compaction test. Then leave the mix for 24 hours in an airtight container.
2. Find weight W of soil mix for the given volume of the mould and hence find the dry density $\gamma_d = W / [V.(1 + w)]$. Here w = water content of the soil mix.
3. Now, assemble the permeameter for static compaction. Attach the 3 cm collar to the bottom end of 0.3 liters mould and the 2 cm collar to the top end. Support the mould assembly over 2.5 cm end plug, with 2.5 cm collar resting on the split collar kept around the 2.5 cm- end plug. The inside of the 0.3 lit. Mould is lightly greased.
4. Put the weighed soil into the mould. Insert the top 3 cm end plug into the top collar, tamping the soil with hand.
5. Keep, now the entire assembly on a compressive machine and remove the split collar. Apply the compressive force until the flange of both end plugs touch the corresponding collars. Maintain this load for 1 min and then release it.
6. Then remove the top 3 cm plug and collar place a filter paper on fine wire mesh on the top of the specimen and fix the perforated base plate.
7. Turn the mould assembly upside down and remove the 2.5 cm end plug and collar. Place the top perforated plate on the top of the soil specimen and fix the top cap on it, after inserting the seating gasket.
8. Now the specimen is ready for test.

(b) Preparation of Dynamically Compacted Disturbed sample:

1. Take 800 to 1000 gms of representative soil and mix it with water to get O.M.C, if necessary. Have the mix in airtight container for 24 hours.
2. Assemble the permeameter for dynamic compaction. Grease the inside of the mould and place it upside down on the dynamic compaction base. Weigh the assembly correct to a gm (w). Put the 3 cm collar to the other end.
3. Now, compact the wet soil in 2 layers with 15 blows to each layer with a 2.5 kg dynamic tool. Remove the collar and then trim off the excess. Weigh the mould assembly with the soil (W_2).
4. Place the filter paper or fine wore mesh on the top of the soil specimen and fix the perforated base plate on it.
5. Turn the assembly upside down and remove the compaction plate. Insert the sealing gasket and place the top perforated plate on the top of soil specimen. And fix the top cap.
6. Now, the specimen is ready for test.

PERMEABILITY TEST: CONSTANT HEAD METHOD

EQUIPMENT

1. Permeameter mould of non-corrodible material having a capacity of 1000 ml, with an internal diameter of 100 ±0.1 mm and internal effective height of 127.3± 0.1 mm.
2. The mould shall be fitted with a detachable base plate and removable extension counter.
3. *Compacting equipment*: 50 mm diameter circular face, weight 2.76 kg and height of fall 310 mm as specified in I.S 2720 part VII 1965.
4. *Drainage bade*: A bade with a 12 mm thick porous disc having its permeability 10 times of that for soil.
5. *Drainage cap*: A porous disc of 12 mm thick having a fitting for connection to water inlet or outlet.
6. *Constant head tank*: A suitable water reservoir capable of supplying water to the permeameter under constant head.
7. Graduated glass cylinder to receive the discharge.
8. Stop watch to note the time, and a meter scale to measure the head differences and length of specimen.

TEST PROCEDURE

1. For the constant head arrangement, the specimen shall be connected through the top inlet to the constant head reservoir.
2. Open the bottom outlet.
3. Establish steady flow of water.
4. The quantity of flow for a convenient time interval may be collected.
5. Repeat three times for the same interval.

OBSERVATION AND RECORDING

The flow is very low at the beginning, gradually increases and then stands constant. Constant head permeability test is suitable for cohesion less soils. For cohesive soils falling head method is suitable.

PRESENTATION OF DATA

The coefficient of permeability is reported in cm/sec at 27º C. The dry density, the void ratio and the degree of saturation shall be reported. The test results should be tabulated as below:

Permeability Test Record

Project: ________________ Tested by:_____________

Location:_______________ Boring No.:________ Depth:________________

Details of sample

Diameter of specimen:________ cm Length of specimen(L):_____________ cm

Area of specimen(A)_________cm³ Specific gravity of soil (G) _____________

Volume of specimen(V) ______cm³ Weight of dry specimen(W)__________gm

Moisture content,w___________% Dry density(γ_d)= W/V =__________gm/cc

Void Raio, e= γ_w/ γ_d =_______ Saturation,S=G.w/e = _____%

Experiment No.		1	2	3
Discharge	Q(cm^3)			
Time t	(sec)			
Height of water	h (cm)			
Temperature	(ºC)			
Coefficient of permeability at ___ºC				
k=Q.L/(A.h.t)	cm/sec			
Average Permeability, k_t	cm/sec			
Permeability at 27º C: $k27= k_t \times \eta_t/\eta_{27}$	cm/sec			

Variation of η_t/η_{27}

Temperature	15	16	17	18	19	20	21	22
ηt/η27	1.336	1.301	1.268	1.237	1.206	1.177	1.149	1.122
Temperature	23	24	25	26	27	28	29	30
ηt/η27	1.096	1.071	1.046	1.023	1	0.979	0.958	0.938

PERMEABILITY TEST: FALLING HEAD METHOD

EQUIPMENT

1.) Permeameter with its accessories: The permeameter is made of non-corrodible material with a capacity of 1000 ml, with an internal diameter of 100±0.1 mm and effective height of 127.3±0.1 mm.
2.) Standard soil specimen, 3.) Deaired water, 4.) Balance to weigh up to 1 gm,
5.) I.S sieves 4.75 mm and 2 mm, 6.) Mixing pan, 7.) Stop watch, 8.) Measuring jar,
9.) Meter scale, 10.) Thermometer, 11.) Container for water, 12.) Trimming knife etc.

EXPERIMENTAL PROCEDURE

1. Prepare the soil specimen as specimen.
2. Saturate the specimen preferably by using deaired water.
3. Assemble the permeameter in the bottom tank and fill the tank with water.
4. Inlet nozzle of the mould is connected to the stand pipe. Allow the water to flow until steady flow is obtained.
5. Note down the time interval ‘t’ for the stand pipe ‘h’.
6. Repeat step 5 three times to determine ‘t’ for the same head.
7. Find ‘a’ by collecting ‘q’ fort the stand pipe. Weigh it correct to 1gm and find ‘a’ from q/h = a.

OBSERVATION AND RECORDING:

Sample No………….. Moulding water content…………………..

Dry Density…………. Specific Gravity…………………………..

Void Ratio……………

			1st set	2nd set	3rd set
1	Area of stand pipe (dia. 5cm)	a (cm)			
2	Cross section area of soil specimen	A (cm^2)			
3	Length of soil specimen	L(cm)			
4	Initial reading of stand pipe	h1(cm)			
5	Final reading of stand pipe	h2(cm)			
6	Time	t(sec)			
7	Test temperature	T(ºC)			
8	Coefficient of permeability at……..ºC $k= 2.303.a.L.(\log_{10} h_1/h_2)/ (A.t)$	k(cm/sec)			
9	Average Permeability, k_t	k_t(cm/sec)			
10	Coefficient of permeability at 27ºC $k_{27} = k_t \times \eta_t/\eta_{27}$	k_{27}(cm/sec)			

GENERAL REMARKS:

1. During test there should be no volume change in soil, there should be no compressible air present in the voids of soil i.e. soil should be completely saturated. The flow should be laminar and in a steady state condition.
2. Coefficient of permeability is used to assess drainage characteristics of soil, to predict the rate of settlement founded on soil bed.
3. Magnitudes of permeability:
    - High permeability: k $>10^{-1}$ cm/sec
    - Medium permeability: k = 10^{-1} cm/sec
    - Low permeability: k < 10^{-1} cm/sec

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DENSITY OF SOIL IN PLACE BY THE CORE CUTTER METHOD

SCOPE:

This method covers the determination of the in-situ density of compacted soils by using core cutter.

APPARATUS:

1. Rammer
2. Dolly
3. Cutter
4. Balance 15kg. capacity
5. Sensitive Balance
6. Moisture tins

PROCEDURE:

In the spot adjacent to that where the field density by sand replacement or balloon method has been determined, drive the core cutter using the dolly over the core cutter. Stop ramming when the dolly is just pround of the surface. Dig out the cutter containing the soil out of the ground and trim off any solid extruding from its ends, so that the cutter contains a volume of soil equal to its internal volume which is determined from the dimensions of the cutter. The weight of the contained soil is found and its moisture content determined.

OBSERVATIONS:

Wt. of Core-Cutter (W_1) = gms.

Wt. of Core-Cutter + Wet Soil (W_2) = gms.

Wt. of Wet Soil ($W_s = W_2 - W_1$) = gms.

Volume of Core-cutter V_c = c.c.

Bulk Density of Soil ($\Upsilon_s = W_s/V_c$) = g/c.c.

Dry Density of Soil ($\Upsilon_d = \dfrac{\Upsilon_s}{1 + w}$) = g/c.c.

Moisture Content:

Wt. of Container + Wet Soil (W)	=	gms.
Wt. of Container (W_c)	=	gms.
Wt. of Container + dry Soil (W_d)	=	gms.
Wt. of Moisture ($W - W_d$)	=	gms.
Wt. of dry Soil ($W_d - W_c$)	=	gms.
Moisture content $w\,\% = \dfrac{(W - W_d)}{W_d - W_c} \times 100$	=	gms.

DENSITY OF SOIL IN PLACE BY THE SAND-CONE METHOD

SCOPE:

This method of test is intended for determining the in-place density of soils. The apparatus herein is restricted to the tests in soils containing particles not larger than 2" in diameter.

APPARATUS:

1. Sand pouring Apparatus
2. Standard sand-graded between the No.25 and No.52 B.S sieves.
3. Soil tray with a central hole
4. Balance of 15kg capacity
5. Sensitive balance accurate to 0.1 gm
6. Oven

Miscellaneous equipments such as small pick chisels or spoon for digging test hole, moisture tins.

PROCEDURE:

1. Density of Sand:

Fill the Sand Pouring Apparatus with known mass of sand (M1) and place it concentrically on top of the calibrating cylinder. Open the shutter and allow sand to drain out. When no further movement of sand takes place in the apparatus close the shutter and weigh the sand remaining in the apparatus (M2). (M1-M2) represents the quantity of the sand used in filling calibrating cylinder as well as cone of the apparatus.
Now [(M1-M2)-(W1-W2)] gives the mess of sand required to fill the calibrating cylinder. Volume (Vc) of the cylinder may be determined either by measuring its internal dimensions or by filling it with water.
Density of the sand can be computed using mess of sand filled in cylinder and volume (Vc) of the cylinder.

2. Weight of Sand Occupying the Cone of the Sand Pouring Apparatus:
Pour sand into apparatus with valve closed and determine weight of apparatus and sand (W1). Place the apparatus on a smooth plate and open the valve to fill the conical portion. After the sand stops running, close the valve sharply, and weigh the remaining sand into the apparatus (W2).

3. Density of Soil:

Prepare the surface of the location to be tested so that it is a level plane. Keep the soil tray firmly on the place surface. Excavate with hand tools a hole with diameter equal to that of the hole of the plate and about 10cm. in depth with smooth walls and rounded bottom edges. Place all loosened soil in a container being careful to avoid losing any material. Seat the already weighed apparatus with sand on the hole of the tray. Open the valve and after the sand has stopped flowing close the valve. Weigh the apparatus with remaining sand and determine the weight of sand occupying the cavity. Weigh the material that was removed from the test hole. Mix the material thoroughly and weigh a representative sample for moisture determination. Dry and weigh the sample to determine moisture content.

CALCULATIONS:

From the known density of sand and the weight of sand occupying the hole, calculate the volume of hole. From the weight of the soil cooped out of hole whose volume is now known and the value of moisture content calculate the wet and dry density of soil.

DETERMINATION OF DENSITY OF SOIL INPLACE BY THE SAND CONE METHOD

No.	Particulars	1	2	3
1.	Bulk density of standard Sand gm			
2.	Weight of Sand pouring apparatus + sand before Experiment gm			
3.	Weight of sand pouring apparatus + sand after Experiment gm			
4.	Weight of sand drained out gm			
5.	Weight of sand occupying cone gm			
6.	Weight of sand occupying cavity gm			
7.	Volume of cavity			
8.	Weight of soil scooped out from the cavity gm			
9.	Wet density gm/cc			
10.	Moisture content			
11.	Dry density gm/cc			

Moisture Content Percent

CONTAINER No.: Wt. of container + Wet Soil	gm			
Wt. of container + Dry soil	gm			
Wt. of container	gm			
Wt. of water	gm			
Wt. of dry soil	gm			
Moisture Content in percent				

Average Moisture Content of the Soil Layer percent

Average Dry Density of the Soil Layer gm/cc

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UNCONFINED COMPRESSION TEST

NEED AND SCOPE OF THE EXPERIMENT:

It is not always possible to conduct the bearing capacity test in the field. Some times it is cheaper to take the undisturbed soil sample and test its strength in the laboratory. Also to choose the best material for the embankment, one has to conduct strength tests on the samples selected. Under these conditions it is easy to perform the unconfined compression test on undisturbed and remolded soil sample. Now we will investigate experimentally the strength of a given soil sample.

EQUIPMENT:

1. Loading frame of capacity of 2 t, with constant rate of movement.
2. Proving ring of 0.01 kg sensitivity for soft soils; 0.05 kg for stiff soils.
3. Soil trimmer, Evaporating dish (Aluminum container).
4. Frictionless end plates of 75 mm diameter (Perspex plate with silicon grease coating).
5. Dial gauge (0.01 mm accuracy), Dial gauge (sensitivity 0.01mm), Vernier calipers
6. Balance of capacity 200 g and sensitivity to weigh 0.01 g.
7. Oven thermostatically controlled with interior of non-corroding material.
8. Soil sample of 75 mm length. Sample extractor and split sampler.

EXPERIMENTAL PROCEDURE (SPECIMEN):

In this test, a cylinder of soil without lateral support is tested to failure in simple compression, at a constant rate of strain. The compressive load per unit area required to fail the specimen as called unconfined compressive strength of the soil.

Preparation of specimen for testing

A. Undisturbed specimen

1. Note down the sample number, bore hole number and the depth at which the sample was taken.
2. Remove the protective cover (paraffin wax) from the sampling tube.
3. Place the sampling tube extractor and push the plunger till a small length of sample moves out.
4. Trim the projected sample using a wire saw, and push the plunger until a 75 mm long sample comes out.
5. Cutout this sample carefully and hold it on the split sampler so that it does not fall.

6. Take about 10 to 15 g of soil from the tube for water content determination.
7. Note the container number and take the net weight of the sample and the container.
8. Measure the diameter at top, middle, and bottom of the sample. Find the average and record the same.
9. Measure the length and weight of the sample and record.

B. Remolded sample

1. For the desired water content and the dry density, calculate the weight of the dry soil Ws required for preparing a specimen of 3.8 cm diameter and 7.5 cm long.

2. Add required quantity of water W_w to this soil.

$$W_w = W_S x\ W/100 \text{ gm}$$

3. Mix the soil thoroughly with water.
4. Place the wet soil in a tight thick polythene bag in a humidity chamber.
5. After 24 hours take the soil from the humidity chamber and place the soil in a constant volume mould, having an internal height of 7.5 cm and internal diameter of 3.8 cm.
6. Place the lubricated mould with plungers in position in the load frame.
7. Apply the compressive load till the specimen is compacted to a height of 7.5 cm.
8. Eject the specimen from the constant volume mould.
9. Record the correct height, weight and diameter of the specimen.

Test procedure

1. Take two frictionless bearing plates of 75 mm diameter.
2. Place the specimen on the base plate of the load frame (sandwiched between the end plates).
3. Place a hardened steel ball on the bearing plate.
4. Adjust the center line of the specimen such that the proving ring and the steel ball are in the same line.
5. Fix a dial gauge to measure the vertical compression of the specimen.
6. Adjust the gear position on the load frame to give suitable vertical displacement.
7. Start applying the load and record the readings of the proving ring dial and compression dial for every 5 mm compression.
8. Continue loading till failure is complete, and then draw the sketch of the failure pattern in the specimen.

OBSERVATION AND READING

Data Sheet for Unconfined Compression Test

Project : Tested by :

Location : Boring No. :

Depth :

<u>Sample details:</u>

Type UD/R: soil description

Specific gravity (G_S) = Bulk density = _____________

Water content = Degree of saturation = _______ %

Diameter (D_o) of the sample ______ cm Area of cross-section = _______ cm^2

Initial length (L_o) of the sample = 76 mm

Elapsed time (minutes) 1	Compression dial reading (L) (mm) 2	Strain (ΔL / L_o).100 (%) 3	Area A $A_o/(1 - \epsilon)$ $(cm)^2$ 4	Proving ring reading (Divns.) 5	Axial load (kg) 6	Compressive stress (kg/cm^2) 7

Interpretation and Reporting

Unconfined compression strength of the soil, q_u =

Shear strength of the soil = $q_u/2$ =

Sensitivity = (q_u for undisturbed sample)/ (q_u for remoulded sample).

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TRIAXIAL TEST

Type of test: UCS

Sample No:…………………………………………………..Depth……………………………………..
Location:……………………………………………………..Diameter:…………………………………….
Weight of Sample:…………………………………………….Area:…………………………………………
Cell Pressure:…………………………………………………Proving Ring Constant:……………………….
Back Pressure:………...……………………………………..Least Count of Dail Gauge:…………………..

Dial Gauge Reading	Proving Ring Reading	Pore Pressure Reading (CU)	Burette Reading(CD)		Dial Gauge Reading	Proving Ring Reading	Pore Pressure Reading (CU)	Burette Reading(CD)
0					725			
25					750			
50					775			
75					800			
100					825			
125					850			
150					875			
175					900			
200					925			
225					950			
250					975			
275					1000			
300					1025			
325					1050			
350					1075			
375					1100			
400					1125			
425					1150			
450					1175			
475					1200			
500					1225			
525					1250			
550					1275			
575					1300			
600					1325			
625					1350			
650					1375			
675					1400			
700					1425			

For Moisture Content:

Container +Wet Weight of Sample:………………………..gm
Container +Dry Weight of Sample:………………………..gm
Container Weight:…………………………………………gm

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TRIAXIAL COMPRESSION TEST

SCOPE:
This method covers the determination of Shear strength values of soils by triaxial compression test. This apparatus is designed to carry out shear strength tests on cohesive and cohesion less soils by subjecting the specimens to three compressive stresses at right angle to each other. The stress conditions at failure are analyzed by Mohr circles and the apparent cohesion and angle of shearing resistance are determined.

APPARATUS:
1) Triaxial compression test apparatus with accessories like cell assembly with loading plunger porous discs, loading pad sheath stretcher, rubber sheaths, lateral pressure assembly and foot pump.
2) Drying Oven
3) Moisture tins
4) Balance
5) Tools for sample preparation

PROCEDURE:
1) (a) Specimen preparation (Undisturbed)
Obtain undisturbed soil sample of 3 to 4 inches diameter. Push in 1.5 inch dia. sampling tubes into the sample and obtain samples in the tubes.

   (b) Specimen preparation (Remoulded)
Compact the soil sample at the required moisture content and dry density in a proctor or C.B.R mould and obtain samples in 1.5 inch dia. tubes as before.

2) Eject the sample from the tube into the split mould by means of hand ejector and trim both sides.

3) Dismantle the cell assembly. Clean the base pedestal and check all the lines and smear the plunger with thin grease. Keep the Perspex disc (for undrained test) or the porous stone (for drained test) on the pedestal and mount the specimen.

4) Slip a rubber sheath into the sheath stretcher. Stretch the lengths of the sheath remaining out on the two sides of sheath stretcher uniformly around the circumference. Stretch the sheath to the walls of the stretcher by sucking, the air through the nipple. Carefully cover the specimen with the stretcher and transfer the sheath from circumference or the stretcher to the of pedestal. Place the top loading pad with either Perspex disc or porous disc on top of the specimen and carefully transfer the top end of the sheath to the loading pad. Remove the stretcher. Bind the

sheath to the pedestal and loading pad by slipping on the rubber rings carefully without causing damage to the specimen and always keeping it lined up vertically. Moisten the gaskets assemble the cell taking care to maintain some minimum clearance between the plunger and loading pad. Tighten the cylinder base to the cell base. Place the cell on the load frame. Make the appropriate water connections taking care the lateral pressure connection is to be peripheral hole in the cell base.

5) Open the air vent on the cell top. Open the valves between all base and lateral pressure assembly. Connect the foot pump to the side valve of the lateral pressure assembly and using the foot pump water into the triaxial cell without undue turbulence. When the water starts to flow out through the air vent of the cell, close it. Continue pumping till the desired lateral pressure is attained in the cell. Any alternative arrangement of filling the cell with water and applying cell pressure may be used.

6) Take axial load reading of a set of deformation readings.

7) Remove the axial load and disassemble the apparatus. Repeat the above tests at least 3 times with specimens of the same soil sample with different lateral pressures.

CALCULATION:

Record all data on the data sheet. Compute the unit stress, unit strain for each reading taken.

Plot a graph with strain as abscissa and compressive stress as ordinate.

Plot on mohr diagram the stress condition at failure for each of the sample tested. Draw the failure lines and determine the empirical constants to coulomb’s equation.

INDIAN INSTITUTE OF TECHNOLOGY KANPUR
DEPARTMENT OF CIVIL ENGINEERING

TRIAXIAL TEST   Type of test: UCS

Sample No:…………………………………………………..Depth………………………………………..
Location:……………………………………………………..Diameter:…………………………………….
Weight of Sample:…………………………………………….Area:…………………………………………
Cell Pressure:…………………………………………………Proving Ring Constant:……………………….
Back Pressure:………...……………………………………….Least Count of Dail Gauge:…………………..

Dial Gauge Reading	Proving Ring Reading	Pore Pressure Reading (CU)	Burette Reading(CD)		Dial Gauge Reading	Proving Ring Reading	Pore Pressure Reading (CU)	Burette Reading(CD)
0					725			
25					750			
50					775			
75					800			
100					825			
125					850			
150					875			
175					900			
200					925			
225					950			
250					975			
275					1000			
300					1025			
325					1050			
350					1075			
375					1100			
400					1125			
425					1150			
450					1175			
475					1200			
500					1225			
525					1250			
550					1275			
575					1300			
600					1325			
625					1350			
650					1375			
675					1400			
700					1425			

For Moisture Content:

Container +Wet Weight of Sample:………………………..gm
Container +Dry Weight of Sample:………………………..gm
Container Weight:…………………………………………gm

NEED AND SCOPE:

The value 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

1. Direct shear box apparatus, and Loading frame (motor attached).
2. Dial gauge, Proving ring, Balance to weigh upto 200 mg.
3. Tamper, Straight edge, Aluminum container, Spatula.

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 volume changes. A two piece square shear box is one type of soil container used. A proving ring is used to indicate the shear load taken by the soil initiated in the shearing plane.

PROCEDURE:

1. Check the inner dimension of the soil container, and put the parts of the soil container together.
2. Calculate the volume of the container. Weigh the container.
3. Place the soil in smooth layers (approximately 10 mm thick).If a dense sample is desired tamp the soil.
4. Weigh the soil container, and find the weight of soil. Calculate the density of soil.
5. Plane the top surface of soil, and put the upper grating stone and loading block on top of soil.
6. Measure the thickness of soil specimen.
7. Apply the desired normal load and Remove the shear pin.

8. Attach the dial gauge which measures the change of volume.

9. Record the initial reading of the dial gauge and calibration values.

10. Check all adjustments to see that there is no connection between two parts except sand/soil.

11. Start the motor. Take the reading of the shear force and volume change till failure.

12. Add 5 kg normal stress 0.5 kg/cm2 and continue the experiment till failure

13. Record carefully all the readings. Set the dial gauges zero, before starting the experiment.

DATA CALCULATION SHEET FOR DIRECT SHEAR TEST

Normal stress = **0.5 kg/cm^2** L.C=....... P.R.C=.........

Horizontal Gauge Reading (1)	Vertical Dial gauge Reading (2)	Proving ring Reading (3)	Hori. dial gauge Reading Initial reading div. gauge (4)	Shear deformation Col.(4) x Least count of dial (5)	Vertical gauge reading Initial Reading (6)	Vertical deformation col.6 x L.C of dial gauge (7)	Proving reading Initial reading (8)	Shear stress = div.col.(8) x proving ring constant Area of the specimen (kg/cm^2) (9)
0								
25								
50								
75								
100								
125								
150								
175								
200								
250								
300								
400								
500								
600								
700								
800								
900								

Normal stress = **1.0 kg/cm^2** L.C=....... P.R.C=........

Horizontal Gauge Reading (1)	Vertical Dial gauge Reading (2)	Proving ring Reading (3)	Hori. dial gauge Reading Initial reading div. gauge (4)	Shear deformation Col.(4) x Least count of dial (5)	Vertical gauge reading Initial Reading (6)	Vertical deformation col.6 x L.C of dial gauge (7)	Proving reading Initial reading (8)	Shear stress = div.col.(8) x proving ring constant Area of the specimen (kg/cm^2) (9)
0								
25								
50								
75								
100								
125								
150								
175								
200								
250								
300								
400								
500								
600								
700								
800								
900								

Normal stress = **1.5 kg/cm²** L.C=....... P.R.C=........

Horizontal Gauge Reading (1)	Vertical Dial gauge Reading (2)	Proving ring Reading (3)	Hori. dial gauge Reading Initial reading div. gauge (4)	Shear deformation Col.(4) x Least count of dial (5)	Vertical gauge reading Initial Reading (6)	Vertical deformation col.6 x L.C of dial gauge (7)	Proving reading Initial reading (8)	Shear stress = div.col.(8) x proving ring constant Area of the specimen (kg/cm^2) (9)
0								
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250								
300								
400								
500								
600								
700								
800								
900								

INDIAN INSTITUTE OF TECHNOLOGY, KANPUR
CIVIL ENGINEERING DEPARTMENT
GEOTECHNICAL ENGINEERING LABORATORY

DETERMINATION OF COEFFICIENT OF CONSOLIDATION

NEED AND SCOPE:

The test is conducted to determine the settlement due to primary consolidation.

a. Rate of consolidation under normal load.

b. Degree of consolidation at any time.

c. Pressure-void ratio relationship.

d. Coefficient of consolidation at various pressures.

e. Compression index.

The above information can be used to predict the time rate and extent of settlement of structures founded on fine-grained soils. It is also helpful in analyzing the stress history of soil.

EQUIPMENT:

1. Consolidometer consisting essentially; a) A ring of diameter = 60mm and height = 20mm, b) Two porous plates or stones of silicon carbide, aluminum oxide or porous metal. c) Guide ring. d) Outer ring. e) Water jacket with base. f) Pressure pad. g) Rubber basket.

2. Loading device consisting of frame, lever system, loading yoke dial gauge fixing device and weights.

3. Dial gauge (accuracy of 0.002 mm), Thermostatically controlled oven, Stopwatch, sample extractor, balance, soil trimming tools, spatula, filter papers, sample containers.

PRINCIPLE INVOLVED:

When a compressive load is applied to soil mass, a decrease in its volume takes place, the decrease in volume of soil mass under stress is known as compression and the property of soil mass pertaining to its tendency to decrease in volume under pressure is known as compressibility. In a saturated soil mass having its void filled with incompressible water, decrease in volume or compression can take place when water is expelled out of the voids. Such a compression resulting from a long time static load and the consequent escape of pore water is termed as consolidation. Then the load is applied on the saturated soil mass, the entire load is carried by pore water in the beginning. As the water begins escaping from the voids, the hydrostatic pressure in water gets gradually dissipated and the load is shifted to the soil particles which increases effective stress on them, as a result the soil mass decrease in volume. The rate of escape of water depends on the permeability of the soil.

1. From the sample tube, eject the sample into the consolidation ring. The sample should project about one cm from outer ring. Trim the sample smooth and flush with top and bottom of the ring by using wire saw. Clean the ring from outside and keep it ready for weighing.

2. Remolded sample:

    a. Choose the density and water content at which sample has to be compacted from the moisture-density curve, and calculate the quantity of soil and water required to mix and compact.

    b. Compact the specimen in compaction mould in three layers using the standard rammers.

    c. Eject the specimen from the mould using the sample extractor.

PROCEDURE:

1. Saturate two porous stones either by boiling in distilled water about 15 minute or by keeping them submerged in the distilled water for 4 to 8 hrs. Fittings of the consolidometer which is to be enclosed shall be moistened.
2. Assemble the consolidometer, with the soil specimen and porous stones at top and bottom of specimen, and providing a filter paper between the soil specimen and porous stone.
3. Position the pressure pad centrally on the top porous stone. Mount the mould assembly on the loading frame, and center it such that the load applied is axial. Make sure that the porous stone and pressure pad are not touching the walls of mould on their sides.

4. Position the dial gauge to measure the vertical compression of the specimen. The dial gauge holder should be set so that the dial gauge is in the begging of its releases run, and also allowing sufficient margin for the swelling of the soil, if any.
5. Fill the mould with water and apply an initial load to the assembly. The magnitude of this load should be chosen by trial, such that there is no swelling. It should be not less than 50 g/cm^2 for ordinary soils & 25 g/cm^2 for very soft soils. The load should be allowed to stand until there is no change in dial gauge readings for two consecutive hours or for a maximum of 24 hours.
6. Note the final dial reading under the initial load. Apply first load of intensity 0.1 kg/cm^2 (Approx.) and start the stop watch simultaneously. Record the dial gauge readings at various time intervals. The dial gauge readings are taken until 90% consolidation is reached. Primary consolidation is gradually reached within 24 hrs.
7. At the end of the period, specified above take the dial reading and time reading. Double the load intensity and take the dial readings at various time intervals. Repeat this procedure fir successive load increments. The usual loading intensity is as follows (Approx.): 0.1, 0.2, 0.5, 1, 2, 4 and 8 kg/cm^2.
8. After the last loading is completed, reduce the load of the value of the last load and allow it to stand for 24 hrs. Reduce the load further in steps of the previous intensity till an intensity of 0.1 kg/cm^2 is reached. Take the final reading of the dial gauge.
9. Reduce the load to the initial load, keep it for 24 hrs and note the final readings of the dial gauge.
10. Quickly dismantle the specimen assembly and remove the excess water on the soil specimen in oven, note its dry weight.

CALCULATIONS

1. **Height of solids** (H_S) is calculated from the equation

$$H_S = W_S/(G_S \text{ x } \gamma_w) \text{ x } A$$

2. **Void ratio.** Voids ratio at the end of various pressures are calculated from equation

$$e = (H - H_S)/H_S$$

3. C**oefficient of consolidation**. The Coefficient of consolidation at each pressures increment is calculated by using the following equations:

i.) $C_v = 0.197\ d^2/t_{50}$ (Log fitting method)

ii.) $C_v = 0.848\ d^2/t_{90}$ (Square fitting method)

In the log fitting method, a plot is made between dial readings and logarithmic of time, and the time corresponding to 50% consolidation is determined.

In the square root fitting method, a plot is made between dial readings and square root of time, and the time corresponding to 90% consolidation is determined. The values of C_v are recorded in table II.

4. Compression Index. To determine the compression index, a plot of voids ratio (e) Vs log(t) is made. The virgin compression curve would be a straight line and the slope of this line would give the compression index C_c.

5. Coefficient of compressibility. It is calculated as follows

$$a_v = 0.435\ C_c/(\text{Avg. pressure}) \quad \text{for the increment}$$

where C_c = Coefficient of compressibility

6. Coefficient of permeability. It is calculated as follows

$$k = C_v.a_v\ .\gamma_w\ /(1+e_o).$$

GRAPHS:

1. Dial reading vs log of time or
2. Dial reading vs square root of time.
3. Voids ratio vs log σ (average pressure for the increment).

General Remarks

1. While preparing the specimen, attempts has to be made to have the soil strata orientated in the same direction in the consolidation apparatus.
2. During trimming care should be taken in handling the soil specimen with least pressure.
3. Smaller increments of sequential loading have to be adopted for soft soils.

PURPOSE: To determine the coefficient of consolidation of a given soil sample.

MATERIAL AND EQUIPMENT: Consolidometer, knife, balance, drying oven, stop watch

PROCEDURE:

1. Note down the height and dia of the specimen.
2. Press the specimen ring into the soil sample. Trim the upper and lower surface flat and parallel.
3. Place the previously saturated porous stones and filter paper one after another on the base water jacket and place the cell in position.
4. Transfer the ring with sample gently to the cell.
5. Take the left out sample fore the moisture content determination.
6. Place the consolidometer in the loading device and adjust the readings.
7. Fill the jacket of the consolidometer with water and note the movement of the dial gauge. If no change in height is indicated apply the first load increment approximately 0.1 Kg/sq.cm after noting the initial dial gauge reading.
8. Take the dial readings at the total elapsed time of 1,2,4,8,16 minutes… until the end of test (usually 24 hrs).
9. After a time when the dial reading becomes steady the consolidation may be assumed to have reached a condition of equilibrium.
10. Increase the load to 0.25/0.5 and 1Kg/sq.cm after 24 hrs on successive days and repeat the same procedure as above.
11. Increase the load to 2, 4 and 8 Kg/sq.cm on successive days.
12. When consolidation has been completed under the last load increment unload the sample completely. Drain off the water and place the soil sample in the drying oven and after 24 hrs record the dry weight.

CALCULATIONS:

1. From the dimension, dry weight and specific gravity of soil sample determine its initial void ratio.
2. Use the compression data to complete the void ratio at the completion of each load increment application.
3. Plot a void ratio log pressure curve.
4. Calculate the coefficient of consolidation Cv and coefficient of compressibility av.

CONSOLIDATION TEST

Sample No………………………… Date………………………………..
Nature of Soil……………………... Location of Sample…………………
L.C of Dial Gauge…………………. Remarks…………………………….

Elapsed Time 't' in minutes	0.1 Load		0.2 Load		0.5 Load		1.0 Load		2.0 Load		4.0 Load		8.0 Load		16.0 Load	
	Date Time	Dail Read-ing	Date Time	Dail Read-ing	Date Time	Dail Read-ing	Date Time	Dail Read-ing	Date Time	Dail Read-ing	Date Time	Dail Read-ing	Date Time	Dail Read-ing	Date Time	Dail Read-ing
0.00																
0.25																
1.00																
2.25																
4.00																
6.25																
9.00																
12.25																
16.00																
20.25																
25.50																
30.00																
60.00																
120.00																
240.00																
480.00																
1440.00																

CONSOLIDATION TEST

Sample No……………………………...   Specific gravity……………………..   Date…………………………………………

Water content w percent………………..   Weight of Dry Sample Ws………………..

Comtaimer No…………………………..   Weight of Ring + soil…………………….. Sample……….. Height Z………………

Wwet ……………………………………   Wt. of ring along…………………………Sample…………..Dia……………………..

Wdry……………………………………   Wt. of wet soil……….................................Sample…………..Area A…………………

Wcont……………………………………   Wt. of dry soil…………………………… Solid Height-2Ho= Ws/GsγAw

Water…………………………….%

Applied Load t/sq.ft.Kg/sq.cm	**Final Dial C.M**	**Dial Change C.M**	**2H**	**Void Height 2H-2Ho**	**Void Ratio = (2H-2Ho)/2H**
0.000					
0.125					
0.250					
0.500					
1.000					
2.000					
4.000					
8.000					
16.000					