IS : 2720 (Part 13) - 1986
(Reaffirmed 1997)

Indian Standard

METHODS OF TEST FOR SOILS

PART 13 DIRECT SHEAR TEST

(Second Revision)

First Reprint JANUARY 1996

UDC 624:131.439.5

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

Gr 3

May 1987

Indian Standard

METHODS OF TEST FOR SOILS

PART 13 DIRECT SHEAR TEST

(Second Revision)

Soil Engineering Sectional Committee, BDC 23

Chairman	*Representing*
*SHRI H. C. VERMA	All India Instrument Manufacturers' and Dealers', Association, Bombay
Members	
SHRI H. K. GUHA (*Alternate* to Shri H. C. Verma)	
ADDITIONAL DIRECTOR (GE)	Ministry of Railways
JOINT DIRECTOR (GE) (*Alternate*)	
DR ALAM SINGH	University of Jodhpur, Jodhpur
SHRI B. ANJIAH	Engineering Research Laboratories, Government of Andhra Pradesh
DR R. K. BHANDARI	Central Building Research Institute (CSIR), Roorkee
SHRI S. K. KANSAL (*Alternate*)	
CHIEF ENGINEER (IrPRI)	Irrigation Department, Government of Punjab, Chandigarh
DIRECTOR (DAM) (*Alternate*)	
DR T. N. CHOJER	Public Works Department, Government of Uttar Pradesh
DEPUTY DIRECTOR (R) (*Alternate*)	
SHRI A. VERGHESE CHUMMAR	F. S. Engineers Private Limited, Madras
SHRI C. S. DABKE	Howe (India) Private Limited, New Delhi
SHRI G. V. MURTHY (*Alternate*)	
SHRI A. G. DASTIDAR	In personal capacity (*5 Hungerford Court, 12/1 Hungerford Street, Calcutta*)

(*Continued on page* 2)

*Chairman for the meeting in which this standard was recommended for finalization.

(*Continued from page* 1)

Members	*Representing*
SHRI N. V. DE-SOUSA	Cemindia Company Limited, Bombay
DIRECTOR	Central Soil and Materials Research Station, New Delhi
DEPUTY DIRECTOR (*Alternate*)	
DIRECTOR (IRI)	Irrigation Department, Government of Uttar Pradesh, Roorkee
SHRI A. H. DIVANJI	Asia Foundations and Construction (Private) Limited, Bombay
SHRI A. N. JANGLE (*Alternate*)	
DR GOPAL RANJAN	University of Roorkee, Roorkee; *and* Institute of Engineers (India), Calcutta
SHRI M. IYENGAR	Engineers India Limited, New Delhi
SHRI ASHOK K. JAIN	G. S. Jain and Associates, New Delhi
SHRI VIJAY K. JAIN (*Alternate*)	
SHRI A. V. S. R. MURTY	India Geotechnical Society, New Delhi
SHRI T. K. NATARAJAN	Central Road Research Institute (CSIR), New Delhi
SHRI RANJIT SINGH	Ministry of Defence (R & D)
SHRI V. B. GHORPADE (*Alternate*)	
DR G. V. RAO	Indian Institute of Technology, New Delhi
DR K. K. GUPTA (*Alternate*)	
RESEARCH OFFICER (B & RRL)	Public Works Department, Government of Punjab, Chandigarh
SECRETARY	Central Board of Irrigation and Power, New Delhi
DIRECTOR (C) (*Alternate*)	
SHRI N. SIVAGURU	Roads Wing, Ministry of Shipping and Transport
SHRI U. JAYAKODI (*Alternate*)	
DR N. SOM	Jadavpur University, Calcutta
SHRI K. S. SRINIVASAN	National Buildings Organization, New Delhi
SHRI SUNIL BERRY (*Alternate*)	
SHRI N. SUBRAMANYAM	Karnataka Engineering Research Station, Government of Karnataka, Krishnarajasagar
COL R. R. SUDHINDRA	Ministry of Defence (Engineer-in-Chief's Branch)
SHRI S. S. JOSHI (*Alternate*)	
SUPERINTENDING ENGINEER (P & D)	Public Works Department, Government of Tamil Nadu
EXECUTIVE ENGINEER (SMRD) (*Alternate*)	
SHRI G. RAMAN, Director (Civ Engg)	Director General, BIS (*Ex-officio Member*)

Secretary

SHRI K. M. MATHUR
Joint Director (Civ Engg), BIS

(*Continued on page* 12)

Indian Standard

METHODS OF TEST FOR SOILS

PART 13 DIRECT SHEAR TEST

(Second Revision)

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.

(*Continued from page* 2)

Soil Testing Procedures Subcommittee, BDC 23 : 3

Convener	*Representing*
DR ALAM SINGH	University of Jodhpur, Jodhpur
Members	
ASSISTANT RESEARCH OFFICER (IrPRI)	Irrigation Department, Government of Punjab, Chandigarh
ASSISTANT RESEARCH OFFICER, IRI	Irrigation Department, Government of Uttar Pradesh
SHRI A. K. CHATURVEDI	Ministry of Defence (Engineer-in-Chief's Branch)
SHRI P. VERDARAJAN (*Alternate*)	
DEPUTY DIRECTOR (GE-III)	Ministry of Railways
ARO (GE) (*Alternate*)	
DIRECTOR	Central Soil and Materials Research Station, New Delhi
DEPUTY DIRECTOR (*Alternate*)	
DR GOPAL RANJAN	University of Roorkee, Roorkee
DR S. C. HANDA (*Alternate*)	
SHRI H. K. GUHA	Geologists' Syndicate Private Limited, Calcutta
SHRI N. N. BHATTACHARYA (*Alternate*)	
DR SHASHI K. GULHATI	Indian Institute of Technology, New Delhi
SHRI M. D. NAIR	Associated Instruments Manufacturers (India) Private Limited, New Delhi
PROF T. S. NAGARAJ (*Alternate*)	
SHRI P. JAGANATHA RAO	Central Road Research Institute (CSIR), New Delhi
SHRI U. N. SINHA	Central Building Research Institute (CSIR), Roorkee
DR N. SOM	Jadavpur University, Calcutta
DR S. C. DAS (*Alternate*)	

BUREAU OF INDIAN STANDARDS

Headquarters :

Manak Bhavan, 9 Bahadur Shah Zafar Marg, NEW DELHI 110002

Telephones : 331 01 31, 331 13 75 — Telegrams : Manaksanstha (Common to all Offices)

Regional Offices :

		Telephone
Central	: Manak Bhavan, 9, Bahadur Shah Zafar Marg, NEW DELHI 110002	331 01 31 331 13 75
* Eastern	: 1/14 C.I.T. Scheme VII M, V.I.P. Road, Maniktola, CALCUTTA 700054	37 86 62
Northern	: SCO 445-446, Sector 35-C, CHANDIGARH 160036	2 18 43
Southern	: C.I.T. Campus, IV Cross Road, MADRAS 600113	41 29 16
† Western	: Manakalaya, E9 MIDC, Marol, Andheri (East), BOMBAY 400093	6 32 92 95

Branch Offices :

'Pushpak', Nurmohamed Shaikh Marg, Khanpur, AHMADABAD 380001	2 63 48
‡ Peenya Industrial Area, 1st Stage, Bangalore-Tumkur Road, BANGALORE 560058	39 49 55
Gangotri Complex, 5th Floor, Bhadbhada Road, T.T. Nagar, BHOPAL 462003	55 40 21
Plot No. 82/83, Lewis Road, BHUBANESHWAR 751002	5 36 27
Kalai Kathir Building, 6/48-A Avanasi Road, COIMBATORE 641037	2 67 05
Quality Marking Centre, N.H. IV, N.I.T., FARIDABAD 121001	—
Savitri Complex, 116 G. T. Road, GHAZIABAD 201001	8-71 19 96
53/5 Ward No. 29, R.G. Barua Road, 5th By-lane, GUWAHATI 781003	3 31 77
5-8-56C L. N. Gupta Marg, (Nampally Station Road) HYDERABAD 500001	23 10 83
R14 Yudhister Marg, C Scheme, JAIPUR 302005	6 34 71
117/418 B Sarvodaya Nagar, KANPUR 208005	21 68 76
Plot No. A-9, House No. 561/63, Sindhu Nagar, Kanpur Road, LUCKNOW 226005	5 55 07
Patliputra Industrial Estate, PATNA 800013	6 23 05
District Industries Centre Complex, Bagh-e-Ali Maidan, SRINAGAR 190011	—
T. C. No. 14/1421, University P. O., Palayam, THIRUVANANTHAPURAM 695034	6 21 04

Inspection Offices (With Sale Point) :

Pushpanjali, First Floor, 205-A West High Court Road, Shankar Nagar Square, NAGPUR 440010	52 51 71
Institution of Engineers (India) Building, 1332 Shivaji Nagar, PUNE 411005	5 24 35

---

*Sales Office Calcutta is at 5 Chowringhee Approach, P. O. Princep Street, CALCUTTA	27 68 00
† Sales Office is at Novelty Chambers, Grant Road, BOMBAY	89 65 28
‡ Sales Office is at Unity Building, Narasimharaja Square, BANGALORE	22 39 71

Reprography Unit, BIS, New Delhi, India