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Indian Standard

METHODS OF TEST FOR SOILS

PART II DETERMINATION OF WATER CONTENT

(Second Revision)

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Indian Standard

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PART II DETERMINATION OF WATER CONTENT

(Second Revision)

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Indian Standard

METHODS OF TEST FOR SOILS

PART II DETERMINATION OF WATER CONTENT

(Second Revision)

0. FOREWORD

0.1 This Indian Standard (Part II) (Second Revision) was adopted by the Indian Standards Institution on 22 March 1973, after the draft finalized by the Soil Engineering Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 With a view to establish uniform procedures for the determination of different characteristics of soils and also for facilitating comparative studies of the results, the Indian Standards Institution is bringing out this Indian Standard methods of test for soils (IS : 2720) which will be published in parts.

0.3 This part was first published in 1964 and revised in 1969 to include two rapid field methods for the determination of water content in soils. In this second revision, rapid determination of water content with infra-red lamp torsion balance moisture meter and rapid determination of water content from the gas pressure developed by the reaction of calcium carbide with the free water content of the soil have been included.

0.4 In the formulation of this standard due weightage has been given to international co-ordination among the standards and practices prevailing in different countries in addition to relating it to the practices in the field in this country.

0.5 In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960*.

SECTION 1 OVEN-DRYING METHOD (STANDARD METHOD)

1. SCOPE

1.1 This method covers the determination of water content of soils expressed as a percentage of the oven-dry weight.

*Rules for rounding off numerical values (*revised*).

2. TERMINOLOGY

2.0 For the purpose of this standard, the definitions given in IS : 2809-1972* shall apply.

3. APPARATUS

3.1 Container — Any suitable non-corrodible air-tight container.

3.2 Balance — of sufficient sensitivity to weigh the soil samples to an accuracy of 0·04 percent of the weight of the soil taken for the test (*see* **4.1**).

3.3 Oven — thermostatically controlled, with interior of non-corroding material to maintain the temperature at 110 ± 5°C.

3.4 Desiccator — A desiccator with any suitable desiccating agent.

4. SOIL SPECIMEN

4.1 The soil specimen taken shall be representative of the soil mass. The size of the specimen selected depends on the quantity required for good representation, which is influenced by the gradation and the maximum size of particles, and on the accuracy of weighing. The following quantities are recommended for general laboratory use:

Size of Particles More Than 90 Percent Passing	*Minimum Quantity of Soil Specimen to be Taken for Test Mass in* g
425-micron IS Sieve	25
2-mm IS Sieve	50
4·75-mm IS Sieve	200
10-mm IS Sieve	300
20-mm IS Sieve	500
40-mm IS Sieve	1 000

NOTE 1 — For sizes of sieves, *see* IS : 460-1962†.

NOTE 2 — Drier the soil, the greater shall be the quantity of the soil taken.

NOTE 3 — Water content specimen should be discarded and should not be used in any other tests.

5. PROCEDURE

5.1 Clean the container with lid, dry and weigh (W_1). Take the required quantity of the soil specimen in the container crumbled and placed loosely,

*Glossary of terms and symbols relating to soil engineering (*first revision*).

†Specification for test sieves (*revised*).

and weigh with lid (W_2). Then keep it in an oven with the lid removed, and maintain the temperature of the oven at 110 ± 5°C (*see* Note). Dry the specimen in the oven for 24 h. Every time the container is taken out for weighing. Replace the lid on the container and cool the container in a desiccator. Record the final mass (W_3) of the container with lid with dried soil sample.

NOTE — Oven-drying at 110 ± 5°C does not result in reliable water content values for soil containing gypsum or other minerals having loosely bound water of hydration or for soil containing significant amounts of organic material. Reliable water content values for these soils can be obtained by drying in an oven at approximately 60 to 80°C.

6. CALCULATION

6.1 The percent of water content shall be calculated as follows:

$$w = \frac{W_2 - W_3}{W_3 - W_1} \times 100$$

where

w = water content percent,

W_2 = mass of container with lid with wet soil in g,

W_3 = mass of container with lid with dry soil in g, and

W_1 = mass of container with lid in g.

7. REPORT

7.1 The water content (w) of the soil shall be reported to two significant figures.

7.2 The results of the test shall be suitably recorded. A recommended *pro forma* for this record is given in Appendix A.

SECTION 2 SAND-BATH METHOD (SUBSIDIARY METHOD)

8. SCOPE

8.1 This method covers the determination of the water content of a soil as a percentage of its dry mass. It is intended as a rapid alternative to the method given in Section 1 but is less accurate and more suitable as a field test. The method shall not be used if it is suspected that the soil contains a large proportion of gypsum calcareous matter or organic matter.

9. APPARATUS

9.1 Container — any suitable non-corrodible air-tight container,

9.2 Heat-Resistant Tray — of suitable metal and about 5 to 7 cm deep.

9.3 Balance — of sufficient sensitivity to weigh the soil samples to an accuracy of 0·4 percent of the mass of the soil taken for the test.

9.4 Sand-Bath — of suitable size and containing clean sand to a depth of at least 3 cm.

9.5 Equipment for Heating the Sand-Bath — kerosene stove or spirit lamp.

9.6 Palette Knife or Steel Spatula — a convenient size is one having a blade 10 cm long and 2 cm wide.

9.7 Scoop — a convenient size is one about 20 cm long and 10 cm wide.

10. SOIL SPECIMEN

10.1 The mass of soil specimen taken for the test shall be in accordance with **4.1.**

11. PROCEDURE

11.1 Clean the container with lid or the tray, as the case may be, dry and weigh (W_1). Take the required quantity of the soil specimen in the container crumbled and placed loosely and weigh (W_2). Add a few pieces of white paper if necessary (*see* Note). Place the container with the lid removed or the tray on the sand-bath and heat the sand-bath. Care shall be taken not to get the sand-bath too hot. During heating, the specimen shall be turned frequently and thoroughly with the palette knife to assist the evaporation of water, care being taken to see that no soil is lost in the process. Dry the specimen to constant mass indicated by the difference between two consecutive masses of the container with lid or the tray with the dried specimen taken at suitable intervals after initial drying, being a maximum of 0·1 percent of the original mass of the soil specimen. When drying is complete, remove the container or the tray from the sand-bath, cool and weigh (W_3). The container should be weighed with lid.

NOTE — Avoid overheating. A convenient method of detecting overheating of the soil is by the use of small pieces of white paper mixed with the soil. Overheating is indicated if the paper turns brown.

12. CALCULATION

12.1 The percentage of water content shall be calculated as follows:

$$w = \frac{W_2 - W_3}{W_3 - W_1} \times 100$$

where

w = water content percent,

W_2 = mass of container with lid (or tray) with wet soil in g,

W_3 = mass of container with lid (or tray) with dry soil in g, and

W_1 = mass of container with lid (or tray) in g.

13. REPORT

13.1 The water content and the results of tests shall be reported in accordance with **7.1** and **7.2.**

SECTION 3 ALCOHOL METHOD (SUBSIDIARY METHOD)

14. SCOPE

14.1 This method covers the determination of the water content of a soil as a percentage of its dry mass. It is intended as a rapid alternative to the method given in Section 1 but is less accurate and is more suitable as a field test. Since methylated spirit is used, care shall be taken against risk of fire. The method shall not be used if the soil contains a large proportion of clay, gypsum, calcareous matter or organic matter.

15. APPARATUS

15.1 Evaporating Dish — 10 to 15 cm in diameter.

15.2 Palette Knife or Steel Spatula — having a blade 10 cm long and 2 cm wide.

15.3 Balance — of sufficient sensitivity to weigh the soil samples to an accuracy of 0·4 percent of the mass of the soil taken for the test.

15.4 Methylated Spirit

16. SOIL SPECIMEN

16.1 The soil specimen taken shall be representative of the soil mass. The size of the specimen selected depends on the quantity required for good representation, which is influenced by the gradation and the maximum size of particles, and on the accuracy of weighing. The following

quantities are recommended for general use:

Size of Particles More Than 90 Percent Passing	*Minimum Quantity of Soil Specimen to be Taken for Test Mass in g*
2-mm IS Sieve	30
20-mm IS Sieve	300

NOTE 1 — For sizes of sieves, *see* IS : 460-1962*.

NOTE 2 — Drier the soil, the greater shall be the quantity of the soil taken.

NOTE 3 — Water content samples should be discarded and should not be used in any other tests.

17. PROCEDURE

17.1 Clean the evaporating dish, dry and weigh (W_1). Take the required quantity of the soil specimen in the evaporating dish and weigh (W_2). Pour over the soil methylated spirit at the rate of about one millilitre for every gram of soil taken so that the soil is well covered. Work the methylated spirit well into the soil with the palette knife and break up any large lumps of soil. Place the evaporating dish on a surface which will not be affected by heat and ignite the methylated spirit. Stir the soil constantly with the spatula or knife, care being taken to see that none of the soil is lost. After the methylated spirit has burnt away completely allow the dish to cool and weigh it with the contents (W_3).

18. CALCULATION

18.1 The percentage of water content shall be calculated as follows:

$$w = \frac{W_2 - W_3}{W_3 - W_1} \times 100$$

where

w = water content percent,

W_2 = mass of dish with wet soil in g,

W_3 = mass of dish with dry soil in g, and

W_1 = mass of dish in g.

19. REPORT

19.1 The water content and the results of tests shall be reported in accordance with **7.1** and **7.2**.

*Specification for test sieves (*revised*).

SECTION 4 RAPID DETERMINATION OF WATER CONTENT WITH INFRA-RED LAMP TORSION BALANCE MOISTURE METER

20. SCOPE

20.1 This section describes a method for rapid determination of water content of soils employing a device providing infra-red lamp for drying and torsion balance for getting of percentage of water on wet basis from a scale, and the results obtained are convertible to water content on dry basis.

NOTE — The water estimation with this method takes 15 to 30 min depending upon the type of soil and quantity of water present. Plastic soils might take about 30 min. The reproducibility of readings is within ±0·25 percent. The probable error is about ± 0·3 percent water content in case of granular soils and about 0·8 to 1 percent in case of clays.

21. APPARATUS

21.1 Infra-red Lamp and Torsion Balance Moisture Meter — The moisture meter is illustrated in its essential details in Fig. 1 and 2.

21.1.1 The equipment should be of two main parts, the infra-red lamp, and the torsion balance. The infra-red radiation should be provided by 250 watt lamp built in the balance for use with an alternating current 220-230 V, 50 cycle, single phase mains supply. Provision should be made to adjust the input voltage to the infra-red lamp to control the heat for drying of specimen. A suitable thermometer graduated from 40 to 150°C should be provided for ascertaining the temperature of drying in the pan housing. The weighing mechanism, a torsion balance, should have a built in magnetic damper. The balance scale should be divided in terms of water percentages, from 1 to 100 percent water content in 0·2 percent divisions.

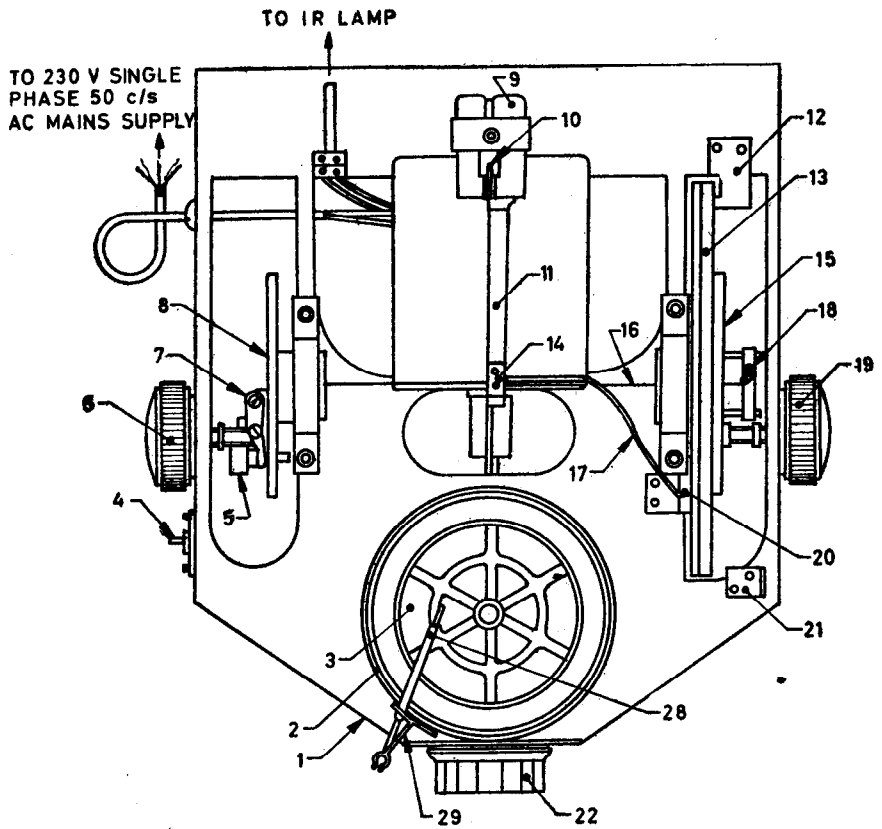
21.2 Palette Knife or Steel Spatula — having a blade 10 cm long and 2 cm wide.

22. SOIL SPECIMEN

22.1 The soil specimen taken shall be representative of the soil mass. The specimen should weigh 25 g. As this moisture meter is calibrated to use 25 g of soil, the maximum size of particle present in the specimen shall be less than 2 mm.

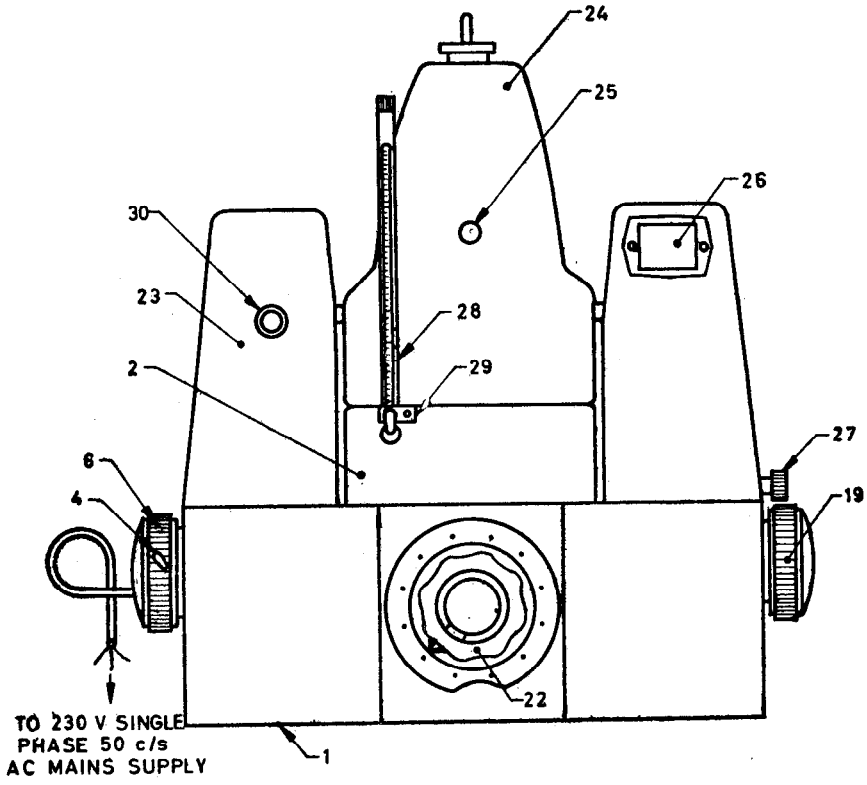
23. PROCEDURE

23.1 Keep the test samples always in suitable containers so that the water content to be determined is not affected by ambient conditions.



Description		*Description*	
1.	Base	13.	Calibrated drum
2.	Pan housing	14.	Wire grip for balance
3.	Pan	15.	Gear
4.	On-off switch	16.	Torsion wire
5.	Wire tensioner	17.	Pointer
6.	Initial adjustment knob	18.	Right-hand wire grip
7.	Left-hand wire grip	19.	Drum drive knob
8.	Gear	20.	Index mark
9.	Damping magnet	21.	Lock
10.	Damping vane	22.	Variac knob (for heat control)
11.	Balance arm	28.	Thermometer
12.	Stopper	29.	Thermometer bracket

FIG. 1 TORSION BALANCE MOISTURE METER (0-100 PERCENT) — PLAN (COVER REMOVED)



Description		*Description*	
1.	Base	24.	Lamp housing
2.	Pan housing	25.	Lifting handle
4.	On-off switch	26.	Viewing lens
6.	Initial adjustment knob	27.	Locking screw
19.	Drum drive knob	28.	Thermometer
22.	Variac knob (for heat control)	29.	Thermometer bracket
23.	Cover	30.	Indicating lamp

FIG. 2 TORSION BALANCE MOISTURE METER (0-100 PERCENT) — FRONT VIEW .

23.2 Set the 100 percent scale division of the calibrated drum to align with the index mark with the help of drum drive knob.

23.3 With the pan placed on the pivot, check that the pointer is aligned with the index line and the 100 percent scale division. If not, set the pointer with the help of initial setting knob.

23.4 Rotate the drum drive knob anti-clockwise and bring the 0 percent scale division in line with the index mark, thus prestressing the wire through an amount equal to 100 percent (this represents the amount of unbalance). The pointer will now be above the index mark.

23.5 Raise the lamp housing and carefully distribute the test material evenly on the sample pan until the pointer returns to the index mark (approximately 25 g of the material will be needed in one operation).

23.6 Lower the lamp housing and switch on the infra-red lamp with the help of the switch provided on the left-hand side. Insert the thermometer in its socket and bracket. Adjust the variac control knob between 95 and 100 on the scale if it is desired that the temperature of drying is around 110°C. The sample will now begin to lose water and the pointer will rise above the index.

NOTE — Keep a watch on the column of mercury on the thermometer when the thermometer records a temperature of 105°C, control the variac in such a manner that there is no more rise in the temperature beyond 110°C and the temperature in the housing is maintained at 110 ± 5°C. If for a particular sample, the temperature is to be higher or lower than 110°C, the variac control knob can be adjusted accordingly.

23.7 To determine the percentage reduction of mass at any instant, rotate the drum scale by turning the drum drive knob until the pointer returns to the index. Read the percentage directly from the scale. The percent water which is read from the scale is the percent water based upon the initial mass of the sample, that is, the wet mass of the sample.

23.8 The criterion for taking the final reading is that the pointer should remain steady on the index mark which shows that the sample has dried to constant mass. Note the drum scale reading against the pointer which is the percent water on the total mass taken. Remove the thermometer from its bracket.

23.9 Repeat steps **23.1** to **23.8** with a fresh sample using a cool and clean pan.

24. CALCULATION

24.1 From the water content (m) as obtained on the moisture balance scale, the water content (w) on the dry weight basis shall be calculated as follows:

$$w = \frac{m}{100 - m} \times 100 \text{ percent}$$

SECTION 5 RAPID DETERMINATION OF WATER CONTENT FROM THE GAS PRESSURE DEVELOPED BY THE REACTION OF CALCIUM CARBIDE WITH THE FREE WATER OF THE SOIL

25. SCOPE

25.1 This section describes 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 (wet) mass of soil is obtained and the same is converted to water content on dry mass of soil.

26. APPARATUS

26.1 Metallic Pressure Vessel — with clamp for sealing cup, and a gauge calibrated in percentage water content (*see* Fig. 3).

26.2 Counterpoised Balance — for weighing sample as shown in Fig. 3.

26.3 Scoop — for measuring absorbent (calcium carbide).

26.4 One Bottle of the Absorbent (Calcium Carbide)

26.5 One Cleaning Brush

26.6 Steel Balls — three steel balls of about 12·5 mm diameter and one steel ball of 25 mm diameter.

27. SOIL SPECIMEN

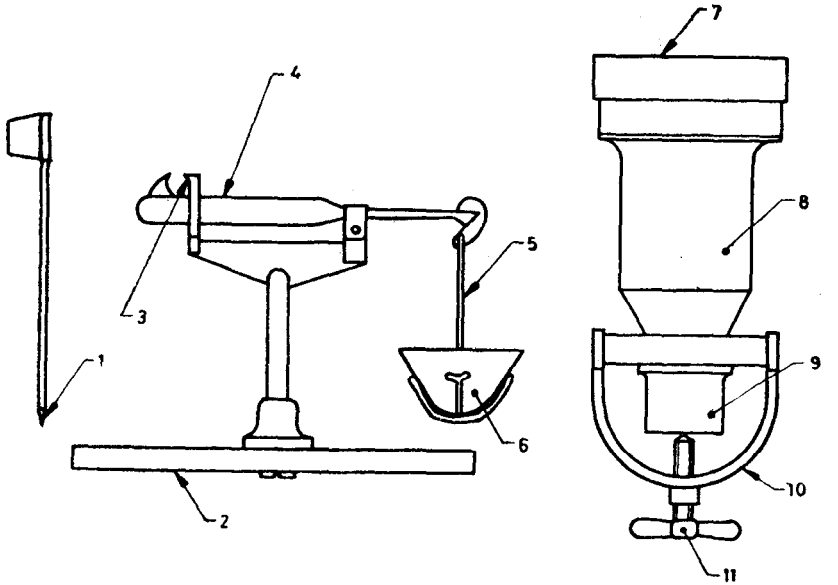
27.1 Sand requires no special preparation. Coarse powders may be ground and pulverized. Cohesive and plastic soils and material are tested with addition of steel balls in the pressure vessels. This test requires about 6 g of soil sample.

28. TEST PROCEDURE

28.1 Set up the balance. Place sample in pan till the mark on the balance arm mass lines up with the index mark.

28.2 Unclamp the clamping screw of the instrument sufficiently to move the U-clamp off the cup. Lift off the cup. Check that cup and body are clean; otherwise clean it using a brush.

28.3 Hold the body horizontal and gently deposit one level scoopful of absorbent (calcium carbide) halfway inside the chamber. Then lay the chamber down without disturbing the absorbent charge. Transfer the



Description		*Description*	
1.	Scoop	7.	Gauge 0-50%
2.	Balance base	8.	Body
3.	Index mark	9.	Cup
4.	Balance arm	10.	U-clamp
5.	Stirrup	11.	Clamp screw
6.	Pan		

FIG. 3 RAPID MOISTURE METER

soil weighed out as above from the pan to the cup. Holding cup and chamber approximately horizontal bring them together without disturbing sample or absorbent, bring the U-clamp round and clamp the cup tightly into place.

NOTE — If the sample is bulky reverse the above placements, that is, put the sample in the chamber and the absorbent in the cup. In the case of clayey soils and pastes, place the 3 smaller steel balls in the cup along with the sample and larger one in the body along with the absorbent.

28.4 With gauge downwards (except when the steel balls are used) shake the moisture meter up and down vigorously for 5 seconds, then quickly turn it so that the gauge is upwards, give a tap to the body of the moisture meter to ensure that all the contents fall into the cup. Hold the rapid

moisture meter downwards, again shake for 5 seconds, then turn it with gauge upwards and tap. Hold for one minute. Repeat this for a third time. Once more invert the rapid moisture meter and shake up and down to cool the gas. Turn the rapid moisture meter with the gauge upwards and dial horizontal held at chest height. When the needle comes to rest take the reading. The readings on the meter are the percentages of water on the wet mass basis.

NOTE — When steel balls are used place the 3 smaller balls in the cup along with the soil and the larger one in the body along with the absorbent and seal up the unit as usual. Hold the rapid moisture meter vertical so that the material in the cup falls into the body. Now holding the unit horizontal rotate it for 10 seconds so that the balls are rolled round the inside circumference of the body. Rest for 20 seconds. Repeat the rotation-rest cycle until the gauge reading is constant (usually this takes 4 to 8 min). Note the reading as usual.

28.5 Finally release the pressure slowly (away from the operator) by opening the clamp screw and taking the cup out, empty the contents and clean the instrument with a brush.

29. CALCULATION

29.1 From the water content (m) obtained on the wet mass basis as the reading on the rapid moisture meter, the water content (w) on the dry mass basis shall be calculated as follows:

$$w = \frac{m}{(100 - m)} \times 100 \text{ percent}$$

NOTE — The absorbent is highly susceptible to absorption of moisture and so shall not be exposed to atmosphere; as a result the absorbent suffers deterioration and will give results on the lower side. Replace the lid of the absorbent container firmly as soon as the required amount of the absorbent for a test is taken from the bottle. The absorbent suffers deterioration with time.

APPENDIX A

(*Clause* 7.2)

PRO FORMA FOR RECORD OF RESULTS OF TEST FOR THE DETERMINATION OF WATER CONTENT OF SOIL

Details of soil sample : Tested by :

Method of test adopted :

Oven drying :

Sand-bath :

Alcohol :

1. Container No.	
2. Mass of container and wet soil W_2, in g	
3. Mass of container and dry soil W_3, in g	
4. Mass of container W_1, in g	
5. Mass of dry soil ($W_3 - W_1$), in g	
6. Mass of moisture ($W_2 - W_3$), in g	
7. Water content $w = \frac{W_2 - W_3}{W_3 - W_1} \times 100\%$	

(*Continued from page* 2)

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53/5, Ward No. 29, R.G. Barua Road, 5th Byelane, GUWAHATI 781003	3 31 77
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117/418 B Sarvodaya Nagar, KANPUR 208005	21 68 76 21 82 92
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Reprography Unit, BIS, New Delhi, India

AMENDMENT NO. 1 AUGUST 1982

TO

IS : 2720 (Part II)-1973 METHODS OF TEST FOR SOILS

PART II DETERMINATION OF WATER CONTENT

(Second Revision)

Alterations

(*Page* 4, *clause* **4.1**):

a) *Informal table, first column* — Substitute the following for the existing matter:

'425μm IS Sieve
2-mm IS Sieve
4·75-mm IS Sieve
9·50-mm IS Sieve
19-mm IS Sieve
37·5-mm IS Sieve'

b) *Note* 1 — Substitute the following for the existing note:

'NOTE 1 — For sizes of sieves, *see* IS: 460 (Part I)-1978† '.

(*Page* 4, *foot-note with* '†' *mark*) — Substitute the following for the existing foot-note:

'†Specification for test sieves: Part I Wire cloth test sieves (*second revision*).'

(*Page* 8, *clause* **16.1**):

a) *Informal table, first column* — Substitute the following for the existing matter:

'2-mm IS Sieve
19-mm IS Sieve'

b) *Note* 1 — Substitute the following for the existing note:

'NOTE 1 — For sizes of sieves, *see* IS : 460 (Part I)-1978* '.

(*Page* 8, *foot-note with* '*' *mark*) — Substitute the following for the existing foot-note:

'*Specification for test sieves: Part I Wire cloth test sieves (*second revision*).'

(*Page* 14, *clause* **28.3**, *Note*) — Substitute the following for the existing note:

'NOTE — If the sample is bulky, reverse the above placement, that is, put the sample in the chamber and the absorbent in the cup. In the case of clayey soils and pastes, place the 3 smaller and one bigger steel balls in the body along with the absorbent. '

(*Page* 15, *clause* **28.4**, *Note*) — Substitute the following for the existing note:

'NOTE — When steel balls are used, place the three smaller and one bigger balls in the body along with the absorbent and the sample in the cup and seal up the unit as usual. Hold the rapid moisture meter vertical with the cup downwards and allow the absorbent with the balls to fall into the cup. Shake the unit up and down vigorously in this position for about 15 seconds. Now invert the unit and allow the material to fall into the body. Now holding the unit horizontal rotate it for 10 seconds so that the balls rolled round the inside circumference of the body. Rest for 20 seconds. Repeat the above cycle until the gauge reading is constant (usually this takes 4 to 8 min). Note the reading as usual. '

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