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METHODS OF TEST FOR SOILS

PART 13 DIRECT SHEAR TEST

(Second Revision)

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Indian Standard

METHODS OF TEST FOR SOILS

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0. FOREWORD

0.1 This Indian Standard (Part 13) (Second Revision) was adopted by the Indian Standards Institution on 28 August 1986, 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 establishing uniform procedures for the determination of various characteristics of soils and also to facilitate comparative study of the results, this standard is being published, in various parts. This standard (Part 13) deals with the method for direct shear test of soils.

0.3 Depending upon the application of shear load, the direct shear test is of two types, controlled stress and controlled strain. The controlled strain test is simpler and provides accurate results and is, therefore, recommended.

0.4 This standard was first published in 1965 and subsequently revised in 1972. In this revision, provisions regarding the requirements for equipment have been deleted as these have now been covered in detail in IS : 11229-1985*. Opportunity has also been taken to make the requirements up-to-date in respect of procedure for the test, based on the experience gained in the use of this test by various laboratories in the past years.

0.5 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†. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

*Specification for shear box for testing of soils.
†Rules for rounding off numerical values (*revised*).

1. SCOPE

1.1 This standard (Part 13) covers the methods for determination of shear strength of soil with a maximum particle size of 4·75 mm in undrained, consolidated undrained and consolidated drained conditions.

NOTE — The undrained test can be performed only for highly impermeable clays. When silty clays and silts are involved, partial drainage is inevitable. This fact should be recognized while interpreting the results.

2. TERMINOLOGY

2.1 For the purpose of this standard, definition of terms given in IS : 2809-1972* shall apply.

3. APPARATUS

3.1 The shear box grid plates, porous stones, base plates, and loading pad and water jacket shall conform to IS : 11229-1985†.

3.2 Loading Frame — It shall satisfy the following requirements:

a) The vertical stress on the sample shall remain vertical and constant during the test and there shall be arrangement to measure compression.

b) The shear stress or strain can be applied in the dividing plane of the two parts of the shear box.

c) It shall be possible to maintain a constant rate of increase in stress during the test (irrespective of the strain rate) with arrangement to get different rates of stress increase.

d) In case of a strain-controlled apparatus, the strain rate should remain constant irrespective of the stress. Suitable arrangement shall be provided to obtain different strain rates.

e) No vibrations should be transmitted to the sample during the test and there should not be any loss of shear force due to friction between the loading frame and the shear box-container assembly.

3.3 Weights — for providing the required normal loads, if necessary.

*Glossary of terms and symbols relating to soil engineering (*first revision*).
†Specification for shear box for testing of soils.

3.4 Proving-Ring — force measuring of suitable capacity, fitted with a dial-gauge accurate to 0·002 mm to measure the shear force.

NOTE — For normal testing, proving-rings of 100 to 250 kg capacity, depending on the type of soil and the normal load on the sample during test, may be needed.

3.5 Micrometer Dial-Gauges — accurate to 0·01 mm; one suitably mounted to measure horizontal movement and the other suitably mounted to measure the vertical compression of the specimen.

3.6 Sample Trimmer or Core Cutter

3.7 Stop Clock

3.8 Balance — of 1 kg capacity, sensitive to 0·1 g.

3.9 Spatula and a Straight Edge

4. PREPARATION OF SPECIMEN

4.1 Undisturbed Specimens — Specimens of required size (*see* **5.1**) shall be prepared in accordance with IS : 2720 (Part 1)-1983*.

4.2 Remoulded Specimens

a) Cohesive soils may be compacted to the required density and moisture content, the sample extracted and then trimmed to the required size. Alternatively, the soil may be compacted to the required density and moisture content directly into the shear box after fixing the two-halves of the shear box together by means of the fixing screws.

b) Cohesionless soils may be tamped in the shear box itself with the base plate and grid plate or porous stone as required in place at the bottom of the box.

4.3 The cut specimen shall be weighed and trimmings obtained during cutting shall be used to obtain the moisture content. Using this information, the bulk dry density of the specimen in the shear box shall be determined.

5. PROCEDURE

5.1 Undrained Test — The shear box with the specimen, plain grid plate over the base plate at the bottom of the specimen, and plain grid plate at

*Methods of test for soils: Part 1 Preparation of dry soil samples for various tests (*second revision*).

the top of the specimen should be fitted into position in the load frame. The serrations of the grid plates should be at right angles to the direction of shear (*see* Note). The loading pad should be placed on the top grid plate. The water jacket should be provided so that the sample does not get dried during the test. The required normal stress should be applied and the rate of longitudinal displacement/shear stress application so adjusted that no drainage can occur in the sample during the test. The upper part of the shear box should be raised such that a gap of about 1 mm is left between the two parts of the box. The test may now be conducted by applying horizontal shear load to failure or to 20 percent longitudinal displacement, whichever occurs first. The shear load readings indicated by the proving ring assembly and the corresponding longitudinal displacements should be noted at regular intervals. If necessary, the vertical compression, if any, of the soil specimen may be measured to serve as a check to ensure that drainage has not taken place from the soil specimen. At the end of the test, the specimen should be removed from the box and the final moisture content measured. A minimum of three (preferably four) tests shall be made on separate specimens of the same density.

NOTE — As porous stones are not used for the undrained tests, plain plates of equal thickness should be substituted in their place so as to maintain the shear plane in the sample in the middle of its thickness.

5.2 Consolidated Undrained Test — The apparatus should be assembled in a way similar to that given in **4.1** except that instead of the plain grid plates, perforated grid plates and saturated porous stones should be used at the top and bottom of the specimen. The procedure is same as in **4.1** except that after the application of normal stress, the vertical compression of the soil with time should be recorded [*see* IS : 2720 (Part 15)-1986*]. The shear test should be conducted only after complete consolidation has occurred under the particular normal stress. The rate of shear should be such that water does not drain from the specimen at the time of application of the shear load. At the end of the test, the specimen should be removed from the box and the final moisture content measured. A minimum of three (preferably four) tests should be made on separated specimens of the same density at different normal stresses.

5.3 Consolidated Drained Test — The shear box with sample and perforated grid plates and porous stones should be fitted into the load frame as in **4.2**. After application of normal stress which is done in increments [*see* IS : 2720 (Part 15)-1986*], the sample should be allowed to consolidate. When the consolidation has completely occurred, the shear test should be done at such a slow rate that at least 95 percent pore pressure

*Methods of test for soils: Part 15 Determination of consolidation properties (*first revision*).

dissipation occurs during the test in this calculated time factor (*see* Appendix A). At the end of the test, the specimen should be removed from the box and the final moisture content measured. A minimum of three (preferably four) tests should be made on separate specimens of the same density at different normal stresses.

5.4 The normal stresses to be selected for the test should correspond to the field conditions and design requirements.

6. CALCULATIONS AND REPORT

6.1 All Tests

6.1.1 Results of tests shall be recorded suitably. A recommended proforma for recording the results is given in Appendix B.

6.1.2 From the calibration chart of the proving-ring, the loads corresponding to the load dial readings obtained during the test should be calculated. The loads so obtained divided by the corrected cross-sectional area of the specimen gives the shear stress in the sample. The corrected cross-sectional area shall be calculated from the following equation:

$$\text{Corrected area} = A_0 \left(1 - \frac{\delta}{3} \right)$$

where

A_0 = initial area of the specimen in cm^2, and

δ = displacement in cm.

6.1.2.1 The longitudinal displacement at a particular load may be either noted directly from the strain dial readings or calculated as the product of the corresponding time reading and the strain rate, allowing for the compression of the proving-ring, where applicable. The stress-longitudinal displacement readings should be plotted and the maximum stress and corresponding longitudinal displacement together with the normal load applied during the test recorded (*see* Note).

NOTE — In general, failure in direct shear may be considered to take place either at maximum shear or at the maximum obliquity of the Mohr failure envelope. If the failure is assumed to take place at maximum shear and not at maximum obliquity, the angle of shearing resistance thus obtained will be smaller, giving an error, if any, on the safe side. It should, however, be noted that differences in the values of the angle of shearing resistance obtained by using the two criteria mentioned above are more important for sands than for clays.

6.1.2.2 The maximum shear stress and the corresponding longitudinal displacement and applied normal stress should be recorded for each test and the results should be presented in the form of a graph in which the applied normal stress is plotted as abcissa and the maximum shearing stress

is plotted as ordinate to the same scale. The angle which the resulting straight line makes with the horizontal axis and the intercept which the straight line makes with the vertical axis shall be reported as the angle of shearing resistance and cohesion intercept respectively (*see* Note).

NOTE — The normal stress-maximum shear stress relationship may not be a straight line in all cases. In such cases, the shear parameters may be obtained by drawing a tangent to the normal stress expected in the field.

6.1.3 In the case of the consolidated undrained and consolidated drained tests, the load at which the specimen is consolidated and the consolidation characteristics as determined during the consolidation part of the test should also be reported.

APPENDIX A

(*Clause* 5.3)

RATE OF SHEAR FOR CONSOLIDATED DRAINED TEST

A-1. RATE OF STRAIN

A-1.1 For sandy soils, a rate of strain of 0·2 mm/min may be suitable. For clayey soils, a rate of strain of 0·01 mm/min or slower may be used but actual rate of strain suitable for the soil under test may be ascertained as in **A-1.1.1**.

A-1.1.1 From the consolidation data collected, the compression dial readings should be plotted against the logarithm of time and from this curve, the value of coefficient of consolidation, C_v, should be computed from the formula:

$$C_v = \frac{0{\cdot}197\ h^2}{t_{50}}$$

where

$2h$ = initial thickness of the specimen, and

t_{50} = time corresponding to 50 percent consolidation.

A-1.1.2 The requisite time to failure when theoretically 95 percent dissipation is ensured, may be obtained from the following equation:

$$t_f = \frac{h^2}{nC_v\,(1 - U_c)} = \frac{20\ h^2}{3\ C_v}$$

where

t_f = time to failure,

$2h$ = initial thickness of the specimen,

n = a constant for drainage from both ends = 3, and

U_c = degree of pore pressure dissipation.

From a knowledge of approximate strain expected at failure, the rate of strain for the test may be calculated. In the case of cohesive soils, the failure may be assumed as taking place at 5 percent deformation.

APPENDIX B

(*Clause* 6.1.1)

PROFORMA FOR RECORDING TEST RESULTS

Project_____ Location of samples_____

Bore hole No.____ Sample No._____

*Rate of strain_____ Proving-ring/load cell No._____

Calibration curve _____

Load-hanger lever ratio _____

Soil Specimen Measurements

Dimensions_____ Area of specimen_____

Thickness _____ Volume of specimen_____

Initial wet weight of specimen_____

Moisture content_____ (Average of_____ tests)

Bulk density_____

Final wet weight of the specimen_____

Moisture content at shear zone_____

Consolidation

Hanger load_____ Applied load_____

Normal stress_____

*Should be decided after analyzing consolidation-time data in the case of drained tests.

Date and Time	Vertical Dial Reading	Vertical Dial Difference	Thickness of Specimen

Shearing Stage

*Rate of shearing_____ mm/min

Date and Time	Displacement Dial Reading	Displacement, δ	Area Correction	Corrected Area	Stress Dial Reading	Shear Force	Shear Stress	Vertical Dial Reading	Vertical Dial Difference	Thickness of Specimen

*Should be decided after analyzing consolidation-time data in the case of drained tests.

Plot shear stress-shear displacement curve and find:

a) Maximum shear stress, and

b) Corresponding shear displacement.

Summary of Results

Test No.	Normal Stress	Shear Stress at Failure	Shear Displacement at Failure	Initial Water Content	Final Water Content	Remarks

Plot shear normal stress displacement curve and find:

a) Cohesion intercept, and

b) Angle or shearing resistance.

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