IS : 2720 (Part XXXIV) - 1972
(Reaffirmed 2001)
Edition 1.1
(1983-08)

Indian Standard

METHODS OF TEST FOR SOILS

PART XXXIV DETERMINATION OF DENSITY OF SOIL IN-PLACE BY RUBBER-BALLOON METHOD

(Incorporating Amendment No. 1)

UDC 624.131.431.5

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Price Group 3

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(*Continued on page* 2)

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Indian Standard

METHODS OF TEST FOR SOILS

PART XXXIV DETERMINATION OF DENSITY OF SOIL IN-PLACE BY RUBBER-BALLOON METHOD

0. FOREWORD

0.1 This Indian Standard (Part XXXIV) was adopted by the Indian Standards Institution on 31 January 1972, 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 is being published in parts. This part deals with the procedure for the determination of the density in-place of compacted or firmly bonded soil using a rubber-balloon apparatus. The in-place density of natural soil is needed for the determination of bearing capacity of soils, for the purpose of stability analysis of natural slopes, for the determination of pressures on underlying strata for calculation of settlement, etc. In compacted soils the in-place density is needed to check the amount of compaction that the soil has undergone for comparison with design data.

0.3 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 this field in this country.

0.4 This edition 1.1 incorporates Amendment No. 1 (August 1983). Side bar indicates modification of the text as the result of incorporation of the amendment.

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*.

1. SCOPE

1.1 This standard (Part XXXIV) covers the procedure for determining the density in-place of compacted or firmly bonded soil using a rubber-balloon apparatus. This method is not suitable for very soft soils which

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

will deform under slight pressure or in which the volume of the hole cannot be maintained at a constant value.

2. APPARATUS

2.1 Calibrated Vessel — designed to contain a liquid with a relatively thin, flexible elastic membrane (rubber-balloon) for measuring the volume of the test hole under the conditions of this method (*see* Fig. 1). The calibrated equipment may also be a graduated glass cylinder provided with a suitable guard and guard base with provisions for attachment of the elastic membrane without leakage. The graduations shall be such that the volumes can be read accurate to 5 ml. The apparatus shall be equipped so that an externally controlled pressure or partial vacuum can be applied to the contained liquid (*see* Note 1). Suitable provision shall also be made for the measurement of the pressure applied. It shall be of such weight and size that it will not cause distortion of the excavated test hole and adjacent test area during the performance of the test. Provision may be made for placing weights (surcharge) on the apparatus, if necessary, when the weight of the apparatus itself is not sufficient to hold it down during the test. The flexible membranes shall be of such sizes as to fill the test holes completely without wrinkles or folds when inflated within the test holes, and their strength shall be sufficient to withstand such pressures as are necessary to ensure complete filling of the test holes (*see* Note 2).

NOTE 1 — Any arrangement for providing pressure and partial vacuum which does not impair the portability of the apparatus may be used. A convenient method is to use a pressure actuator bulb similar to the one used in the blood-pressure measuring apparatus used by doctors. By providing suitable valves and other arrangements the same actuator can be used for creating the required vacuum.

NOTE 2 — The description and requirements given in **2.1** are intended to be non-restrictive. Any apparatus using a flexible membrane (rubber) and liquid that can be used to measure the volume of a test hole in soil under the conditions of this method to an accuracy within 1-0 percent is satisfactory.

2.2 Balances — A balance or scale of approximately 20-kg capacity accurate to 1 g and a balance of 2-kg capacity accurate to 0.2 g.

2.3 Apparatus for the Determination of Moisture Content — shall be in accordance with IS : 2720 (Part 2)-1973*.

2.4 Miscellaneous Equipment — Small pick, chisels, spoons for digging test holes, plastic bags, buckets with lids, or other suitable metal containers that can be closed for retaining the soil taken from the test holes, thermometer for determining temperature of water, small paint brush.

*Methods of test for soils: Part 2 Determination of water content (*second revision*).

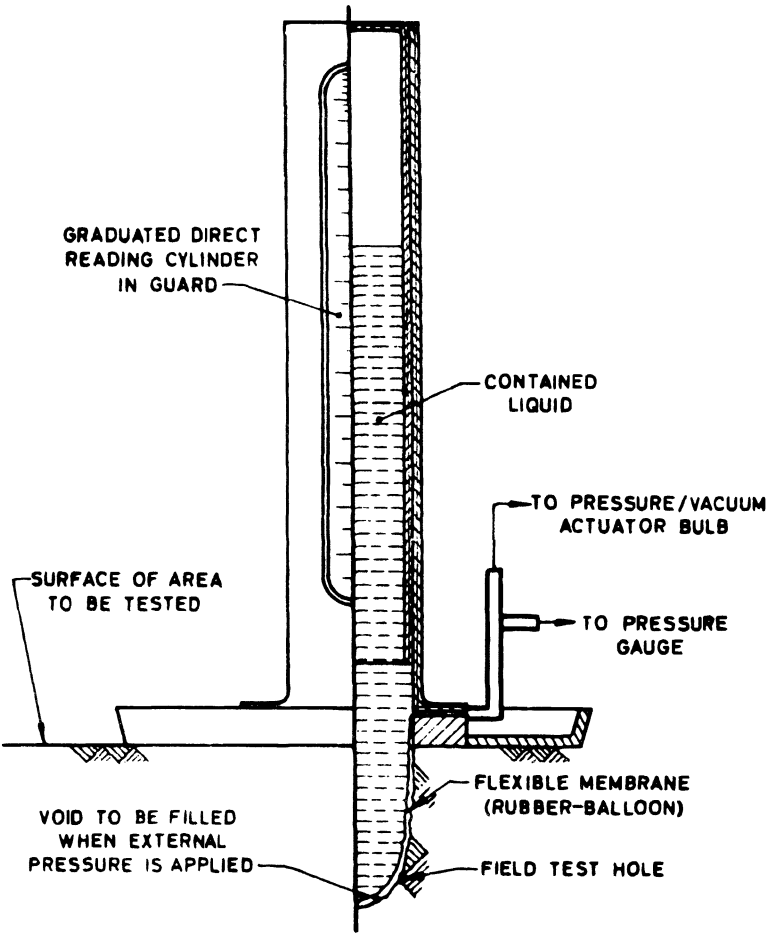

FIG. 1 SCHEMATIC DRAWING OF CALIBRATED VESSEL INDICATING PRINCIPLE

3. CALIBRATION CHECK OF VOLUME INDICATOR

3.1 Verify the procedure to be used and the accuracy of the volume indicator by using the apparatus to measure containers or moulds of determinable volume that dimensionally simulate test holes that will be used in the field. The apparatus and procedure shall be such that these

volumes shall be measured to within 1.0 percent (*see* Note). Containers of different volumes shall be used so that the calibration check of the volume indicator covers the range of anticipated test hole sizes.

NOTE — The 100-mm and 150-mm moulds described in IS : 2720 (Part 7)-1980* and IS : 2720 (Part 8)-1983† or other moulds prepared to simulate actual test holes may be used. Where several sets of apparatus are used, it may be desirable to cast duplicates of actual test holes. These sets should represent the range of sizes and irregularities in the walls of test holes that will be encountered. These fabricated holes may be used as standards for the calibration check of the volume indicator. This may be accomplished by forming plaster of Paris negatives in the test holes and using these as forms for Portland cement concrete castings. After removing the plaster of Paris negative from the concrete casting, the inside surface of the fabricated holes should be sealed watertight and their volume determined as indicated in **3.1**.

3.1.1 *Volumes of Containers* — Determine the weight of water, in grams required to fill one of the containers. Slide a glass plate carefully over the top surface of the container in such a manner as to ensure that the container is filled completely with water. Determine the temperature of the water in the container. A thin film of cup grease smeared on the top surface of the container shall make a watertight joint between the glass plate and the top of the container. Calculate the volume of the container, in millilitres, by multiplying the weight of water, in grams, used to fill the container by the unit volume of water, in millilitres per gram, at the observed temperature, taken from Table 1. Repeat this procedure until three values are secured for the volume of the container having maximum range of variation of 3 ml. Repeat the procedure for each of the containers to be used in the calibration check.

3.1.2 *Calibration Check Tests* — Place the rubber-balloon apparatus filled with water to the required level (*see* Note 1) on a relatively smooth horizontal surface and take an initial reading on the volume indicator. Transfer the apparatus to one of the containers and take the reading on the volume indicator when the rubber-balloon completely fills the container (*see* Notes 2 and 3). Apply pressure to the liquid in the apparatus until there is no further change indicated on the volume indicator. Note and record the pressure. Where necessary, add weight (surcharge) to the apparatus to prevent it from rising (*see* Note 4). Note and record the total amount of weights added. The difference between the initial and final readings of the volume indicator is the indicator volume value for the container. The membrane may be withdrawn from the container by applying a partial vacuum to the liquid in the apparatus. Repeat the procedure for the other containers.

NOTE 1 — Water may be used as fill liquid and in freezing temperatures anti-freeze fluids may be used in the calibrated vessel or cylinder.

*Methods of test for soils: Part 7 Determination of moisture content-dry density relation using light compaction (*second revision*).

†Methods of test for soils: Part 8 Determination of moisture content-dry density relation using heavy compaction (*second revision*).

NOTE 2 — If the calibration container or mould is airtight, it may be necessary to provide an air escape, since the rubber membrane can entrap air within the container and cause erroneous volume measurement. After the volume of the container has been determined with water and prior to the insertion of the rubber-balloon, small air escape-holes may be provided by placing lengths of small diameter string over the edge of the container and down the inside wall slightly beyond the bottom centre. This will permit air leakage during the filling of the container with the membrane. If such a procedure is necessary in the laboratory, it may be necessary to use a similar procedure on tightly-bounded soil in the field.

NOTE 3 — Before any measurements are made, it may be necessary to distend the rubber-balloon and remove air bubbles adhering to the inside of the membrane by kneading.

NOTE 4 — In field tests the additional weights (surcharge) will increase the stress in the unsupported soil surrounding the test hole and will tend to cause it to deform. The stress may be reduced by using a base plate.

TABLE 1 VOLUME OF WATER PER GRAM BASED ON TEMPERATURE

(*Clause* 3.1.1)

TEMPERATURE °C	VOLUME OF WATER, ml/g
12	1.000 48
14	1.000 73
16	1.001 03
18	1.001 38
20	1.001 77
22	1.002 21
24	1.002 68
26	1.003 20
28	1.003 75
30	1.004 35
32	1.004 97
34	1.005 63
36	1.006 33
38	1.007 06
40	1.007 86
42	1.008 57
44	1.009 39
46	1.010 31
48	1.011 12
50	1.012 04

4. PROCEDURE

4.1 Prepare the surface of the test hole site so that it is reasonably plane. Set the apparatus on the test hole site and take an initial reading on the volume indicator of the calibrated vessel using the same pressure on the liquid in the vessel and the same amount of surcharge weight as was used in the calibration check. After taking this initial reading on the volume indicator, scribe the outline of the apparatus on the test hole site. Record the pressure used, the amount of the surcharge, and the initial volume reading. If the apparatus was calibrated with a base plate, the base plate shall remain in-place throughout the field test.

4.2 Remove the apparatus from the test hole site and dig a hole centered within the outline scribed for the apparatus. Exercise care in digging the test hole so that soil around the top edge of the hole is not disturbed. Place all the soil removed from the test hole in an airtight container for weight and moisture content determinations. The test hole shall be of the minimum volume given in Table 2. Larger holes will provide improved accuracy and shall be used, where practicable. The dimensions of the test holes are related to the apparatus design and the pressure used. In general, the dimensions shall approximate those used in the calibration check procedure.

TABLE 2 MINIMUM FIELD TEST HOLE VOLUMES AND MINIMUM MOISTURE CONTENT SAMPLES BASED ON MAXIMUM SIZE OF PARTICLE

(*Clauses* 4.2 *and* 4.4)

SL NO.	MAXIMUM PARTICLE SIZE	TEST HOLE VOLUME, *Min*	MOISTURE CONTENT SAMPLE, *Min*
(1)	(2)	(3)	(4)
	mm	cm^3	g
i)	4.75	700	200
ii)	10	1 400	300
iii)	20	2 100	500
iv)	40	2 800	1 000
v)	63	3 800	1 500

4.3 After the test hole has been dug, place the apparatus over the test hole in the same position used for the initial reading and inflate the flexible membrane in the hole, allowing air from the hole to escape without getting entrapped between the inner surface of the test hole and the flexible membrane (*see* Note 2 under **3.1.2**). Apply the same surcharge weight and pressure on the liquid in the vessel as used during the calibration check procedure. Take and record the reading on the volume indicator. The difference between this reading and the initial reading obtained in **4.1** is the 'volume of the test hole (*see* Note). Note the temperature of the water used and correct the volume for temperature, taking into consideration the temperature at which the apparatus was calibrated. After the test, pump the water and flexible membrane back into the cylinder by applying vacuum.

NOTE — Attention is called to instances in weak soils, where the pressure applied to the liquid in the vessel may deform the test hole to such an extent as to give an erroneous volume. In such instances, the apparatus shall be re-calibrated using less surcharge weight and less pressure on the liquid in the vessel, or it may be necessary to resort to another method such as that given in IS : 2720 (Part 28)-1974*.

*Methods of test for soils: Part 28 Determination of dry density of soils, in-place, by the sand replacement method (*first revision*).

4.4 Determine the weight of all the moist soil removed from the test hole to the nearest 5 g. Mix this soil thoroughly, select a sample in accordance with Table 2 for the determination of moisture content and determine its weight to the nearest 0.1g. Dry the moisture content sample to a constant weight at a temperature 100 to 110°C and determine the dry weight to the nearest 0.1g [*see also* IS : 2720 (Part 2)-1973*].

5. CALCULATIONS

5.1 Calculate the moisture content, w, of the soil as follows:

$$w = \frac{\text{weight of moisture}}{\text{weight of dry soil}} \times 100$$

5.2 Calculate the wet unit weight, γ_m, of the soil removed from the test hole, in g/cm^3, as follows:

$$\gamma_m = \frac{\text{weight of moist soil}}{\text{volume of test-hole}}$$

5.3 Calculate the dry unit weight, γ_d, of the soil removed from the test hole, in g/cm^3, as follows:

$$\gamma_d = \left(\frac{\gamma_m}{w + 100}\right) \times 100$$

*Methods of test for soils: Part 2 Determination of moisture content (*second revision*).

(*Continued from page* 2)

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This Indian Standard has been developed by Technical Committee : BDC 23

Amendments Issued Since Publication

Amend No.	Date of Issue
Amd. No. 1	August 1983

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