DETERMINATION OF MOISTURE CONTENT

OBJECTIVE

Determine the natural content of the given soil sample.

NEED AND SCOPE OF THE EXPERIMENT

In almost all soil tests natural moisture content of the soil is to be determined. The knowledge of the natural moisture content is essential in all studies of soil mechanics. To sight a few, natural moisture content is used in determining the bearing capacity and settlement. The natural moisture content will give an idea of the state of soil in the field.

DEFINITION

The natural water content also called the natural moisture content is the ratio of the weight of water to the weight of the solids in a given mass of soil. This ratio is usually expressed as percentage.

APPARATUS REQUIRED

1. Non-corrodible air-tight container.
2. Electric oven, maintain the temperature between 1050 C to 1100 C.
3. Desiccator.
4. Balance of sufficient sensitivity.

PROCEDURE

1. Clean the container with lid dry it and weigh it (W1).
2. Take a specimen of the sample in the container and weigh with lid (W2).
3. Keep the container in the oven with lid removed. Dry the specimen to constant weight maintaining the temperature between 1050 C to 1100 C for a period varying with the type of soil but usually 16 to 24 hours.
4. Record the final constant weight (W3) of the container with dried soil sample. Peat and other organic soils are to be dried at lower temperature (say 600) possibly for a longer period.

Certain soils contain gypsum which on heating loses its water if crystallization. If itb is suspected that gypsum is present in the soil sample used for moisture content determination it shall be dried at not more than 800 C and possibly for a longer time.

OBSERVATIONS AND RECORDING

Data and observation sheet for water content determination

S.No.	Sample No.	1	2	3
1	Weight of container with lid W_1 gm			
2	Weight of container with lid +wet soil W_2 gm			
3	Weight of container with lid +dry soil W_3 gm			
4	Water/Moisture content $W = [(W_2-W_3)/(W_3-W_1)]\text{\textregistered}100$			

INTERPRETATION AND REPORTING

RESULT

The natural moisture content of the soil sample is _____

GENERAL REMARKS

1. A container with out lid can be used, when moist sample is weighed immediately after placing the container and oven dried sample is weighed immediately after cooling in desiccator.

2. As dry soil absorbs moisture from wet soil, dried samples should be removed before placing wet samples in the oven.

DETERMINATION OF SPECIFIC GRAVITY

OBJECTIVE

Determine the specific gravity of soil fraction passing 4.75 mm I.S sieve by density bottle.

NEED AND SCOPE

The knowledge of specific gravity is needed in calculation of soil properties like void ratio, degree of saturation etc.

DEFINITION

Specific gravity G is defined as the ratio of the weight of an equal volume of distilled water at that temperature both weights taken in air.

APPARATUS REQUIRED

1. Density bottle of 50 ml with stopper having capillary hole.
2. Balance to weigh the materials (accuracy 10gm).
3. Wash bottle with distilled water.
4. Alcohol and ether.

PROCEDURE

1. Clean and dry the density bottle

   a. wash the bottle with water and allow it to drain.
   b. Wash it with alcohol and drain it to remove water.
   c. Wash it with ether, to remove alcohol and drain ether.

2. Weigh the empty bottle with stopper (W_1)

3. Take about 10 to 20 gm of oven soil sample which is cooled in a desiccator. Transfer it to the bottle. Find the weight of the bottle and soil (W_2).

4. Put 10ml of distilled water in the bottle to allow the soil to soak completely. Leave it for about 2 hours.

5. Again fill the bottle completely with distilled water put the stopper and keep the bottle

   under constant temperature water baths (T_x^0).

6. Take the bottle outside and wipe it clean and dry note. Now determine the weight of the bottle and the contents (W_3).

7. Now empty the bottle and thoroughly clean it. Fill the bottle with only disttiled water and weigh it. Let it be W_4 at temperature (T_x^0 C).

8. Repeat the same process for 2 to 3 times, to take the average reading of it.

OBSERVATIONS

S. No.	Observation Number	1	2	3
1	Weight of density bottle (W_1 g)			
2	Weight of density bottle + dry soil (W_2 g)			
3	Weight of bottle + dry soil + water at temperature T_x^0 C (W_3 g)			
4	Weight of bottle + water (W_4 g) at temperature T_x^0 C			
	Specific gravity G at T_x^0 C			
	Average specific gravity at T_x^0 C			

CALCULATIONS

INTERPRETATION AND REPORTING

Unless or otherwise specified specific gravity values reported shall be based on water at 27^0C. So the specific gravity at 27^0C = K$\diamondsuit$Sp. gravity at T_x^0C.

The specific gravity of the soil particles lie with in the range of 2.65 to 2.85. Soils containing organic matter and porous particles may have specific gravity values below 2.0. Soils having heavy substances may have values above 3.0.

GRAIN SIZE DISTRIBUTION

I.SIEVE ANALYSIS

OBJECTIVE

(a). Select sieves as per I.S specifications and perform sieving.
(b). Obtain percentage of soil retained on each sieve.
(c). Draw graph between log grain size of soil and % finer.

NEED AND SCOPE OF EXPERIMEN

The grain size analysis is widely used in classification of soils. The data obtained from grain size distribution curves is used in the design of filters for earth dams and to determine suitability of soil for road construction, air field etc. Information obtained from grain size analysis can be used to predict soil water movement although permeability tests are more generally used.

PLANNING AND ORGANISATION

Apparatus

1.Balance

2.I.S sieves

3.Rubber pestle and mortar

4.Mechanical Sieve Shaker

KNOWLEDGE OF EQUIPMENT

1.The balance to be used must be sensitive to the extent of 0.1% of total weight of sample taken.

2.I.S 460-1962 are to used. The sieves for soil tests: 4.75 mm to 75 microns.

PROCEDURE

1.For soil samples of soil retained on 75 micron I.S sieve

(a) The proportion of soil sample retained on 75 micron I.S sieve is weighed and recorded weight of soil sample is as per I.S 2720.

(b) I.S sieves are selected and arranged in the order as shown in the table.

(c) The soil sample is separated into various fractions by sieving through above sieves placed in the above mentioned order.

(d) The weight of soil retained on each sieve is recorded.

(e) The moisture content of soil if above 5% it is to be measured and recorded.

2.No particle of soil sample shall be pushed through the sieves.

OBSERVATIONS AND RECORDING

Weight of soil sample:

Moisture content:

I.S sieve number or size in mm	**Wt. Retained in each sieve (gm)**	**Percentage on each sieve**	**Cumulative %age retained on each sieve**	**% finer**	**Remarks**
4.75					
4.00					
3.36					
2.40					
1.46					
1.20					
0.60					
0.30					
0.15					
0.075					

GRAPH

Draw graph between log sieve size vs % finer. The graph is known as grading curve. Corresponding to 10%, 30% and 60% finer, obtain diameters from graph are designated as $D_{10,}$ $D_{30,}$ $D_{60.}$

CALCULATION

1. The percentage of soil retained on each sieve shall be calculated on the basis of total weight of soil sample taken.
2. Cumulative percentage of soil retained on successive sieve is found.

LIQUID AND PLASTIC LIMIT TESTS

APPLICATIONS: -

The value of liquid limit and plastic limit are directly used for classifying the fine-grained cohesive soils according to Indian Standard on soil classification. Once the soil is classified, it helps a lot in understanding the behavior of soils and selecting the suitable methods of design, construction and maintenance of the structures made up or and resting on soils.

The values of these limits are also used in calculating the flow index, toughness, index and relative plasticity, cohesiveness, compressibility, shear strength, permeability, consistency and state of cohesive soils. Atterberg (1911) shows the correlations between the plasticity index, soil type, degree of plasticity and degree of cohesiveness.

APPARATUS: -

Special

1. Casagrande liquid limit device
2. A.S.T.M. and B.S. grooving tool (Casagrande type).
3. Glass Plate 20 x 15cm
4. 425 micron I.S. Sieve
5. 3mm diameter rod.

General

1. Spatula 2. Basin (300c.c. capacity) 3. Balance (0.01 gm sensitivity)

4. Water content tins or crucibles 5. Drying Ovens 6. Distilled Water

7. Measuring Cylinder 8. Desiccators

PROCEDURE: -

a) Liquid Limit:

1. Adjust the cup of the liquid limit apparatus with the help of the grooving tool gauge and the adjustment plate to give a drop of exactly 1 cm on the point of contact on base.
2. Take about 120gm of an air-dried sample passing 425micron sieve.
3. Mix it thoroughly with some distilled water to form a uniform paste.
4. Place a portion of the paste in the cup of the liquid limit devices, smooth the surface with spatula to a maximum depth of 1cm. Draw the grooving tool through the sample along the symmetrical axis of the cup, holding the tool perpendicular of the cup.
5. Turn the handle at a rate of 2 revolutions per second and count blows until the two parts of the soil sample come into contact at the bottom of the groove along the distance of 10mm.
6. Transfer about 15 cm of the soil forming the edges of the groove that flowed together to water content tin, and determine the water content.
7. Transfer the remaining soil in the cup to the main soil sample in the basin and mix thoroughly after adding a small amount of water.
8. Repeat the steps 4, 5 and 6. Obtain at least four sets of reading in the range of 10 to 40 blows.

b) Plastic Limits:

1. Take about the 30 gm of air-dried sample passing 425-micron sieve.
2. Mix thoroughly with distilled water on the glass plate until it is plastic enough to be snapped into a small ball.
3. Take about 10gm of the plastic soil mass and roll between the hand and the glass plate to form the soil mass into the thread. If diameter of thread becomes less than 3mm without cracks, it shows that water added in the soil is more than the plastic limit; hence the soil is kneaded further and rolled into thread again.

4. Repeat this rolling and remolding process until the thread starts just crumpling at a diameter of 3mm.

5. If crumpling starts before 3mm diameter thread in step 3, it shows that water added in step 2 is less than the plastic limit of the soil, hence some more water should be added and mixed to a uniform mass and rolled again, until the thread starts just crumpling at a diameter of 3mm.

6. Collect the pieces of crumbled soil thread at 3mm diameter in an airtight container and determine the moisture content.

7. Repeat this procedure twice more with fresh samples of 10 gm each.

PRECAUTIONS: -

1. Use Distilled water in order to minimize the possibility of iron exchange between the soil and any impurities in the water.

2. Soil used for liquid and plastic limit determinations should not be oven dried prior to testing.

3. In liquid limit test, the groove should be closed by a flow of the soil and not by slippage between the soil and the cup.

4. After mixing distilled water to the soil sample, sufficient time should be given to permeate the water throughout the soil mass.

5. Wet soil taken in the container for moisture content determinations should not be left open in the air even for some time, the containers with soil samplers should either be placed in desiccators or immediately be weighed.

6. For each test, cup and grooving tool, should be clean.

OBSERVATIONS: -

a) Liquid Limit:

1. Use table I for recording the number of blows and calculating the moisture contents.

2. Use semi long graph paper; take number of blows on semi long scale (x-axis) and water contents on ordinary scale (y-axis). Plot all the points and draw a straight line (flow curve) passing through these points.

3. Read the water content at 25 blows that is the value of liquid limit.

b) Plastic Limit:

Use the table 2 for calculating the plastic limit.

c) Classification of Soil:

1. Calculate the plasticity index (P.I.).
2. Use plasticity chart for classification of given soil. Calculate the plasticity index 'A' line

Where Plastic limit is in percentage

If P.I. the soil is clay

If P.I. the soil is slit

LL=0-35 low compressibility

LL=35-50 medium compressibility

LL=50above high compressibility

COMPACTION TEST APPARATUS

EQUIPMENT

1). Compaction Mould

2). Collar

3). Base Plate

4). Rammer and Guide Tube, 2.6Kg x 310mm-drop.

5). Instruction Manual

INTRODUCTION: -

The Compaction Test Apparatus is made according to IS: 2720 (Part-VII) and is for the determination of the relationship between moisture content and the dry density. From the curve obtained, the value of the optimum moisture content when the dry density is maximum can be determined. This aids in evaluating the moisture content at which a given amount of rolling equipment gives the greatest compaction for any given soil that is proposed to be used as a rolled fill embankments. Earth dams, highway fill and other embankments must be placed in a dense state, if they are to have maximum strength and imperviousness, if they are to be free of excessive settlement by shrinkage of and in the case of granular soils x free of danger from liquefaction.

This tests plays in important part in the infestations and in the construction control of rolled fill materials. The test may be viewed as a Laboratory Procedure designed to bring soils to approximately the same state of density as is obtained when earth dams are compacted by rolling equipment. The comprise on the data given by control tests in the field with optimum values obtained in Laboratory tests furnishes a check on whether the desired compaction is obtained.

In recent years, heavier compacting equipment has come into use, and in order to reproduce the greater densities obtained with the equipment, heavy compaction tests

(IS: 2720 Part-VIII) have been developed. In the heavy compaction test, 25 blows of 450mm drop with a 4.89Kg rammer on each of five layers are given (Rammer is not supplied with the outfit).

DESCRIPTION: -

This Apparatus consists of a cylindrical mould known as compaction mould of 1000 cc in volume a detachable base plate and collar and a rammer of 2.6 Kg wt. with a guide tube for 310mm drop. The mould can be held rigidly to the base plate through the projected studs with locking nuts. The collar can be attached to the mould through the pins, which form the cached.

SPECIMEN PREPARATION: -

Take eight (8) Kg representative air-dried sample passing through a 20mm (3/4 in B.S.) Sieve. Remove the stones if any. Mix the sample thoroughly with a known percentage of water and keep if for some time in moist room to obtain uniform the moisture distribution. After the test is carried at particular moisture content, the compacted soil is to be crumbled to individual-to-individual particulars sample.

Increase the water content by 3 to 15% in steps of 1.5% in case of sandy soils and 9 to 26% in steps of about 8% for cohesive soils and repeat the above-mentioned operation.

It is always desirable to use different batches of soil and prepare the specimens with different moisture contents and keep them for sometime for uniform distribution of the moisture content. The plastic limit of

the soil gives a useful indication of the approximate upper limit of the range of moisture contents to be employed.

TEST PROCEDURE: -

Determine the weight of the mould to the nearest 1g(w). Apply grease lightly to the inside of the mould. Attach the base plate to the mould and fix it tightly through the studs with locking wing nuts. Attach the collar. Compact the soil in three equal layers; each layer being given 25 well distributed blows with the light rammer dropped from a height of 310mm above the soil. After compacting each layer, scratch the surface to give the bond with the succeeding layer. The amount of soil used shall be only just sufficient to fill the mould, leaving not more than 5mm to be struck of when the collar is removed. This should not be much to avoid the wastage of compactive energy and if the soil struck off is too great, the test result would be in accurate.

Rotate the Collar slowly to free the compacted soil and detach the collar without causing any disturbance. With a knife-edge, trim the sample to the required height. This should not be done from one end to the other end and is to be done from the center of the edge.

Determine the weight of the soil with the mould to the nearest 1 g (w). Take a representative soil sample (collection at the top, middle, and bottom) for the moisture content determination.

Repeat the above-described operations increasing the moisture content by 3 to 15% in steps of about 1.5% for sandy soils, and 9 to 26% in steps of about 3% for cohesive soils until there is a substantial decrease in the wet weight.

CALCULATION: -

Wet Density: $r_m = w\text{-}w_m$ gms/C.C.

Dry Density: $r_d = \frac{r_m \times 100}{100+m}$ gms/C.C.

Where,

m = Percentage moisture content.

r_m = The Wet Density of compacted soil.

w = Weight of the mould with the soil.

w_m = Weight of the empty mould.

And

r_d = The Dry Density of the compacted soil.

Plot the dry densities obtained in a series of compaction tests against the corresponding moisture contents. Draw a smooth curve. From this determine the maximum density and the optimum moisture content.

MAINTENANCE: -

Keep all the parts clean. Apply grease to the projected studs.

UNCONFINED COMPRESSION TEST APPARATUS

CONTENTS

APPARATUS: -

The Apparatus comprises of the following: -

1. Motorized Load Frame 5000Kg capacity with three strain rates 1.25, 1.5 & 2.5mm per min.
2. Upper platen with springs for self-alignment.

3. Bracket for strain dial gauge (Fitted to one pillar).
4. Proving Ring adaptor (fitted to upper cross head).
5. Cone seating for both top & bottom platen.
6. Instructions & Drawing.

INTRODUCTION: - The maximum load that can be transmitted to the sub-soil by a foundation depends upon the resistance of the underlying soil or rock to deformation in shear or compression. It becomes necessary to investigate the factors that control the shear character instincts of the materials. Shear strength is normally found out by compression tests in which a dial load is applied to the sample and increased until failure occurs. The use of compression tests to investigate the shearing strength of materials depends upon the facts that the failure occurs by shear on one or more inclined planes. It is possible to compute the normal pressure and shearing stress on such a plane at the instant of failure. The specimen may or may not be objected to a lateral pressure during the test. When it is not, the test is known as unconfined compression test.

DESCRIPTION: - The apparatus consists of a motorized load frame. The Load Frame consists of a cast base to which to steel columns are fitted. Across head connects the two vertical columns at the top. The top crosshead can be adjusted to be at different heights with the help of nuts and threaded portion of columns. The crosshead is provided in the center with the hexagonal nut for taking any standard proving ring. A lead screw moves up or on to the lead screw. A motor screw the lead screw through a gearbox giving three strains rates can be divided both forwards and backwards. A bracket for fitting a strain dial gauge is not in the scope of supply. A top platen has also supplied to be attached to proving ring bottom. Two cone seatings are provided for attaching to top and bottom plates. The load frame is wired for 230V sph 50Hz power supply.

SPECIMEN PREPARATION: - The specimen for the test shall be of a minimum diameter of 38mm. The largest particle contained within the test specimen shall be smaller than 1/8 of the specimen diameter. If after completion of test on an undisturbed sample, it is found that larger particles are present that permitted, it shall be noted in the test results under remarks. The height to diameter ratio shall be 2. Measurements of diameter and height shall be made with vernier calipers or any other similar gadgets up to an accuracy of 0.1mm.

UNDISTURBED PREPARATION: - Undisturbed specimen shall be prepared from large undisturbed samples or relevant size samples can be secured as per standards. The specimen shall be uniform circular cross section with ends perpendicular to long axis of specimen. If found necessary the specimens shall be

sealed with rubber membranes, thin plastic coating, grease coat, or sprayed plastic. Representative sample cuttings shall be used to find water content.

REMOULDED SPECIMEN: - In the case of failed undisturbed specimen, the materials shall be thoroughly worked to assure complete remolding. Care shall be taken to preserve uniform density and water content.

COMPACTED SPECIMEN: - The initial length, diameter and weight of sample shall be measured and sample placed on the bottom platen. The upper platen shall be adjusted to make contact with the specimen top. The deformation dial gauge shall be adjusted to Zero. Force shall be applied to produce an axial strain of ½ to percent per minute. Force and deformation readings shall be recorded at suitable intervals. Up to 6% strain the readings may be taken at every 30 sec after 6% frequency may be halved and beyond 112% it may be decreased further.

The specimen shall be compressed until failure surface have developed or stress-strain curve is well past its peak or until axial strain of 20% is reached.

The failure pattern shall be sketched carefully and shown on date sheet. The angle between failure plane and horizontal shall be measured and noted. The water content shall be determined using standard methods.

CALCULATIONS & RESULTS: -

a. The axial strain E, shall be determined from

$$E = \frac{AL}{-Lo}$$ where,

AL=the change in specimen length read from strain dial gauge.

Lo=Initial length of specimen.

b. The average cross-sectional area A, at a particular strain shall be determined from.

A = $\frac{Ao}{1-0}$ were

Ao=Initial cross sectional area of specimen.

c. Compressive stressive stress Se shall be determined from

Se = $\frac{P}{A}$ where,

P=the compressive force, and

A=Average cross-sectional area

Values of stress Se and strain e obtained so shall be plotted. The maximum stress from this plot gives the value of unconfined compressive strength qu. In case no maximum occurs within 20% axial strain, the unconfined compressive strength shall be taken as the stress at 20% axial strain.

In case of soils which we have as if the shear angle is equal to zero (as in the case of saturated or cohesion of the soil may be taken to behalf the unconfined compressive strength obtained).

PRECAUTIONS & MAINTENANCE

1. Gear Box, lead screw shall be kept greased at intervals to secure a smooth operation.
2. Plated components shall be cleaned and oiled to avoid rusting.
3. The instrument shall be kept clean after a test.
4. Strain rate shall be chosen to suit soil type and sample size under test.
5. Cone seats are preferred to apply stress axially.
6. Water contents have to be estimated from a representative sample.