IS 2720 (Part 11) : 1993
(Reaffirmed 1997)

भारतीय मानक

मृदा परीक्षण पद्धतियां

भाग 11 छेदजल-दबाव मापन के बिना असेमकित और अपवाहित तीन-अक्षीय संपीडन में परीक्षित की गई बानगी की अपरूपण सामर्थ्य के प्राचल ज्ञात करना

(पहला पुनरीक्षण)

Indian Standard

METHODS OF TEST FOR SOILS

PART 11 DETERMINATON OF THE SHEAR STRENGTH PARAMETERS OF A SPECIMEN TESTED IN UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION WITHOUT THE MEASUREMENT OF PORE WATER PRESSURE

(First Revision)

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Soils and Soil Engineering Sectional Committee, CED 23

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft had been finalized by the Soils and Soil Engineering Sectional Committee had been approved by the Civil Engineering Division Council.

With a view to establish uniform procedures for determination of different characteristics of soils and also for facilitating the comparative study of the results, an Indian Standard Method of test for soils, IS 2720 has been published in 41 parts. This part covers the determination of the compressive strength of a specimen of saturated cohesive soil in the triaxial compression apparatus under conditions in which the cell pressure is maintained constant and there is no change in the total water content of the specimen.

This standard was first published in 1971. In this first revision apart from general updation, the three amendments issued have been incorporated and the quantities and dimensions have been given in SI units.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

METHODS OF TEST FOR SOILS

PART 11 DETERMINATON OF THE SHEAR STRENGTH PARAMETERS OF A SPECIMEN TESTED IN UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION WITHOUT THE MEASUREMENT OF PORE WATER PRESSURE

(*First Revision*)

1 SCOPE

1.1 This standard (Part 11) describes the test for the determination of the compressive strength of a specimen of saturated cohesive soil in the triaxial compression apparatus under conditions in which the cell pressure is maintained constant and there is no change in the total water content of the specimen (*see* Notes 1 and 2).

NOTES

1 In this standard the term 'sample' is used to denote the soil submitted to the laboratory for the testing and the term 'specimen' refers to a portion of the sample upon which the test is performed.

2 The result of any test made in accordance with this standard requires interpretation in relation to the nature of the soil and the way in which the specimen was obtained and prepared.

1.1.1 This test is limited to specimens in the form of right cylinders of nominal diameter 38, 50, 70 and 100 mm and of height approximately equal to twice the nominal diameter (*see* Note). In case of remoulded samples; ratio of diameter of specimen to maximum size of particle in the soil should not be less than 5.

NOTE — The diameter of the specimen is to be selected having regard to the character of the soil and the maximum size of the particles present in the sample. Generally, a diameter of 38 mm will be suitable for homogeneous fine-grained soils.

2 REFERENCES

2.1 The Indian Standard listed below is necessary adjunct to this standard:

IS No.	*Title*
2720 (Part 2) : 1973	Methods of test for soils: Part 2 Determination of water content (*second revision*)

3 APPARATUS

3.1 Apparatus required for the preparation of a test specimen are listed in **3.2** and **3.3** to cover the three possible following procedures:

a) Procedure 1 — For obtaining a specimen from a sampler tube of the same internal diameter as the required specimen.

b) Procedure 2 — For obtaining a specimen from a sampler tube of larger diameter than the required specimen.

c) Procedure 3 — For obtaining a specimen from a block sample.

3.2 Articles Common to a Sample Preparation by all Three Procedures

3.2.1 *Split Mould*

Of diameter and length to suit the test specimen.

3.2.2 *Trimming Knife*

Sharp-bladed for example a spatula or pallet knife.

3.2.3 *Piano Wire Saw*

3.2.4 *Metal Straightedge*

3.2.5 *Metal Scale*

3.2.6 *Non-Corrodible Metal or Plastic End-Caps*

Of the same diameter as the test specimen. The upper end cap is to have a central spherical seating to receive the loading ram (*see* Note).

NOTE — A plastic upper end cap, 20 mm thick, is normally satisfactory for use on soft or very soft soils. Metal end caps are considered preferable for use on stiff soils. A metal upper end cap 12 to 20 mm thick is normally satisfactory.

3.2.7 *Seamless Rubber Membrane*

In the form of a tube, open at both ends of internal diameter equal to the specimen diameter and of length 50 mm greater than the height of the specimen. The membrane thickness should be selected having regard to the size, strength and nature of the soil to be tested. A thickness of 0·2 to 0·3 mm is normally satisfactory.

3.2.8 *Membrane Stretcher*

To suit the size of the specimen.

3.2.9 *Rubber Rings*

Of circular cross section to suit the diameter of the end caps.

3.2.10 *Apparatus for Moisture Content Determination*

As described in section 1 of IS 2720 (Part 2) : 1973.

3.2.11 *Balance*

Readable and accurate to 0·5 g.

3.3 Additional Items for the Specific Procedures

3.3.1 *Extruders* [*For Procedures (a) and (b) of* **3.1** *Extruders*]

3.3.2 *Thin-walled Tubes* [*For Procedure (b) of* **3.1**] (*for obtaining test specimens*)

The tubes shall be smooth inside and out and turned at one end to form a cutting edge at the inner surface of the tube. The area ratio (*see* Note) shall be kept as low as posible consistent with the strength requirements of the specimen tubes and its value shall not exceed 10 percent. The length of the tubes shall be at least 50 mm more than the required length of the specimens.

NOTE — The area ratio is defined as the volume of soil displaced by the sampler in proportion to the volume of the sample and is defined as:

$$\text{Area ratio} = \frac{D_0^2 - D_C^2}{D_C^2} \times 100 \text{ percent}$$

where

D_0 = outside diameter of the tube, and

D_C = inside diameter of the cutting edge.

3.3.3 *Soil Lathe* [*For Procedure (c) of* **3.1**]

For preparing test specimens.

3.3.4 *Meter Box* [*For Procedure (c) of* **3.1**]

For cutting the ends of the specimen perpendicular to their axes.

3.4 Apparatus Required for Triaxial Test

3.4.1 *Triaxial Test Cell*

A triaxial test cell of dimensions appropriate to the size of the specimen, capable of being opened for the insertion of the specimen, suitable for use with the fluid selected for use at internal pressures up to 1 MPa and provided with a means of applying additional axial compressive load to the specimen by means of a loading ram. A transparent chamber is recommended. The base of the cell shall be provided with a suitable central pedestal with drainage outlets with valves.

3.4.2 *An Apparatus for Applying and Maintaining the Desired Pressure on the Fluid Within the Cell*

To an accuracy of 10 kPa (preferably 5 kPa) with a gauge for measuring the pressure. The gauge shall be regularly calibrated.

3.4.3 *Machine Capable of Applying Axial Compression to the Specimen*

At convenient speeds to cover the range 0·05 to 5 mm per minute. The machine should have a capacity of 50 KN. A means of measuring the axial compression of the specimen to an accuracy of 0·01 mm shall be provided and the machine shall be capable of applying an axial compression of about one-third the height of the specimen tested.

NOTE — In case the travel of the dial gauges is not sufficient a magnetic spacer of known thickness may be used.

3.4.4 Provision shall be made for measuring the additional axial load on the specimen. Proving ring of 1 KN capacity with sensitivity of 2 N for low strength soils and one of 10 KN capacity with sensitivity of 10 N for high strength soils are found suitable.

4 PREPARATION OF SPECIMENS

4.1 Undisturbed Specimens

4.1.1 The object of the specimen preparation is to produce cylindrical specimens of height twice the specimen diameter with plane ends normal to the axis and with the minimum change of the soil structure and moisture content.

The method of preparation will depend on whether the sample is received in the laboratory in a tube or as a block sample and any one of the procedures given in **4.1.1.1**, **4.1.1.2** or **4.1.1.3** may be used.

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1 kPa = 100 kgf/m²

1 KN = 100 kgf

4.1.1.1 *A specimen from a sampler tube of the same internal diameter as the required specimen*

May be obtained as given in (a) to (e):

a) When the ends of the sampling tube are not flat and normal to the axis of the tube, a length of the sample sufficient to form a specimen shall be extruded from the tube and cut off. This specimen shall then be placed in the split mould and the ends trimmed flat and normal to its axis.

b) As an alternative to (a) when the tube enclosing the sample is in good condition and the ends are plane and normal to the axis of the tube, the specimen may be prepared in the tube and extracted.

c) Any wax, used for sealing, shall be removed and the cutting edge end of the sample smoothed so that it is approximately normal to the axis of the tube. The extruder shall then be used to push the sample through the tube so that the other end may be cut normal to the axis and finally smoothed with the metal straight edge. The sample should be extruded from the tube pushing from the cutting edge side and cut to the required length. During this operation the sample tube shall be held vertical. Precautions shall be taken to prevent adhesion between the soil and the extruder, for example, by interposing oiled paper discs or lightly oiling the face of the extruder.

d) The length, diameter and mass of the specimen shall be measured to an accuracy enabling the bulk density to be calculated to an accuracy of $\pm$ 1·0 percent.

e) The specimen shall be placed on one of the end caps and the other end cap shall be put on top of the specimen. The rubber membrane shall then be placed around the specimen using the membrane stretcher and the membrane sealed to the end caps by means of rubber rings. The specimen is then ready to be placed on the pedestal in the triaxial cell. The pedestal should be either covered with a solid end cap or the drainage valve should be kept closed.

4.1.1.2 *For obtaining a specimen from a sample tube of larger diameter then the required specimen*

Two methods are available, either the specimen may be cut to size by means of thin walled tubes or by hand trimming on a soil lathe. Specimens of sensitive clays and, in some cases, of stiff fissured, clays, may be best prepared by the latter method. The preparation of specimens on the soil lathe is dealt with in **4.1.1.3**. To prepare specimens by means of thin-walled tubes the sample shall be extruded from the sample tube directly into a number of thin-walled specimen tubes rigidly clamped with their cutting ends a short distance from the end of the sampling tube. Test specimens shall be prepared from the thin-walled specimens tubes in the manner described in **4.1.1.1**.

4.1.1.3 *A specimen from a block sample*

May be obtained as given in (a) to (c) :

a) A rectangular prism slightly larger than the required final dimension of the specimen shall be cut from the block sample. The rectangular prism shall be cut either on a required orientation or an orientation as best suited to the sample. The ends of the prism shall be made plane and parallel using the meter box and the prism shall be placed in the soil lathe. The excess soil shall be cut off in this layer. The trimming operation, rotating, the sample between each cutting operation, shall be continued until a cylindrical specimen results.

b) The specimen shall be removed from the soil lathe, placed in the split mould and cut to the correct length and the ends made plane and normal to the axis of the specimen.

c) The remainder of the preparation shall be as described in **4.1.1.1**.

4.2 Remoulded Samples

Remoulded samples prepared at the desired moisture and density by static and dynamic methods of compaction or by any other suitable method, where necessary.

5 TESTING

5.1 The specimen prepared as described in **4** shall be placed centrally on the pedestal of the triaxial cell. The cell shall be assembled with the loading ram initially clear of the top cap of the specimen and the cell containing the specimen shall be placed in the loading machine. The operating fluid shall be admitted to the cell and the pressure raised to the desired value.

5.2 The loading machine shall be adjusted to bring the loading ram a short distance away from the seat on the top cap of the specimen and the initial reading of the load measuring gauge shall be recorded. The loading machine shall then be further adjusted to bring the loading ram just in contact with the seat on the top cap of the specimen and the initial reading of the gauge measuring the axial compression of the specimen shall be recorded. A rate of axial compression shall be selected such that failure is produced within a period of approximately 5 to 15 minutes. The test shall be commenced, a sufficient number of simultaneous readings of the load and compression measuring gauges being taken to define the stress strain curve (*see* Note). The test shall be continued until the maximum value of the stress has been passed or until an axial strain of 20 percent has been reached. The specimen shall then be unloaded and the final reading of the load measuring gauge shall be recorded as a check on the initial reading.

NOTE — It is often convenient to make a plot of load versus compression as the rest proceeds, to enable the point of failure to be determined.

5.3 The cell shall be drained of fluid and dismantled, and the specimen taken out. The rubber membrane shall be removed from the specimen and the mode of failure shall be noted (*see* Note 1). The specimen shall be weighed (*see* Note 2) and samples for the determination of the moisture content of the specimen shall be taken [see Section 1 of IS 2720 (Part 2) : 1973]. If there is a moisture change in the specimen it should be recorded and discretion used with regard to acceptability of the test.

NOTES

1 The most convenient method of recording the mode of failure is by means of sketch indicating the position of the failure planes. The angle of the failure plan (s) to the horizontal may be recorded, if required. These records should be completed without undue delay to avoid loss of moisture from specimen.

2 Comparison with the recorded mass of the specimen before testing provides a check on the impermeability of the rubber membrane if water has been used as the operating fluid in the cell.

6 CALCULATIONS

6.1 According to the procedure given in this standard the difference between the initial reading and any subsequent reading of the loading measuring device is the axial load applied to the specimen in addition to that due to cell pressure.

6.1.1 The area of the specimen normal to its axis at any stage of the test shall be computed on the assumption that the sample deforms as a right cylinder. This area at any strain is given by:

$$A = \frac{A_0}{1-e}$$

where

A_0 = initial area of the specimen normal to the axis, and

e = $(L_0 - L)/L_0$

where

L_0 = initial length of the specimen, and

L = length of the specimen at the stage of test at which area is to be determined.

6.1.1.1 The principal stress difference ($\sigma_1 - \sigma_3$) for any stage of the test shall be determined by dividing the additional axial load by the corresponding area A.

6.1.1.2 A correction to allow for the restraining effect of the rubber membrane shall be made as given below:

$$\text{Correction} = 4M \frac{1-\varepsilon}{D}$$

where

M = the compression modulus of the rubber membrane in kg/cm of width (*see* 6.1.1.4),

ε = the axial strain at the maximum principal stress different, and

D = initial diameter of the sample in cm.

6.1.1.3 The value of the correction calculated as given in 6.1.1.2 shall be deducted from the measured maximum principal stress difference to give the corrected value of the maximum principal stress different.

6.1.1.4 The compression modulus of the rubber membrane cannot be measured directly but may be assumed to be equal to the modulus measured in extension. The extension modulus of a circumferential strip (25) mm wide cut from the membrane may be determined by means of the arrangement shown in Fig. 1. The contact faces between the rubber and the glass rods should be dusted with talc powder to reduce friction.

7 REPORTING OF RESULTS

7.1 The dimensions of each test specimen, the bulk density, the moisture content, the cell pressure, the value of the maximum principal stress difference ($\sigma_1 - \sigma_3$), and the corresponding strain and time to failure and the rate of strain at which the test was conducted shall be reported.

7.1.1 When required the stress-strain curve of the test shall be plotted with the axial strain as abscissa and the principal stress difference as ordinate.

7.1.2 The type of sampler and method of sampling in the field shall be reported.

7.2 The shear parameters shall be obtained from a plot of Mohr circles for which purpose peak values of principal stress difference or principal stress ratio or the ultimate value as desired may be used.

7.3 A proforma for the record of the test results is given in Annex A.

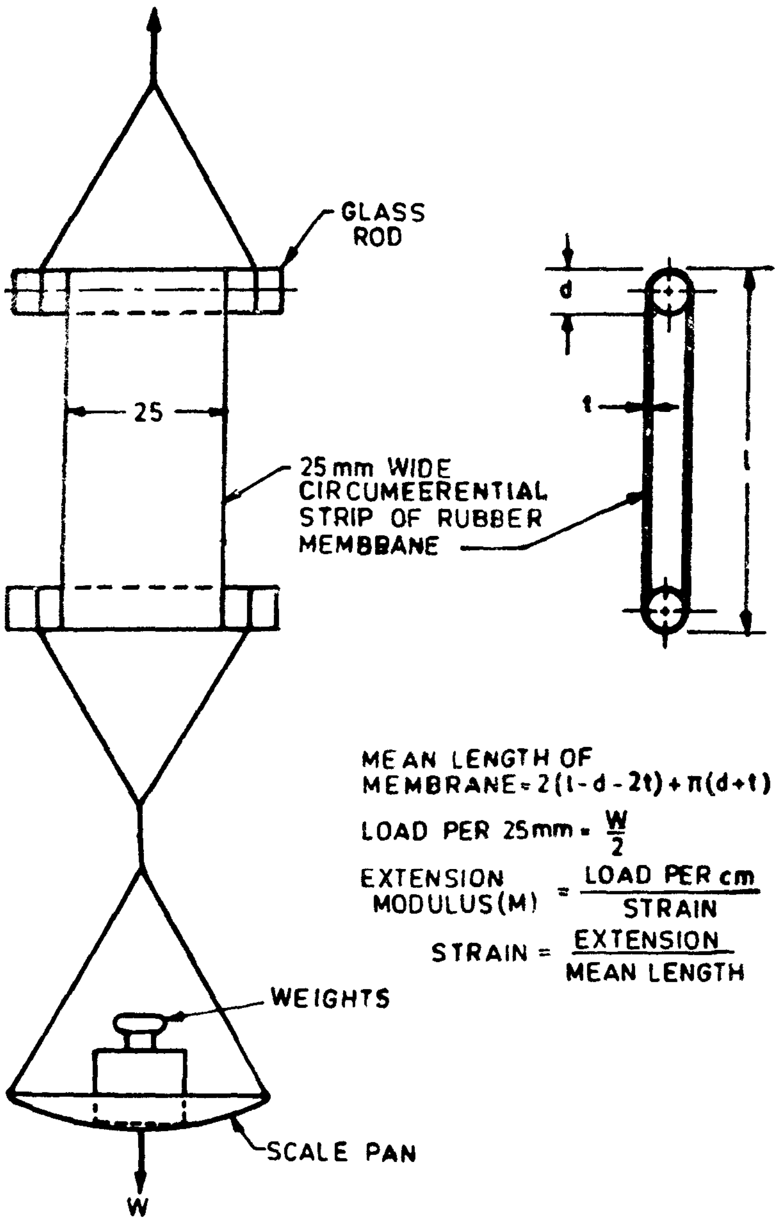

FIG. 1 APPARATUS FOR MEASURING THE EXTENSION MODULUS OF RUBBER MEMBRANE

ANNEX A

(*Clause* 7.3)

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST WITHOUT THE MEASUREMENT OF POREWATER PRESSURE

Operator Date Depth

Borehole No.

Site Sample No.

Specimen preparation procedure

Initial length of specimen

Initial diameter specimen Bulk density

Initial weight of specimen Moisture content

Load gauge No. Load gauge constant

Cell pressure (σ_3) = Rate of strain

Description of sample Sketch of specimen after failure

Mode of failure

Angle of shear plane with vertical axis

Compression Gauge Reading	Load Gauge Reading	Compression of Sample	Strain	Corrected Area	Load	Deviator Stress $(\sigma_1 - \sigma_3)$	Vertical Stress σ_1	$\frac{\sigma_1}{\sigma_3}$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)

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