**CE701 Geotechnical Engineering**

**Civil Engineering**

**EXPERIMENT NO.1**

**DETERMINATION OF WATER CONTENT**

**Date of conduction:-**

**Date of submission:-**

**Submitted by other members:-**

**1.**

**2.**

**3.**

**4.**

**5.**

**Group no:-**

**Signature**

**Name of faculty in charge:**

**Name of Technical Assistant:**

**Objective**

Determine the natural moisture 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 1050C to 1100C.
3. Desiccator.
4. Balance of sufficient sensitivity.

### Procedure

1. Clean the containers 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 1050C to 1100C 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 600C) possibly for a longer period.

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

### Observations

Tabe. 1.1 Data and observation sheet for water content determination

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S. No.** | **Sample No.** | **1** | **2** | **3** |
| 1 | Weight of container with lid (W1 gm) |  |  |  |
| 2 | Weight of container with lid +wet soil  (W2 gm) |  |  |  |
| 3 | Weight of container with lid +dry soil (W3  gm) |  |  |  |
| 4 | Water/Moisture content  W = [(W2W3)/(W3W1)]\*100 |  |  |  |

### Interpretation of Results

The natural moisture content of the given 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.

**Specimen Calculations**

**CE701 Geotechnical Engineering**

**Civil Engineering**

**EXPERIMENT NO.5**

**DETERMINATION OF SPECIFIC GRAVITY**

**Date of conduction:-**

**Date of submission:-**

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**1.**

**2.**

**3.**

**4.**

**5.**

**Group no:-**

**Signature**

**Name of faculty in charge:**

**Name of Technical Assistant:**

**DETERMINATION OF SPECIFIC GRAVITY**

### Objective

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

### Need and scope of the experiment

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
   1. Wash the bottle with water and allow it to drain.
   2. Wash it with alcohol and drain it to remove water.
   3. Wash it with ether, to remove alcohol and drain ether.
2. Weigh the empty bottle with stopper (W1)
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 (W2).
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 (T 0 C).

x

1. Take the bottle, wipe it clean and dry note. Now determine the weight of the bottle and the contents (W3).
2. Now empty the bottle and thoroughly clean it. Fill the bottle with only distilled water and weigh it. Let it be W4 at temperature (T 0 C).

x

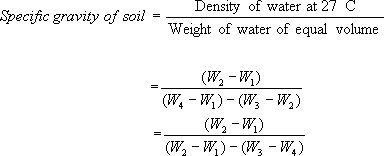
1. Repeat the same process for 2 to 3 times, to take the average reading of it.

### Observations

**Table 2.1 Observations for the Specific gravity determination**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S. No.** | **Observation Number** | **1** | **2** | **3** |
| 1 | Weight of density bottle (W1 g) |  |  |  |
| 2 | Weight of density bottle + dry soil (W2 g) |  |  |  |
| 3 | Weight of bottle + dry soil + water at  0  temperature T x C (W3 g) |  |  |  |
| 4 | Weight of bottle + water (W4 g) at  0  temperature Tx C |  |  |  |
|  | 0  Specific gravity G at Tx C |  |  |  |
|  | 0  Average specific gravity at Tx C |  | | |

### Calculations



**Interpretation**

Unless or otherwise specified specific gravity values reported shall be based on water at 270 C. So the specific gravity at 270C = K\*Sp. gravity at Tx0C.

img21

### Result

The specific gravity of the soil sample is .

### General Remarks

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.

**Specimen Calculations**

**CE701 Geotechnical Engineering**

**Civil Engineering**

**EXPERIMENT NO.6**

**DETERMINATION OF CONSISTENCY LIMITS**

**Date of conduction:-**

**Date of submission:-**

**Submitted by other members:-**

**1.**

**2.**

**3.**

**4.**

**5.**

**Group no:-**

**Signature**

**Name of faculty in charge:**

**Name of Technical Assistant:**

1. **Determination of Liquid Limit:**

### Objective

Determine the liquid limit for the given soil sample.

### Need and scope

Liquid limit is significant to know the stress history and general properties of the soil met with construction. From the results of liquid limit the compression index may be estimated. The compression index value will help us in settlement analysis. If the natural moisture content of soil is closer to liquid limit, the soil can be considered as soft if the moisture content is lesser than liquids limit, the soil can be considered as soft if the moisture content is lesser than liquid limit. The soil is brittle and stiffer.

### Theory

The liquid limit is the moisture content at which the groove, formed by a standard tool into the sample of soil taken in the standard cup, closes for 10 mm on being given 25 blows in a standard manner. At this limit the soil possess low shear strength.

### Apparatus required

1. Balance
2. Liquid limit device (Casagrande’s)
3. Grooving tool
4. Mixing dishes
5. Spatula
6. Electrical oven

### Procedure

1. About 120 gm of air-dried soil from thoroughly mixed portion of material passing 425 micron I.S sieve is to be obtained.
2. Distilled water is mixed to the soil thus obtained in a mixing disc to form uniform paste. The paste shall have a consistency that would require 30 to 35 drops of cup to cause closer of standard groove for sufficient length.
3. Trim it to a depth of 1cm at the point of maximum thickness and return excess of soil to the dish.
4. The soil in the cup shall be divided by the firm strokes of the grooving tool along the diameter through the centre line of the follower so that clean sharp groove of proper dimension is formed.
5. Lift and drop the cup by turning crank at the rate of two revolutions per second until the two halves of soil cake come in contact with each other for a length of about 1 cm by flow only.
6. The number of blows required to cause the groove close for about 1 cm shall be recorded.
7. A representative portion of soil is taken from the cup for water content determination.
8. Repeat the test with different moisture contents at least three more times for blows between 10 and 40.

##### Observations

Tab 7.1 Observation and Calculation sheet for the water content determination

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Determination Number** | **1** | **2** | **3** | **4** |
| Container number |  |  |  |  |
| Weight of container |  |  |  |  |
| Weight of container  + wet soil |  |  |  |  |
| Weight of container  + dry soil |  |  |  |  |
| Weight of water |  |  |  |  |
| Weight of dry soil |  |  |  |  |
| Moisture content (%) |  |  |  |  |
| No. of blows |  |  |  |  |

### Calculations

Draw a graph showing the relationship between water content (on y-axis) and number of blows (on x-axis) on semi- log graph. The curve obtained is called flow curve. The moisture content corresponding to 25 drops (blows) as read from the represents liquid limit. It is usually expressed to the nearest whole number.

### Result

Liquid Limit of the given soil sample is

Flow index If = (W2-W1)/(logN1/N2) = slope of the flow curve.

**Specimen Calculations**

# (ii) Determination of Plastic Limit:

### Objective

Determine the plastic limit for the given soil sample.

### Need and scope

Soil is used for making bricks, tiles and soil cement blocks in addition to its use as foundation for structures.

### Apparatus required

* 1. Porcelain dish.
  2. Glass plate for rolling the specimen.
  3. Air tight containers to determine the moisture content.
  4. Balance of capacity 200gm and sensitive to 0.01gm.
  5. Oven thermostatically controlled with interior of non-corroding material to maintain the temperature around 1050 and 1100c.

##### Procedure

1. Take about 20gm of thoroughly mixed portion of the material passing through 425 micron i.s. Sieve obtained in accordance with i.s. 2720 (part 1).
2. Mix it thoroughly with distilled water in the evaporating dish till the soil mass becomes plastic enough to be easily molded with fingers.
3. Allow it to season for sufficient time (for 24 hrs) to allow water to permeate throughout the soil mass.
4. Take about 10gms of this plastic soil mass and roll it between fingers and glass plate with just sufficient pressure to roll the mass into a threaded of uniform diameter throughout its length. The rate of rolling shall be between 60 and 90 strokes per minute.
5. Continue rolling till you get a threaded of 3 mm diameter.
6. Kneed the soil together to a uniform mass and re-roll.
7. Continue the process until the thread crumbles when the diameter is 3 mm.
8. Collect the pieces of the crumbled thread in air tight container for moisture content determination.
9. Repeat the test to at least 3 times and take the average of the results calculated to the nearest whole number.

### Observations

Compare the diameter of thread at intervals with the rod. When the diameter reduces to 3 mm, note the surface of the thread for cracks.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Container No.** |  |  |  |  |
| **Wt. of container + lid,W1** |  |  |  |  |
| **Wt. of container + lid + wet sample,W2** |  |  |  |  |
| **Wt. of container + lid + dry sample,W3** |  |  |  |  |
| **Wt. of dry sample = W3 -W1** |  |  |  |  |
| **Wt. of water in the soil = W3 - W2** |  |  |  |  |
| **Water content (%) = (W3 -W2) / (W3 - W1) \* 100** |  |  |  |  |

**Tab 8.1 Calculation sheet for Plastic Limit determination**

### Result

Average Plastic Limit for the given soil sample is

**Specimen Calculations**

# (iii) Determination of Shrinkage Limit:

### Objective

Determine the shrinkage limit and calculate the shrinkage ratio for the given soil sample.

### Theory

As the soil loses moisture, either in its natural environment, or by artificial means in laboratory it changes from liquid state to plastic state, from plastic state to semi-solid state and then to solid state. Volume changes also occur with changes in water content. But there is particular limit at which any moisture change does not cause soil any volume change.

### Need and scope

Soils which undergo large volume changes with change in water content may be troublesome. Usually volume changes may not be equal.

A shrinkage limit test should be performed on a soil.

1. 1. To obtain a quantitative indication of how much change in moisture can occur before any appreciable volume changes occurs.
2. To obtain an indication of change in volume.
3. The shrinkage limit is useful in areas where soils undergo large volume changes when going through wet and dry cycles (as in case of earth dams)

### Apparatus

1. Evaporating Dish. Porcelain, about 12cm diameter with flat bottom.
2. Spatula
3. Shrinkage Dish. Circular, porcelain or non-corroding metal dish (3 nos) having a flat bottom and 45 mm in diameter and 15 mm in height internally.
4. Straight Edge. Steel, 15 cm in length.
5. Glass cup. 50 to 55 mm in diameter and 25 mm in height, the top rim of which is ground smooth and level.
6. Glass plates. Two, each 75 , 75 mm one plate shall be of plain glass and the other shall have prongs.
7. Sieves. 2mm and 425- micron IS sieves.
8. Oven-thermostatically controlled.
9. Graduate-Glass, having a capacity of 25 ml and graduated to 0.2 ml and 100 cc one-mark flask.
10. Balance-Sensitive to 0.01 g minimum.
11. Mercury. Clean, sufficient to fill the glass cup to over flowing.
12. Wash bottle containing distilled water.

### Procedure

###### Preparation of soil paste

1. Take about 100 gm of soil sample from a thoroughly mixed portion of the material passing through 425-micron I.S. sieve.
2. Place about 30 gm the above soil sample in the evaporating dish and thoroughly mixed with distilled water and make a creamy paste.

Use water content some where around the liquid limit.

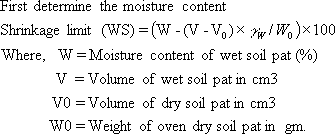
###### Filling the shrinkage dish

1. Coat the inside of the shrinkage dish with a thin layer of Vaseline to prevent the soil sticking to the dish.
2. Fill the dish in three layers by placing approximately 1/3 rd of the amount of wet soil with the help of spatula. Tap the dish gently on a firm base until the soil flows over the edges and no apparent air bubbles exist. Repeat this process for 2nd and 3rd layers also till the dish is completely filled with the wet soil. Strike off the excess soil and make the top of the dish smooth. Wipe off all the soil adhering to the outside of the dish.
3. Weigh immediately, the dish with wet soil and record the weight.
4. Air- dry the wet soil cake for 6 to 8hrs, until the colour of the pat turns from dark to light. Then oven- dry the constant weight at 1050C to 1100C say about 12 to 16 hrs.
5. Remove the dried disk of the soil from oven. Cool it in a desiccator. Then obtain the weight of the dish with dry sample.
6. Determine the weight of the empty dish and record.
7. Determine the volume of shrinkage dish which is evidently equal to volume of the wet soil as follows. Place the shrinkage dish in an evaporating dish and fill the dish with mercury till it overflows slightly. Press it with plain glass plate firmly on its top to remove excess mercury. Pour the mercury from the shrinkage dish into a measuring jar and find the volume of the shrinkage dish directly. Record this volume as the volume of the wet soil pat.

###### Volume of the Dry Soil Pat

1. Determine the volume of dry soil pat by removing the pat from the shrinkage dish and immersing it in the glass cup full of mercury in the following manner.
2. Place the glass cup in a larger one and fill the glass cup to overflowing with mercury. Remove the excess mercury by covering the cup with glass plate with prongs and pressing it. See that no air bubbles are entrapped. Wipe out the outside of the glass cup to remove the adhering mercury. Then, place it in another larger dish, which is, clean and empty carefully.
3. Place the dry soil pat on the mercury. It floats submerge it with the pronged glass plate which is again made flush with top of the cup. The mercury spills over into the larger plate. Pour the mercury that is displayed by the soil pat into the measuring jar and find the volume of the soil pat directly

### Calculation



###### Caution

Do not touch the mercury with gold rings.

### Tabulation and Results

Tab 9.1 Calculation sheet for shrinkage limit determination

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S.No** | **Determination No.** | **1** | **2** | **3** |
| 1 | Wt. of container in gm,W1 |  |  |  |
| 2 | Wt. of container + wet soil pat in gm,W2 |  |  |  |
| 3 | Wt. of container + dry soil pat in gm,W3 |  |  |  |
| 4 | Wt. of oven dry soil pat, W0 in gm |  |  |  |
| 5 | Wt. of water in gm |  |  |  |
| 6 | Moisture content (%), W |  |  |  |
| 7 | Volume of wet soil pat (V), in cm |  |  |  |
| 8 | Volume of dry soil pat (V0) in cm3 |  |  |  |
| 9 | By mercury displacement method |  |  |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | a. Weight of displaced mercury |  |  |  |
|  | b. Specific gravity of the mercury |  |  |  |
| 10 | Shrinkage limit (WS) |  |  |  |
| 11 | Shrinkage ratio (R) |  |  |  |

**Specimen Calculation**

**CE701 Geotechnical Engineering**

**Civil Engineering**

**EXPERIMENT NO.4**

**DETERMINATION OF SOIL FIELD DENSITY BY SAND REPLACEMENT METHOD**

**Date of conduction:-**

**Date of submission:-**

**Submitted by other members:-**

**1.**

**2.**

**3.**

**4.**

**5.**

**Group no:-**

**Signature**

**Name of faculty in charge:**

**Name of Technical Assistant:**

### Objective

Determine the in situ density of natural or compacted soils using sand pouring cylinders.

### Apparatus required

* 1. Sand pouring cylinder of 3 litre/16.5 litre capacity mounted above a pouring come and separated by a shutter cover plate.
  2. Tools for excavating holes, suitable tools such as scraper tool to make a level surface.
  3. Cylindrical calibrating container with an internal diameter of 100 mm/200 mm and an internal depth of 150 mm/250 mm fitted with a flange 50 mm/75 mm wide and about 5 mm surrounding the open end.
  4. Balance to weigh unto an accuracy of 1g.
  5. Metal containers to collect excavated soil.
  6. Metal tray with 300 mm/450 mm square and 40 mm/50 mm deep with a 100 mm/200 mm diameter hole in the centre.
  7. Glass plate about 450 mm/600 mm square and 10mm thick.
  8. Clean, uniformly graded natural sand passing through 1.00 mm i.s.sieve and retained on the 600micron i.s.sieve. It shall be free from organic matter and shall have been oven dried and exposed to atmospheric humidity.
  9. Suitable non-corrodible airtight containers.
  10. Thermostatically controlled oven with interior on non-corroding material to maintain the temperature between 1050c to 1100c.
  11. A desiccator with any desiccating agent other than sulphuric acid.

### Procedure

Calibration of the Cylinder

1. Fill the sand pouring cylinder with clean sand so that the level of the sand in the cylinder is within about 10 mm from the top. Find out the initial weight of the cylinder plus sand (W1) and this weight should be maintained constant throughout the test for which the calibration is used.
2. Allow the sand of volume equal to that of the calibrating container to run out of the cylinder by opening the shutter, close the shutter and place the cylinder on the glass plate and open the shutter to allow the sand to run out and close the cylinder shutter when there is no movement of sand and remove the cylinder carefully. Weigh the sand collected on the glass plate. Its weight (W2) gives the weight of sand filling the cone portion of the sand pouring cylinder.

Repeat this step at least three times and take the mean weight (W2) Put the sand back into the sand pouring cylinder to have the same initial constant weight (W1)

###### Determination of Bulk Density of Soil

1. Determine the volume (V) of the container be filling it with water to the brim. Check this volume by calculating from the measured internal dimensions of the container.
2. Place the sand poring cylinder centrally on the calibrating container making sure that constant weight (W1) is maintained. Open the shutter and permit the sand to run into the container. When no further movement of sand is seen close the shutter, remove the pouring cylinder and find its weight (W3).

**Determination of Dry Density of Soil In Place**

1. Approximately 60 sqcm of area of soil to be tested should be trimmed down to a level surface, approximately of the size of the container. Keep the metal tray on the level surface and excavate a circular hole of volume equal to that of the calibrating container. Collect all the excavated soil in the

tray and find out the weight of the excavated soil (Ww). Remove the tray, and place the sand pouring cylinder filled to constant weight so that the base of the cylinder covers the hole concentrically. Open the shutter and permit the sand to run into the hole. Close the shutter when no further movement of the sand is seen. Remove the cylinder and determine its weight (W3).

1. Keep a representative sample of the excavated sample of the soil for water content determination.

### Observations and Calculations

Tab. 3.1 Calculation sheet for sand density determination

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S.No.** | **Sample Details** | **1** | **2** | **3** |
| **Calibration** |
| 1 | Weight of sand in cone (on glass plate from pouring cylinder) W2 gm |  |  |  |
| 2 | Volume of calibrating container (V) in cc |  |  |  |
| 3 | Weight of sand + cylinder before pouring in calibrating container W1 gm |  |  |  |
| 4 | Weight of sand + cylinder after pouring in calibrating container W3 gm |  |  |  |
| 5 | Weight of sand filled in calibrating container Wa = (W1-W3-W2) gm |  |  |  |
| 6 | Bulk density of sand s = Wa / V gm/cc |  |  |  |

Tab. 3.2 Calculation sheet for density of soil

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S. No.** | **Measurement of Soil Density** | **1** | **2** | **3** |
| 1 | Weight of wet soil from hole Ww gm |  |  |  |
| 2 | Weight of sand + cylinder before pouring into the hole & cone, W1 gm |  |  |  |
| 3 | Weight of sand + cylinder after pouring into the hole & cone, W4 gm |  |  |  |
| 4 | Weight of sand in hole Wh = (W1-W2-W4) gm |  |  |  |
| 5 | Volume of the hole = Vh =Wh / s |  |  |  |
| 6 | Bulk density b = (Ww / Vh ) gm/cc |  |  |  |
| 7 | Water content determination |  |  |  |
| 8 | Container number |  |  |  |
| 9 | Weight of wet soil |  |  |  |
| 10 | Weight of dry soil |  |  |  |
| 11 | Moisture content (%) |  |  |  |
| 12 | Dry density d = b / (1+w) gm/cc |  |  |  |

### General Remarks

1. Great care has to be taken while calibrating the bulk density of sand.
2. The excavated hole must be equal to the volume of the calibrating container.

**Specimen Calculations**

**CE701 Geotechnical Engineering**

**Civil Engineering**

**EXPERIMENT NO.3**

**DETERMINATION OF SOIL FIELD DENSITY BY CORE CUTTER METHOD**

**Date of conduction:-**

**Date of submission:-**

**Submitted by other members:-**

**1.**

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**Group no:-**

**Signature**

**Name of faculty in charge:**

**Name of Technical Assistant:**

### Objective

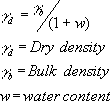
Determine the dry density of the soil by using core cutter method.

### Apparatus required

1. Cylindrical core cuter, 100 mm internal diameter and 130 mm long
2. Steel rammer, mass 9kg. Overall length, with the foot and staff about 900mm
3. Steel dolly, 25 mm high and 100mm internal diameter
4. Weighing balance, accuracy 1g.
5. Palette knife
6. Straight edge, steel rule etc

### Theory

A cylindrical core cutter is a seamless steel tube. For determination of the dry density of the soil, the cutter is pressed into the soil mass so that it is filled with the soil. The cutter filled with the soil is lifted up. The mass of the soil is determined. The dry density is obtained as



M = mass of wet soil in the cutter

### Procedure

V = internal volume of the cutter

* 1. Determine the internal diameter and height of the core cutter to the nearest 0.25 mm.
  2. Determine the mass (M1) of the cutter to the nearest gram.
  3. Expose a small area of the soil mass to be tested. Level the surface, about 300 mm square in area.
  4. Place dolley over the top of the core cutter and press the core cutter in to the soil mass using the rammer. Stop the process of pressing when about 15 mm of the dolley protrudes above the soil surface.
  5. Remove the soil surrounding the core cutter and takeout the core cutter. Some soil would project from the lower end of the cutter.
  6. Remove the dolley. Trim the top and bottom surface of the core cutter carefully using a straight edge.
  7. Weigh the core cutter filled with the soil to the nearest gram (M2).
  8. Remove the core of the soil from the cutter. Take a representative sample for the water content determination.

### Observations and Calculations

Tab 4.1 Calculation sheet for dry density of soil

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S.No** | **Observations** | **Sample No.** | | |
| **1** | **2** | **3** |
| 1 | Internal diameter |  |  |  |
| 2 | Internal Height |  |  |  |
| 3 | Mass of empty core cutter (M1) |  |  |  |
| 4 | Mass of core cutter with soils (M2) |  |  |  |
| 5 | Mass of wet soil, M = M2-M1 |  |  |  |
| 6 | Volume of the cutter, V |  |  |  |
| 7 | Water content (%), w |  |  |  |
| 8 | Bulk Density = M / V |  |  |  |
| 9 | Dry density = Bulk Density/ (1+ w) |  |  |  |

**Result:** The field dry density of the soil is .

**Specimen Calculations**

**CE701 Geotechnical Engineering**

**Civil Engineering**

**EXPERIMENT NO.8**

**GRAIN SIZE DISTRIBUTION BY SIEVE SHAKING METHOD**

**Date of conduction:-**

**Date of submission:-**

**Submitted by other members:-**

**1.**

**2.**

**3.**

**4.**

**5.**

**Group no:-**

**Signature**

**Name of faculty in charge:**

**Name of Technical Assistant:**

### Objective

Determine the relative proportions of different grain sizes which make up a given soil mass.

### Need and scope of experiment

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.

### Apparatus

* + 1. Balance
    2. I.s sieves
    3. Rubber pestle and mortar
    4. Manual/mechanical sieve shaker

### Procedure

1. For soil samples of soil retained on 75 micron i.s sieve
   1. 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.
   2. I.S.sieves are selected and arranged in the order as shown in the table.
   3. The soil sample is separated into various fractions by sieving through above sieves placed in the above mentioned order.
   4. The weight of soil retained on each sieve is recorded.
   5. The moisture content of soil if above 5% it is to be measured and recorded.
2. The sieves for soil tests: 4.75 mm to 75 microns.
3. No particle of soil sample shall be pushed through the sieves.
4. The balance to be used must be sensitive to the extent of 0.1% of total weight of sample taken.

### Observations

Weight of soil sample taken:

Tab 5.1 Calculation sheet for soil particle % finer

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S.No** | **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** |
| 1 | 4.75 |  |  |  |  |  |
| 2 | 2.00 |  |  |  |  |  |
| 3 | 1.00 |  |  |  |  |  |
| 4 | 0.600 |  |  |  |  |  |
| 5 | 0.425 |  |  |  |  |  |
| 6 | 0.300 |  |  |  |  |  |
| 7 | 0.150 |  |  |  |  |  |
| 8 | 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 d10, d30, d60.

Calculations

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 each successive sieve is found and graph between log grain size of soil and % finer is drawn.

### Specimen Calculations

**CE701 Geotechnical Engineering**

**Civil Engineering**

**EXPERIMENT NO.10**

**DETERMINATION OF COEFFICIENT OF PERMEABILITY OF SOIL**

**Date of conduction:-**

**Date of submission:-**

**Submitted by other members:-**

**1.**

**2.**

**3.**

**4.**

**5.**

**Group no:-**

**Signature**

**Name of faculty in charge:**

**Name of Technical Assistant:**

**Objective**

## (a) PERMEABILITY TEST BY CONSTANT HEAD

Determine the coefficient of permeability of a given soil sample by using constant head method.

### Need and scope

The knowledge of this property is much 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.

###### Planning and organization

1. Preparation of the soil sample for the test
2. Finding the discharge through the specimen under a particular head of water.

###### Definition of coefficient of permeability

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

### Apparatus

1. Permeameter mould of non-corrodible material having a capacity of 1000 ml, with an internal diameter of 100mm and internal effective height of 127.3 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 porous disc, 12 mm thick which has the permeability 10 times the expected permeability of 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.
9. A meter scale to measure the head differences and length of specimen.

### Preparation of specimen for testing

###### Undisturbed soil sample

* 1. Note down the sample number, bore hole number and its depth at which the sample was taken.
  2. Remove the protective cover (paraffin wax) from the sampling tube.
  3. Place the sampling tube in the sample extraction frame, and push the plunger to get a cylindrical form sample not longer than 35 mm in diameter and having height equal to that of mould.
  4. The specimen shall be placed centrally over the porous disc to the drainage base.
  5. The angular space shall be filled with an impervious material such as cement slurry or wax, to provide sealing between the soil specimen and the mould against leakage from the sides.
  6. The drainage cap shall then be fixed over the top of the mould.
  7. Now the specimen is ready for the test.

###### Disturbed soil sample

* 1. A 2.5 kg sample shall be taken from a thoroughly mixed air dried or oven dried material.
  2. The initial moisture content of the 2.5 kg sample shall be determined. Then the soil shall be placed in the air tight container.
  3. Add required quantity of water to get the desired moisture content.
  4. Mix the soil thoroughly.
  5. Weigh the empty permeameter mould.
  6. After greasing the inside slightly, clamp it between the compaction base plate and extension collar.
  7. Place the assembly on a solid base and fill it with sample and compact it.
  8. After completion of a compaction the collar and excess soil are removed.
  9. Find the weight of mould with sample.
  10. Place the mould with sample in the Permeameter, with drainage base and cap having discs that are properly saturated.

### Test procedure

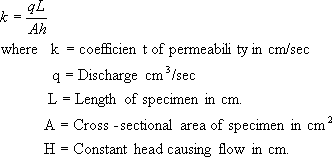
1. For the constant head arrangement, the specimen shall be connected through the top inlet to the constant head reservoir.
2. Open the bottom outlet.
3. Establish steady flow of water.
4. The quantity of flow for a convenient time interval may be collected.
5. Repeat three times for the same interval.

### 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.

### Computation of result

Coefficient of permeability for a constant head test is given by



###### 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:

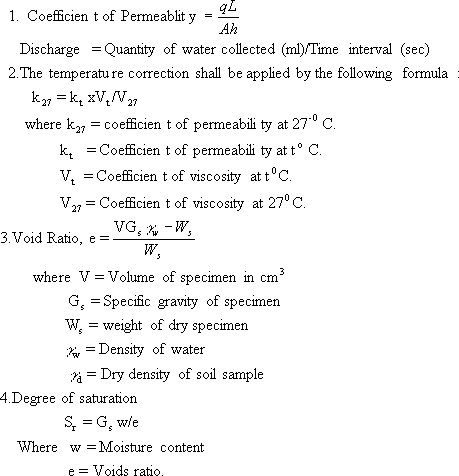
Boring No.: Depth:

###### Details of sample

Diameter of specimen cm Length of specimen (L) cm Area of specimen (A) cm2 Specific gravity of soil Gs  Volume of specimen (V) cm3 Weight of dry specimen (Ws) gm Moisture content %

Tab 10.1 Observation sheet for Permeability determination

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Experiment No.** | | **1** | **2** | **3** |
| Length of specimen | L(cm) |  |  |  |
| Area of specimen | A(cm2) |  |  |  |
| Time t | (sec) |  |  |  |
| Discharge | q(cm3) |  |  |  |
| Height of water | h(cm) |  |  |  |
| Temperature | (o C) |  |  |  |

**Interpretation**

**Specimen Calculations**

# (b)

# PERMEABILITY TEST BY FALLING HEAD METHOD

### Objective

Determine the coefficient of permeability of the given soil sample, using falling head method.

### Need and scope

The test results of the permeability experiments are used

1. To estimate ground water flow.
2. To calculate seepage through dams.
3. To find out the rate of consolidation and settlement of structures.
4. To plan the method of lowering the ground water table.
5. To calculate the uplift pressure and piping.
6. To design the grouting.
7. To design pits for recharging.
8. And also for soil freezing tests.

.

### Principle of the experiment

The passage of water through porous material is called seepage. A material with continuous voids is called a permeable material. Hence permeability is a property of a porous material which permits passage of fluids through inter connecting conditions. Hence permeability is defined as the rate of flow of water under laminar conditions through a unit cross-sectional area perpendicular to the direction of flow through a porous medium under unit hydraulic gradient and under standard temperature conditions.

The principle behind the test is Darcy’s law for laminar flow. The rate of discharge is proportional to (i x A) q= kiA

Where, q= Discharge per unit time.

A=Total area of c/s of soil perpendicular to the direction of flow. i=hydraulic gradient.

k=Darcy’s coefficient of permeability

= the mean velocity of flow that will occur through the cross-sectional area under unit hydraulic gradient.

### Apparatus

1. Permeameter with its accessories.
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.

### Knowledge of equipment

1. 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. The mould has a detachable base plate and a removable exterior collar.
3. The compacting equipment has a circular face with 50 mm diameter and a length of 310 mm with a weight of 2.6 kg.
4. The drainage base is a porous disc, 12 mm thick with a permeability 10 times that of soil.
5. The drainage cap is also a porous disc of 12 mm thickness with an inlet/outlet fitting.
6. The container tank has an overflow valve. There is also a graduated jar to collect discharge.

### 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.

###### Undisturbed soil specimen

The preparation of the sample is as follows.

* 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 extractor 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.
  6. Protect the porous disc when cement slurry is poured.
  7. Compact the slurry with a small tamper.
  8. The drainage cap is also fixed over the top of the mould.
  9. The specimen is now ready for test.

###### Disturbed specimen

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

###### 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. img63Find weight W of soil mix for the given volume of the mould and hence find the dry
  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.

* 1. Put the weighed soil into the mould. Insert the top 3 cm end plug into the top collar, tamping the soil with hand.
  2. Keep, now the entire assembly on a compressive machine and remove the split collar. Apply the compressive force till the flanges of both end plugs touch the corresponding collars. Maintain this load for 1 mt and then release it.
  3. 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.
  4. 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.
  5. Now the specimen is ready for test.

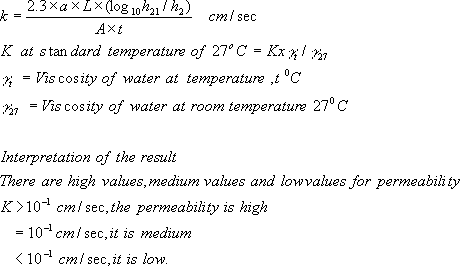
###### Preparation of Dynamically Compacted Disturbed sample

* 1. Take 800 to 1000 gm 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 gram (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 (W2).
  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.

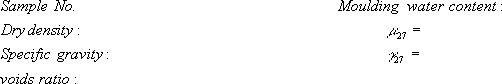
###### Experimental Procedure

1. Prepare the soil specimen as specified.
2. Saturate it. Deaired water is preferred.
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 some water to flow until steady flow is obtained.
5. Note down the time interval t for a fall of head in the stand pipe h.
6. Repeat step 5 three times to determine t for the same head.
7. Find a by collecting q for the stand pipe. Weigh it correct to 1 gm and find a from q/h=a.

Therefore the coefficient of permeability



### Observations



Tab 11.1 Observation sheet for coefficient of permeability determination

|  |  |  |  |
| --- | --- | --- | --- |
| **S.No** | **Details** | **1st set** | **2nd set** |
| 1 | Area of stand pipe (dia. 5 cm) a |  |  |
| 2 | Cross sectional area of soil specimen A |  |  |
| 3 | Length of soil specimen L |  |  |
| 4 | Initial reading of stand pipe h1 |  |  |
| 5 | Final reading of stand pipe h2 |  |  |
| 6 | Time t |  |  |
| 7 | Test temperature T |  |  |
| 8 | Coefficient of permeability at T kt |  |  |
| 9 | Coefficient of permeability at 27o C k27 |  |  |

###### General Remarks

1. During test there should be no volume change in the 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 rate of settlement founded on soil bed.

### Specimen Calculations

**CE701 Geotechnical Engineering**

**Civil Engineering**

**EXPERIMENT NO.14**

**UNCONFINED COMPRESSION STRENGH TEST**

**Date of conduction:-**

**Date of submission:-**

**Submitted by other members:-**

**1.**

**2.**

**3.**

**4.**

**5.**

**Group no:-**

**Signature**

**Name of faculty in charge:**

**Name of Technical Assistant:**

### Objective

To determine shear parameters of cohesive soil

### Need and scope

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 remoulded soil sample. Investigate experimentally the strength of a given soil sample.

### Planning and organization

Find out the diameter and length of the specimen.

##### Equipment

1. Loading frame of capacity of 2 t, with constant rate of movement. (note the least count of the dial gauge attached to the proving ring)
2. Proving ring of 0.01 kg sensitivity for soft soils; 0.05 kg for stiff soils
3. Soil trimmer
4. Frictionless end plates of 75 mm diameter (perspex plate with silicon grease coating)
5. Evaporating dish (aluminum container)
6. Soil sample of 75 mm length
7. Dial gauge (0.01 mm accuracy)
8. Balance of capacity 200 g and sensitivity to weigh 0.01 g
9. Oven thermostatically controlled with interior of non-corroding material to maintain the temperature at the desired level
10. Sample extractor and split sampler
11. Dial gauge (sensitivity 0.01mm)
12. Vernier calipers 13.

###### 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**

1. **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.
2. Place the sampling tube extractor and push the plunger till a small length of sample moves out.
3. Trim the projected sample using a wire saw.
4. Again push the plunger of the extractor till 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 the top, middle, and the bottom of the sample and find the average and record the same.
9. Measure the length of the sample and record.
10. Find the weight of the sample and record.
11. **Disturbed 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 Ww to this soil. Ww = WS - W/100 gm
    3. Mix the soil thoroughly with water.
    4. Place the wet soil in a tight thick polythene bag in a 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.
    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 moulded 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.
9. Draw the sketch of the failure pattern in the specimen.

##### Sample details

Type UD/D: soil description

Specific gravity (GS) 2.71 Bulk density :

Water content : Degree of saturation % : Diameter (Do) of the sample cm Area of cross-section = cm2 Initial length (Lo) of the sample = 76 mm

Tab 15.1 Calculation sheet for Compressive stress determination

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Elapsed time (minutes)** | **Compression dial**  **reading (L) (mm)** | **Strain L \* 100/Lo (%)**  **(e)** | **Area A**  **Ao /(1- e) (cm)2** | **Proving ring reading (Divns.)** | **Axial load (kg)** | **Compressive stress (kg/cm2)** |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

*Interpretation of test Results*

Unconfined compression strength of the soil = qu = Shear strength of the soil = qu/2 =

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

*General Remarks*

Minimum three samples should be tested; correlation can be made between unconfined strength and field SPT value N. Up to 6% strain the readings may be taken at every min (30 sec).

### Specimen Calculations

**CE701 Geotechnical Engineering**

**Civil Engineering**

**EXPERIMENT NO.13**

**TRIAXIAL TEST**

**Date of conduction:-**

**Date of submission:-**

**Submitted by other members:-**

**1.**

**2.**

**3.**

**4.**

**5.**

**Group no:-**

**Signature**

**Name of faculty in charge:**

**Name of Technical Assistant:**

**Objective**

To find the shear parameters of the soil by undrained triaxial test.

### Need and scope

The standard consolidated undrained test is compression test, in which the soil specimen is first consolidated under all round pressure in the triaxial cell before failure is brought about by increasing the major principal stress.

##### Knowledge of equipment

A constant rate of strain compression machine of which the following is a brief description of one is in common use.

1. A loading frame in which the load is applied by a yoke acting through an elastic dynamometer, more commonly called a proving ring which used to measure the load. The frame is operated at a constant rate by a geared screw jack. It is preferable for the machine to be motor driven, by a small electric motor.
2. A hydraulic pressure apparatus including an air compressor and water reservoir in which air under pressure acting on the water raises it to the required pressure, together with the necessary control valves and pressure dials.

A tri axial cell is to take 3.8 cm dia and 7.6 cm long samples, in which the sample can be subjected to an all round hydrostatic pressure, together with a vertical compression load acting through a piston. The vertical load from the piston acts on a pressure cap. The cell is usually designed with a non-ferrous metal top and base connected by tension rods and with walls formed of Perspex.

### Apparatus for preparation of the sample

1. 3.8 cm (1.5 inch) internal diameter 12.5 cm (5 inches) long sample tubes.
2. Rubber ring.
3. An open ended cylindrical section former, 3.8 cm inside dia, fitted with a small rubber tube in its side.
4. Stop clock.
5. Moisture content test apparatus.
6. A balance of 250 gm capacity and accurate to 0.01 gm.

### Experimental Procedure

1. The sample is placed in the compression machine and a pressure plate is placed on the top. Care must be taken to prevent any part of the machine or cell from jogging the sample while it is being setup, for example, by knocking against this bottom of the loading piston. The probable strength of the sample is estimated and a suitable proving ring selected and fitted to the machine.
2. The cell must be properly set up and uniformly clamped down to prevent leakage of pressure during the test, making sure first that the sample is properly sealed with its end caps and rings (rubber) in position and that the sealing rings for the cell are also correctly placed.
3. When the sample is setup water is admitted and the cell is fitted under water escapes from the beed valve, at the top, which is closed. If the sample is to be tested at zero lateral pressure water is not required.
4. The air pressure in the reservoir is then increased to raise the hydrostatic pressure in the required amount. The pressure gauge must be watched during the test and any necessary adjustments must be made to keep the pressure constant.
5. The handle wheel of the screw jack is rotated until the under side of the hemispherical seating of the proving ring, through which the loading is applied, just touches the cell piston.
6. The piston is then removed down by handle until it is just in touch with the pressure plate on the top of the sample, and the proving ring seating is again brought into contact for the begging of the test.

### Observations

1. The machine is set in motion (or if hand operated the hand wheel is turned at a constant rate) to give a rate of strain 2% per minute.
2. The strain dial gauge reading is then taken and the corresponding proving ring reading is taken the corresponding proving ring chart. The load applied is known.
3. The experiment is stopped at the strain dial gauge reading for 15% length of the sample or 15% strain.

Date: Job:

Location: Size of specimen:

Length: Proving ring constant:

*Diameter: Initial area L:*

Initial Volume: Strain dial gauge least count (const):

Tab 16.1 Tabulation sheet for tri axial test

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Cell pressure kg/cm2** | **Strain dial** | **Proving ring reading** | **Load on sample kg** | **Corrected area cm2** | **Deviator stress** |
| 0.5 | 0 |  |  |  |  |
| 50 |
| 100 |
| 150 |
| 200 |
| 250 |
| 300 |
| 350 |
| 400 |
| 450 |
| 0.5 | 0 |  |  |  |  |
| 50 |
| 100 |
| 150 |
| 200 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | 250 |  |  |  |  |
| 300 |
| 350 |
| 400 |
| 450 |
| 0.5 | 0 |  |  |  |  |
| 50 |
| 100 |
| 150 |
| 200 |
| 250 |
| 300 |
| 350 |
| 400 |
| 450 |

Tab 16.2 Tabulation sheet for shear strength determination

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Sample No.** | **Wet bulk density gm/cc** | **Cell pressure kg/cm2** | **Compressive stress at failure** | **Strain at failure** | **Moisture content** | **Shear strength (kg/cm2)** | **Angle of shearing resistance** |
| **1** |  |  |  |  |  |  |  |
| **2** |
| **3** |

**General Remarks**

1. It is assumed that the volume of the sample remains constant and that the area of the sample increases uniformly as the length decreases. The calculation of the stress is based on this new area at failure, by direct calculation, using the proving ring constant and the new area of the sample. By constructing a chart relating strain readings, from the proving ring, directly to the corresponding stress.
2. The strain and corresponding stress is plotted with stress abscissa and curve is drawn. The maximum compressive stress at failure and the corresponding strain and cell pressure are found out.
3. The stress results of the series of triaxial tests at increasing cell pressure are plotted on a mohr stress diagram. In this diagram a semicircle is plotted with normal stress as abscissa shear stress as ordinate.
4. The condition of the failure of the sample is generally approximated to by a straight line drawn as a tangent to the circles, the equation of which is  = C +  tan. The value of cohesion, C is read of the shear stress axis, where it is cut by the tangent to the mohr circles, and the angle of shearing resistance () is angle between the tangent and a line parallel to the shear stress.

## Specimen Calculations

**CE701 Geotechnical Engineering**

**Civil Engineering**

**EXPERIMENT NO.12**

**DIRECT SHEAR TEST**

**Date of conduction:-**

**Date of submission:-**

**Submitted by other members:-**

**1.**

**2.**

**3.**

**4.**

**5.**

**Group no:-**

**Signature**

**Name of faculty in charge:**

**Name of Technical Assistant:**

**Objective**

Determine the shearing strength of the soil using the direct shear apparatus.

### Need and scope

In many engineering problems such as design of foundation, retaining walls, slab bridges, pipes, sheet piling, the value of the angle of internal friction and cohesion of the soil involved are required for the design. Direct shear test is used to predict these parameters quickly. The laboratory reports cover the laboratory procedures for determining these values for cohesionless soils.

### Apparatus

1. Direct shear box apparatus
2. Loading frame (motor attached)
3. Dial gauge
4. Proving ring
5. Tamper
6. Straight edge
7. Balance to weigh up to 200 mg
8. Aluminum container
9. 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.

### Procedure

* 1. Check the inner dimension of the soil container.
  2. Put the parts of the soil container together.
  3. Calculate the volume of the container. Weigh the container.
  4. Place the soil in smooth layers (approximately 10 mm thick). If a dense sample is desired tamp the soil.
  5. Weigh the soil container, the difference of these two is the weight of the soil. Calculate the density of the soil.
  6. Make the surface of the soil plane.
  7. Put the upper grating on stone and loading block on top of soil.
  8. Measure the thickness of soil specimen.
  9. Apply the desired normal load.
  10. Remove the shear pin.
  11. Attach the dial gauge which measures the change of volume.
  12. Record the initial reading of the dial gauge and calibration values.
  13. Before proceeding to test check all adjustments to see that there is no connection between two parts except sand/soil.
  14. Start the motor. Take the reading of the shear force and record the reading.
  15. Take volume change readings till failure.
  16. Add 5 kg normal stress 0.5 kg/cm2 and continue the experiment till failure
  17. 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/cm2 L.C= P.R.C = Normal stress 1.0 kg/cm2 L.C= P.R.C = Normal stress 1.5 kg/cm2 L.C= P.R.C =

The Below table is used for all the above normal stress of 0.5,1.0, 1.5 kg/cm2 separately with respect to their

L.C and P.R.

Tab. 14.1 Observation and Calculation sheet for shear stress determination

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Horizonta l Gauge Reading** | **Vertical Dial gauge Readin g** | **Proving ring Readin g** | **Hori. Dial gauge Readin g Initial reading div. gauge** | **Shear deformatio n Col.(4) x Leastcount of dial** | **Vertical gauge reading Initial Readin g** | **Vertical deformation**  **= div.in col.6 xL.C of dial gauge** | **Provin g reading Initial reading** | **Shear stress = div.col.(8)x proving ring constant Area of the specimen(kg/cm2**  **)** |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 0 |  |  |  |  |  |  |  |  |
| 25 |
| 50 |
| 75 |
| 100 |
| 125 |
| 150 |
| 175 |
| 200 |
| 250 |
| 300 |
| 400 |
| 500 |
| 600 |
| 700 |
| 800 |
| 900 |

###### Observations

Proving Ring constant Calibration factor Leverage factor

Dimensions of shear box 60 x 60 mm Empty weight of shear box Least count of dial gauge Volume change

least count of the dial

Tab 14.2 Observation sheet for shear stress

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S.No** | **Normal load (kg)** | **Normal stress(kg/cm2) load x leverage/Area** | **Normal stress(kg/cm2) load x leverage/Area** | **Shear stress Proving Ring reading x calibration / Area of container** |
| **1** |  |  |  |  |
| **2** |
| **3** |

###### 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 draw back 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.

1. 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 28o(uniformly graded sands with round grains in very loose state) to 46o(well graded sand with angular grains in dense state).
2. 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.
3. 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.

**Specimen Calculations**