TESTS ON SOIL

WATER CONTENT

1·Oven Drying Method

AIM

To determine the water content in soil by oven drying method as per IS code

PRINCIPLE

The water content (w) of a soil sample is equal to the mass of water divided by the mass of solids·

APPARATUS

i) Thermostatically controlled oven maintained at a temperature of 110 ±5oC
ii) Weighing balance, with an accuracy of 0·04% of the weight of the soil taken
iii) Air-tight container made of non-corrodible material with lid
iv) Tongs

SAMPLE

The soil specimen should be representative of the soil mass. The quantity of the specimen taken would depend upon the gradation and the maximum size of particles as under:

Size of particles more than 90 percent passing through IS Sieve.	Minimum quantity of the soil specimen to be taken for test (g)
425µm	25
2·0mm	50
4·75mm	200
9·50mm	300
19mm	500
37·5mm	1000

PROCEDURE

i) Clean the container, dry it and weigh it with the lid (Weight)'W

ii) Take the required quantity of the wet soil specimen in the container and weigh it with the lid (Weight 'W_2').

iii) Place the container, with its lid removed, in the oven till its weight becomes constant (Normally for 24hrs.).

iv) When the soil has dried, remove the container from the oven, using tongs.

v) Find the weight 'W_3' of the container with the lid and the dry soil sample

REPORTING OF RESULTS

The water content $W = \frac{W_2 - W_3}{W_3 - W_1} \times 100\%$

An average of three determinations should be taken.

2. Calcium Carbide Method

AIM

To determine the water content in soil by calcium carbide method as per IS CODE

PRINCIPLE

It is a method for rapid determination of water content from the gas pressure developed by the reaction of calcium carbide with the free water of the soil. From the calibrated scale of the pressure gauge the percentage of water on total mass of wet soil is obtained and the same is converted to water content on dry mass of soil.

APPARATUS

i) Metallic pressure vessel, with a clamp for sealing the cup, along with a gauge calibrated in percentage water content
ii) Counterpoised balance, for weighing the sample
iii) Scoop, for measuring the absorbent (Calcium Carbide)
iv) Steel balls - 3 steel balls of about 12·5mm dia· and 1 steel ball of 25mm dia·
v) One bottle of the absorbent (Calcium Carbide)

PREPARATION OF SAMPLE

Sand - No special preparation. Coarse powders may be ground and pulverized.
Cohesive and plastic soil - Soil is tested with addition of steel ball in the pressure vessels.
The test requires about 6g of sample.

PROCEDURE

i) Set up the balance, place the sample in the pan till the mark on the balance arm matches with the index mark.
ii) Check that the cup and the body are clean.
iii) Hold the body horizontally and gently deposit the levelled, scoop-full of the absorbent (Calcium Carbide) inside the chamber.
iv) Transfer the weighed soil from the pan to the cup.
v) Hold cup and chamber horizontally, bringing them together without disturbing the sample and the absorbent.

vi) Clamp the cup tightly into place. If the sample is bulky, reverse the above placement, that is, put the sample in the chamber and the absorbent in the cup.

vii) In case of clayey soils, place all the 4 steel balls (3 smaller and 1 bigger) in the body along with the absorbent.

viii) Shake the unit up and down vigorously in this position for about 15 seconds.

ix) Hold the unit horizontally, rotating it for 10 seconds, so that the balls roll around the inner circumference of the body.

x) Rest for 20 seconds.

xi) Repeat the above cycle until the pressure gauge reading is constant and note the reading. Usually it takes 4 to 8 minutes to achieve constant reading. This is the water content (m) obtained on wet mass basis.

xii) Finally, release the pressure slowly by opening the clamp screw and taking the cup out, empty the contents and clean the instrument with a brush.

REPORTING OF RESULTS

The water content on dry mass basis, $$W = \frac{m}{100 - m} \times 100\%$$

PARTICLE SIZE DISTRIBUTION

AIM

To determine the particle size distribution of soil as per IS code

APPARATUS

i) A set of fine IS Sieves of sizes - 2mm, 600µm, 425µm, 212µm and 75µm
ii) A set of coarse IS Sieves of sizes - 20mm, 10mm and 4·75mm
iii) Weighing balance, with an accuracy of 0·1% of the weight of sample
iv) Oven
v) Mechanical shaker
vi) Mortar with rubber pestle
vii) Brushes
viii) Trays

PREPARATION OF SAMPLE

i) Soil sample, as received from the field, should be dried in air or in the sun. In wet weather, the drying apparatus may be used in which case the temperature of the sample should not exceed 60°C. The clod may be broken with wooden mallet to hasten drying. Tree roots and pieces of bark should be removed from the sample.

ii) The big clods may be broken with the help of wooden mallet. Care should be taken not to break the individual soil particles.

iii) A representative soil sample of required quantity as given below is taken and dried in the oven at 105 to 120°C.

Maximum size of material present in substantial quantities (mm)	Weight to be taken for test (kg)
75	60
40	25
25	13
19	6.5
12.5	3.5
10	1.5
6.5	0.75
4.75	0.4

PROCEDURE

i) The dried sample is taken in a tray, soaked in water and mixed with either 2g of sodium hex metaphosphate or 1g of sodium hydroxide and 1g of sodium carbonate per liter of water, which is added as a dispersive agent. The soaking of soil is continued for 10 to 12hrs.

ii) The sample is washed through 4.75mm IS Sieve with water till substantially clean water comes out. Retained sample on 4.75mm IS Sieve should be oven-dried for 24hrs. This dried sample is sieved through 20mm and 10mm IS Sieves.

iii) The portion passing through 4.75mm IS Sieve should be oven-dried for 24hrs. This oven-dried material is riffled and about 200g taken.

iv) This sample of about 200g is washed through 75μm IS Sieve with half liter distilled water, till substantially clear water comes out.

v) The material retained on 75μm IS Sieve is collected and dried in oven at a temperature of 105 to 120oC for 24hrs. The dried soil sample is sieved through 2mm, 600μm, 425μm and 212μm IS Sieves. Soil retained on each sieve is weighed.

vi) If the soil passing 75μm is 10% or more, hydrometer method is used to analyze soil particle size.

HYDROMETER ANALYSIS

i) Particles passed through 75μm IS Sieve along with water are collected and put into a 1000ml jar for hydrometer analysis. More water, if required, is added to make the soil water suspension just 1000ml. The suspension in the jar is vigorously shaken horizontally by keeping the jar in-between the palms of the two hands. The jar is put on the table.

ii) A graduated hydrometer is carefully inserted into the suspension with minimum disturbance.

iii) At different time intervals, the density of the suspension at the center of gravity of the hydrometer is noted by seeing the depth of sinking of the stem. The temperature of the suspension is noted for each recording of the hydrometer reading.

iv) Hydrometer readings are taken at a time interval of 0.5 minute, 1.0 minute, 2.0 minutes, 4.0 minutes, 15.0 minutes, 45.0 minutes, 90.0 minutes, 3hrs., 6hrs., 24hrs. and 48hrs.

v) By using the nomogram given in IS: 2720 (Part 4) - 1985, the diameter of the particles for different hydrometer readings is found out.

REPORTING OF RESULTS

After completing mechanical analysis and hydrometer analysis, the results are plotted on a semi-log graph with particle size as abscissa (log scale) and the percentage smaller than the specified diameter as ordinate .

LIQUID LIMIT

AIM

To determine the liquid limit of soil as per IS code

PRINCIPLE

The liquid limit of fine-grained soil is the water content at which soil behaves practically like a liquid, but has small shear strength. It's flow closes the groove in just 25 blows in Casagrande's liquid limit device.

APPARATUS

i) Casagrande's liquid limit device
ii) Grooving tools of both standard and ASTM types
iii) Oven
iv) Evaporating dish
v) Spatula
vi) IS Sieve of size 425μm
vii) Weighing balance, with 0·01g accuracy
viii) Wash bottle
ix) Air-tight and non-corrodible container for determination of moisture content

PREPARATION OF SAMPLE

i) Air-dry the soil sample and break the clods. Remove the organic matter like tree roots, pieces of bark, etc.
ii) About 100g of the specimen passing through 425μm IS Sieve is mixed thoroughly with distilled water in the evaporating dish and left for 24hrs. for soaking.

PROCEDURE

i) Place a portion of the paste in the cup of the liquid limit device.

ii) Level the mix so as to have a maximum depth of 1cm.

iii) Draw the grooving tool through the sample along the symmetrical axis of the cup, holding the tool perpendicular to the cup.

iv) For normal fine grained soil: The Casagrande's tool is used to cut a groove 2mm wide at the bottom, 11mm wide at the top and 8mm deep.

v) For sandy soil: The ASTM tool is used to cut a groove 2mm wide at the bottom, 13·6mm wide at the top and 10mm deep.

vi) After the soil pat has been cut by a proper grooving tool, the handle is rotated at the rate of about 2 revolutions per second and the no. of blows counted, till the two parts of the soil sample come into contact for about 10mm length.

vii) Take about 10g of soil near the closed groove and determine its water content (see Para 5·1).

viii) The soil of the cup is transferred to the dish containing the soil paste and mixed thoroughly after adding a little more water. Repeat the test.

ix) By altering the water content of the soil and repeating the foregoing operations, obtain at least 5 readings in the range of 15 to 35 blows. Don't mix dry soil to change its consistency.

x) Liquid limit is determined by plotting a 'flow curve' on am semi-log graph, with no· of blows as abscissa (log scale)and the water content as ordinate and drawing the best straight line through the plotted points·

xi) Water content corresponding to 25 blows, is the value of the liquid limit·

REPORTING OF RESULTS

Report the water content corresponding to 25 blows, read from the 'flow curve' as the liquid limit·

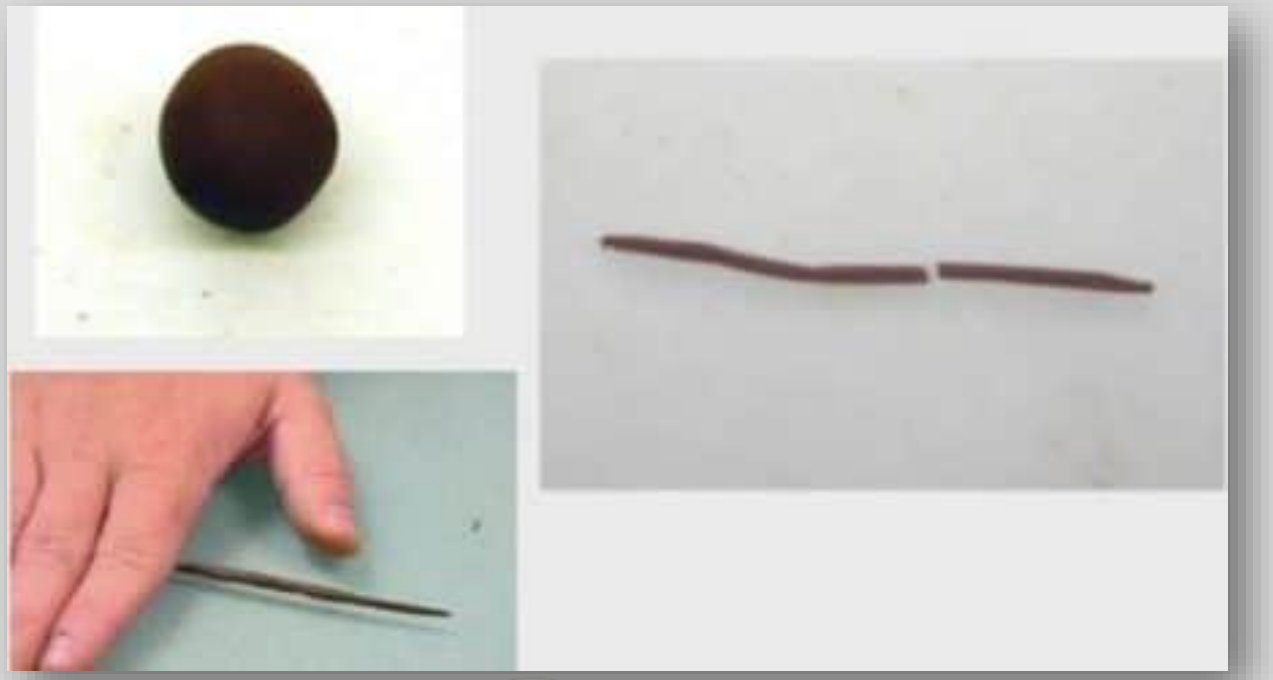
PLASTIC LIMIT

AIM

To determine the plastic limit of soil as per IS code

PRINCIPLE

The plastic limit of fine-grained soil is the water content of the soil below which it ceases to be plastic. It begins to crumble when rolled into threads of 3mm dia.



APPARATUS

i) Porcelain evaporating dish about 120mm dia.
ii) Spatula
iii) Container to determine moisture content
iv) Balance, with an accuracy of 0.01g
v) Oven
vi) Ground glass plate - 20cm x 15cm
vii) Rod - 3mm dia. and about 10cm long

PREPARATION OF SAMPLE

Take out 30g of air-dried soil from a thoroughly mixed sample of the soil passing through 425µm IS Sieve. Mix the soil with distilled water in an evaporating dish and leave the soil mass for nattering. This period may be up to 24hrs.

PROCEDURE

i) Take about 8g of the soil and roll it with fingers on a glass plate. The rate of rolling should be between 80 to 90 strokes per minute to form a 3mm dia.

ii) If the dia. of the threads can be reduced to less than 3mm,without any cracks appearing, it means that the water content is more than its plastic limit. Knead the soil to reduce the water content and roll it into a thread again.

iii) Repeat the process of alternate rolling and kneading until the thread crumbles.

iv) Collect and keep the pieces of crumbled soil thread in the container used to determine the moisture content.

v) Repeat the process at least twice more with fresh samples of plastic soil each time.

REPORTING OF RESULTS

The plastic limit should be determined for at least three portions of the soil passing through 425μm IS Sieve. The average water content to the nearest whole number should be reported.

FREE SWELL INDEX

AIM

To determine the free swell index of soil as per IS code

PRINCIPLE

Free swell or differential free swell, also termed as free swell index, is the increase in volume of soil without any external constraint when subjected to submergence in water.

APPARATUS

i) IS Sieve of size 425µm
ii) Oven
iii) Balance, with an accuracy of 0·01g
iv) Graduated glass cylinder- 2 nos., each of 100ml capacity

PROCEDURE

i) Take two specimens of 10g each of pulverized soil passing through 425µm IS Sieve and oven-dry.

ii) Pour each soil specimen into a graduated glass cylinder of 100ml capacity.

iii) Pour distilled water in one and kerosene oil in the other cylinder up to 100ml mark.

iv) Remove entrapped air by gently shaking or stirring with a glass rod.

v) Allow the suspension to attain the state of equilibrium (for not less than 24hrs.).

vi) Final volume of soil in each of the cylinder should be read out.

REPORTING OF RESULTS

$$\text{Free swell index} = \frac{V_d - V_k}{V_k} \times 100\%$$

where,

V_d = volume of soil specimen read from the graduated cylinder containing distilled water.

V_k = volume of soil specimen read from the graduated cylinder containing kerosene.

SPECIFIC GRAVITY

AIM

To determine the specific gravity of fine-grained soil by density bottle method as per IS

PRINCIPLE

Specific gravity is the ratio of the weight in air of a given volume of a material at a standard temperature to the weight in air of an equal volume of distilled water at the same stated temperature.

APPARATUS

i) Two density bottles of approximately 50ml capacity along with stoppers

ii) Constant temperature water bath (27·0 + 0·2°C)

iii) Vacuum desiccator

iv) Oven, capable of maintaining a temperature of 105 to 110°C

v) Weighing balance, with an accuracy of 0·001g

vi) Spatula

PREPARATION OF SAMPLE

The soil sample (50g) should if necessary be ground to pass through a 2mm IS Sieve. A 5 to 10g sub-sample should be obtained by riffling and oven-dried at a temperature of 105 to 110°C.

PROCEDURE

i) The density bottle along with the stopper, should be dried at a temperature of 105 to 110°C, cooled in the desiccator and weighed to the nearest 0·001g (W_1)·

ii) The sub-sample, which had been oven-dried should be transferred to the density bottle directly from the desiccator in which it was cooled· The bottles and contents together with the stopper should be weighed to the nearest 0·001g
(W2)·

iii) Cover the soil with air-free distilled water from the glass wash bottle and leave for a period of 2 to 3hrs· for soaking· Add water to fill the bottle to about half·

iv) Entrapped air can be removed by heating the density bottle on a water bath or a sand bath·

v) Keep the bottle without the stopper in a vacuum desiccator for about 1 to 2hrs· until there is no further loss of air·

vi) Gently stir the soil in the density bottle with a clean glass rod, carefully wash off the adhering particles from the rod with some drops of distilled water and see that no more soil particles are lost·

vii) Repeat the process till no more air bubbles are observed in the soil-water mixture·

viii) Observe the constant temperature in the bottle and record.
ix) Insert the stopper in the density bottle, wipe and weigh (W3).
x) Now empty the bottle, clean thoroughly and fill the density bottle with distilled water at the same temperature. Insert the stopper in the bottle, wipe dry from the outside and weigh (W4).
xi) Take at least two such observations for the same soil.

REPORTING OF RESULTS

$$\text{The specific gravity G of the soil} = \frac{W_2 - W_1}{(W_4 - W_1) - (W_3 - W_2)}$$

The specific gravity should be calculated at a temperature of 27°C and reported to the nearest 0.01. If the room temperature is different from 27°C, the following correction should be done:- $G' = kG$

where,

G′ = Corrected specific gravity at 27oC

$$k = \frac{\text{Relative density of water at room temperature}}{\text{Relative density of water at 27oC}}$$

MAXIMUM DRY DENSITY AND OPTIMUM MOISTURE CONTENT

AIM

To determine the maximum dry density and the optimum moisture content of soil using heavy compaction as per IS code

APPARATUS

i) Cylindrical metal mould - it should be either of 100mm dia· and 1000cc volume or 150mm dia· and 2250cc volume and should conform to IS: 10074 - 1982

ii) Balances - one of 10kg capacity, sensitive to 1g and the other of 200g capacity, sensitive to 0·01g

iii) Oven - thermostatically controlled with an interior of no corroding material to maintain temperature between 105 and 110°C ·

iv) Steel straightedge - 30cm long

v) IS Sieves of sizes - 4·75mm, 19mm and 37·5mm

PREPARATION OF SAMPLE

A representative portion of air-dried soil material, large enough to provide about 6kg of material passing through a 19mm IS Sieve (for soils not susceptible to crushing during compaction) or about 15kg of material passing through a 19mm IS Sieve (for soils susceptible to crushing during compaction), should be taken. This portion should be sieved through a 19mm IS Sieve and the coarse fraction rejected after its proportion of the total sample has been recorded. Aggregations of particles should be broken down so that if the sample was sieved through a 4·75mm IS Sieve, only separated individual particles would be retained.

PROCEDURE

A) Soil not susceptible to crushing during compaction -

i) A 5kg sample of air-dried soil passing through the 19mm IS Sieve should be taken. The sample should be mixed thoroughly with a suitable amount of water depending on the soil type (for sandy and gravelly soil - 3 to 5% and for cohesive soil - 12 to 16% below the plastic limit). The soil sample should be stored in a sealed container for a minimum period of 16hrs.

ii) The mould of 1000cc capacity with base plate attached, should be weighed to the nearest 1g (W_1). The mould should be placed on a solid base, such as a concrete floor or plinth and the moist soil should be compacted into the mould, with the extension attached, in five layers of approximately equal mass, each layer being given 25 blows from the 4·9kg rammer dropped from a height of 450mm above the soil. The blows should be distributed uniformly over the surface of each layer. The amount of soil used should be sufficient to fill the mould, leaving not more than about 6mm to be struck off when the extension is removed. The extension should be removed and the compacted soil should be levelled off carefully to the top of the mould by means of the straight edge. The mould and soil should then be weighed to the nearest gram (W2).

iii) The compacted soil specimen should be removed from the mould and placed onto the mixing tray. The water content (w) of a representative sample of the specimen should be determined .

iv) The remaining soil specimen should be broken up, rubbed through 19mm IS Sieve and then mixed with the remaining original sample. Suitable increments of water should be added successively and mixed into the sample, and the above operations i.e. Para ii) to iv) should be repeated for each increment of water added. The total number of determinations made should be at least five and the moisture contents should be such that the optimum moisture content at which the maximum dry density occurs,
lies within that range.

B) Soil susceptible to crushing during compaction –
Five or more 2·5kg samples of air-dried soil passing through the 19mm IS Sieve, should be taken· The samples should each be mixed thoroughly with different amounts of water and stored in a sealed container as mentioned in Para A) i), above· Follow the operations given in Para A) ii) to iv), above·
C) Compaction in large size mould –
For compacting soil containing coarse material up to 37·5mm size, the 2250cc mould should be used· A sample weighing about 30kg and passing through the 37·5mm IS Sieve is used for the test· Soil is compacted in five layers, each layer being given 55 blows of the 4·9kg rammer· The rest of the procedure is the same as in Para A) or B), above·

REPORTING OF RESULTS

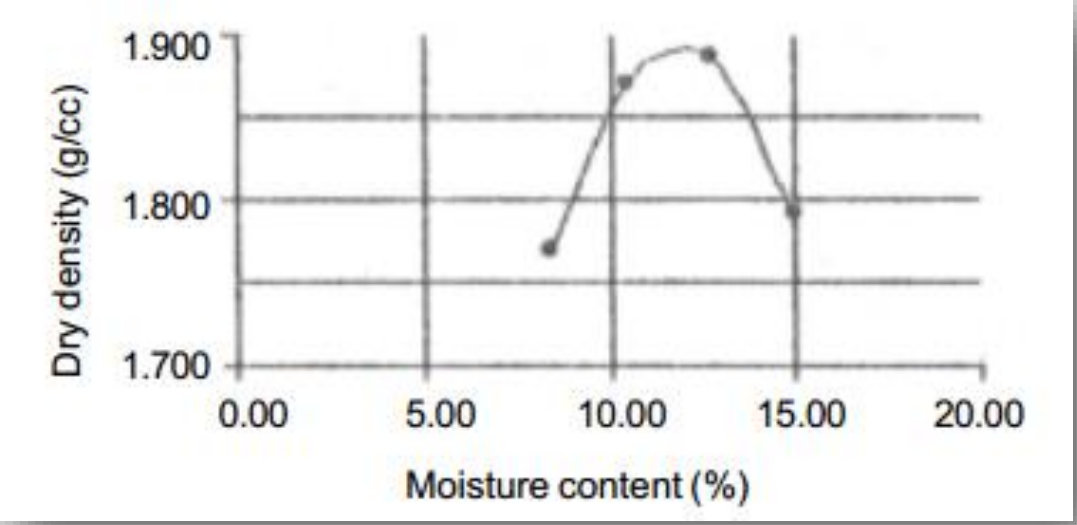
Bulk density γ in g/cc of each compacted specimen should be

calculated from the equation $\gamma = \frac{W_2 - W_1}{V}$

where, V = volume in cc of the mould·

The dry density γd in g/cc $= \dfrac{100\gamma}{100 + W}$

The dry densities, γ_d obtained in a series of determinations should be plotted against the corresponding moisture contents. A smooth curve should be drawn through the resulting points and the position of the maximum on the curve should be determined. A sample graph is shown below:



The dry density in g/cc corresponding to the maximum point on the moisture content/dry density curve should be reported as the maximum dry density to the nearest 0·01.

The percentage moisture content corresponding to the maximum dry density on the moisture content/dry density curve should be reported as the optimum moisture content and quoted to the nearest 0·2 for values below 5 percent, to the nearest 0·5 for values from 5 to 10 percent and to the nearest whole number for values exceeding 10 percent.

IN-SITU DRY DENSITY

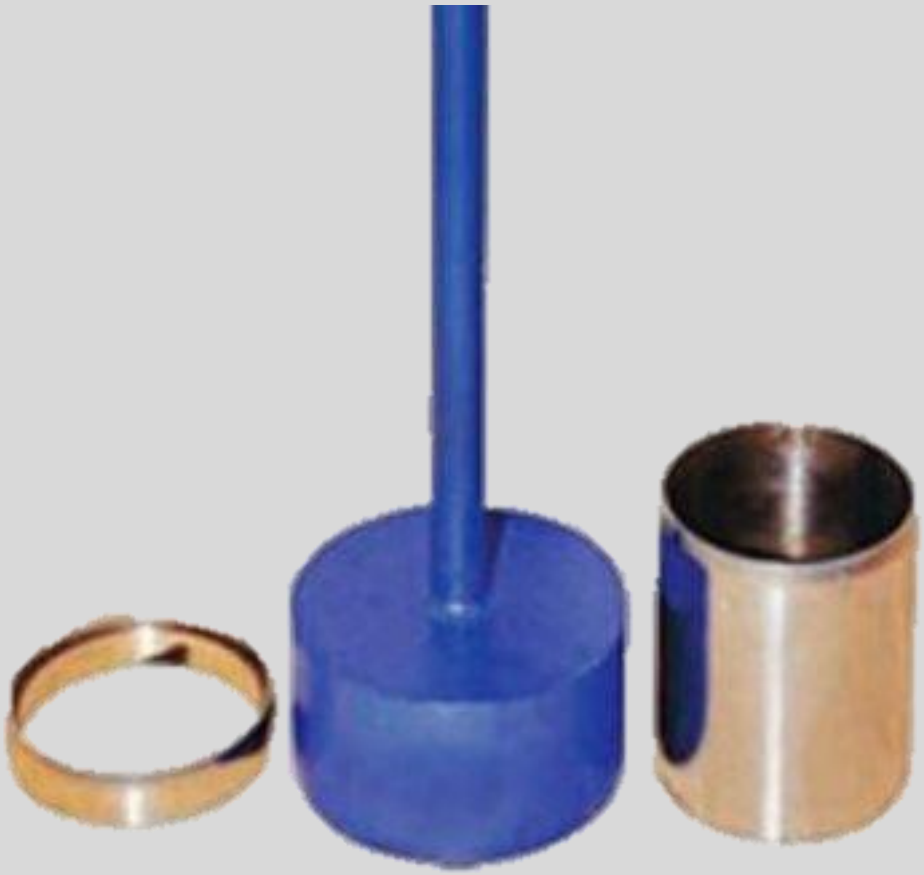
1 ·CORE CUTTER METHOD

AIM

To determine the in-situ dry density of soil by core cutter method as per IS code

APPARATUS

i) Cylindrical core cutter
ii) Steel dolly
iii) Steel rammer
iv) Balance, with an accuracy of 1g
v) Straightedge
vi) Square metal tray - 300mm x 300mm x 40mm
vii) Trowel



PROCEDURE

i) The internal volume (V) of the core cutter in cc should be calculated from its dimensions which should be measured to the nearest 0·25mm.

ii) The core cutter should be weighed to the nearest gram (W_1).

iii) A small area, approximately 30cm square of the soil layer to be tested should be exposed and levelled. The steel dolly should be placed on top of the cutter and the latter should be rammed down vertically into the soil layer until only about 15mm of the dolly protrudes above the surface, care being taken not to rock the cutter. The cutter should then be dug out of the surrounding soil, care being taken to allow some soil to project from the lower end of the cutter. The ends of the soil core should then be trimmed flat in level with the ends of the cutter by means of the straightedge.

iv) The cutter containing the soil core should be weighed to the nearest gram (W_2).

v) The soil core should be removed from the cutter and a representative sample should be placed in an air-tight container and its water content (w)

REPORTING OF RESULTS

$$\text{Bulk density of the soil } \gamma = \frac{W_2 - W_1}{V}$$

$$\text{The dry density } \gamma d \text{ in g/cc} = \frac{100\gamma}{100 + W}$$

Average of at least three determinations should be reported to the second place of decimal in g/cc.

2 ·SAND REPLACEMENT METHOD

AIM

To determine the in-situ dry density of soil by sand replacement method as per IS code

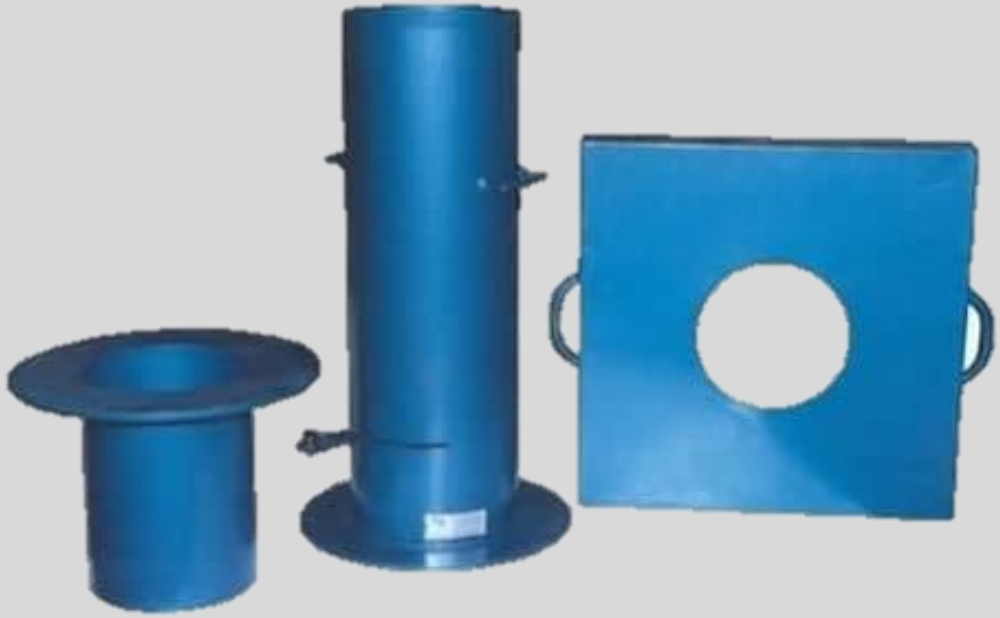
APPARATUS

i) Sand-pouring cylinder conforming to IS: 2720 (Part XXVIII) - 1974

ii) Cylindrical calibrating container conforming to IS: 2720 (Part XXVIII) - 1974

iii) Soil cutting and excavating tools such as a scraper tool, bent spoon

iv) Glass plate - 450mm square and 9mm thick or larger



v) Metal containers to collect excavated soil
vi) Metal tray - 300mm square and 40mm deep with a 100mm hole in the center
vii) Balance, with an accuracy of 1g

PROCEDURE

A. Calibration of apparatus

a) The method given below should be followed for the determination of the weight of sand in the cone of the pouring cylinder:
i) The pouring cylinder should be filled so that the level of the sand in the cylinder is within about 10mm of the top. Its total initial weight (W_1) should be maintained constant throughout the tests for which the calibration is used. A volume of sand equivalent to that of the excavated hole in the soil (or equal to that of the calibrating container) should be allowed to runout of the cylinder under gravity. The shutter of the pouring cylinder should then be closed and the cylinder placed on a plain surface, such as a glass plate.

ii) The shutter of the pouring cylinder should be opened and sand allowed to runout. When no further movement of sand takes place in the cylinder, the shutter should be closed and the cylinder removed carefully.

iii) The sand that had filled the cone of the pouring cylinder (that is, the sand that is left on the plain surface) should be collected and weighed to the nearest gram.

iv) These measurements should be repeated at least thrice and the mean weight (W_2) taken.

b) The method described below should be followed for the determination of the bulk density of the sand (γ_s):

i) The internal volume (V) in ml of the calibrating container should be determined from the weight of water contained in the container when filled to the brim. The volume may also be calculated from the measured internal dimensions of the container.

ii) The pouring cylinder should be placed concentrically on the top of the calibrating container after being filled to the constant weight (W_1) as in Para a) i), above. The shutter of the pouring cylinder should be closed during the operation. The shutter should be opened and sand allowed to runout. When no further movement of sand takes place in the cylinder, the shutter should be closed. The pouring cylinder should be removed and weighed to the nearest gram.

iii) These measurements should be repeated at least thrice and the mean weight (W_3) taken.

B. Measurement of soil density

The following method should be followed for the measurement of soil density:

i) A flat area, approximately 450sq.mm of the soil to be tested should be exposed and trimmed down to a level surface, preferably with the aid of the scraper tool.

ii) The metal tray with a central hole should be laid on the prepared surface of the soil with the hole over the portion of the soil to be tested. The hole in the soil should then be excavated using the hole in the tray as a pattern, to the
depth of the layer to be tested up to a maximum of 150mm. The excavated soil should be carefully collected, leaving no loose material in the hole and weighed to the nearest gram (W_w). The metal tray should be removed before the pouring cylinder is placed in position over the excavated hole.

iii) The water content (w) of the excavated soil should be determined by the method specified in Para 5.1. Alternatively, the whole of the excavated soil should be dried and weighed (W_d).

iv) The pouring cylinder, filled to the constant weight (W1) as in Para A.a) i) above, should be so placed that the base of the cylinder covers the hole concentrically. The shutter should then be opened and sand allowed to runout into the hole. The pouring cylinder and the surrounding area should not be
vibrated during this period. When no further movement of sand takes place, the shutter should be closed. The cylinder should be removed and weighed to the nearest gram (W4).

CALCULATIONS

i) The weight of sand (W_a) in gram, required to fill the calibrating container should be calculated from the formula: $W_a = W_1 - W_3 - W_2$

ii) The bulk density of the sand γ_s in kg/m3 should be calculated from the formula: $\gamma s = \frac{W_a}{V} x1000$

iii) The weight of sand (W_b) in gram, required to fill the excavated hole should be calculated from the formula: $W_b = W_1 - W_4 - W_2$

iv) The bulk density (γ_b), that is, the weight of the wet soil per cubic meter should be calculated from the formula: $\gamma b = \frac{W_a}{V} x\, \gamma s \ kg/m3$

v) The dry density (γ_d), that is, the weight of dry soil per cubic meter should be calculated from the formula: $\gamma d = \frac{\gamma_d}{100+W} kg/m3$ $\gamma d = \frac{w_d}{w_b} \times \gamma s \ kg/m3$

REPORTING OF RESULTS

The following values should be reported:

i) dry density of soil in kg/m3 to the nearest whole number; also to be calculated and reported in g/cc correct to the second place of decimal

ii) water content of the soil in percent reported to two significant figures·