IS : 4434 - 1978
(Reaffirmed 1997)

Indian Standard

CODE OF PRACTICE FOR *IN-SITU* VANE SHEAR TEST FOR SOILS

(First Revision)

First Reprint FEBRUARY 1989

UDC 624.131.439.5:006.76

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

Gr 4 *August* 1978

Indian Standard

CODE OF PRACTICE FOR *IN-SITU* VANE SHEAR TEST FOR SOILS

(First Revision)

Soil Engineering Sectional Committee, BDC 23

Chairman	*Representing*
PROF DINESH MOHAN	Central Building Research Institute (CSIR), Roorkee
Members	
ADDITIONAL CHIEF ENGINEER	Public Works Department, Government of Uttar Pradesh
SHRI D. C. CHATURVEDI (*Alternate*)	
ADDITIONAL DIRECTOR RESEARCH, RDSO	Railway Board (Ministry of Railways)
DEPUTY DIRECTOR RESEARCH, RDSO (*Alternate*)	
PROF ALAM SINGH	University of Jodhpur, Jodhpur
LT-COL AVTAR SINGH	Engineer-in-Chief's Branch, Army Headquarters, New Delhi
MAJ V. K. KANITKAR (*Alternate*)	
DR A. BANERJEE	Cementation Co Ltd, Calcutta
SHRI S. GUPTA (*Alternate*)	
CHIEF ENGINEER (D&R)	Irrigation Department, Government of Punjab, Chandigarh
DIRECTOR (IPRI) (*Alternate*)	
SHRI K. N. DADINA	In personal capacity (*P-820, 'P' New Alipore, Calcutta 700058*)
SHRI A. G. DASTIDAR	In personal capacity (*5 Hungerford Street, 12/1 Hungerford Court, Calcutta 700017*)
SHRI R. L. DEWAN	Irrigation Research Institute, Khagaul, Patna
DR G. S. DHILLON	Indian Geotechnical Society, New Delhi
SHRI A. H. DIVANJI	Asia Foundations and Construction (P) Ltd, Bombay
SHRI A. N. JANGLE (*Alternate*)	
DR SHASHI K. GULHATI	Indian Institute of Technology, New Delhi
DR G. V. RAO (*Alternate*)	
SHRI V. G. HEGDE	National Buildings Organization, New Delhi
SHRI S. H. BALCHANDANI (*Alternate*)	
SHRI O. P. MALHOTRA	Public Works Department, Government of Punjab, Chandigarh
SHRI J. S. MARYA	Roads Wing, Ministry of Shipping & Transport
SHRI N. SEN (*Alternate*)	

(*Continued on page 2*)

(*Continued from page* 1)

Members	*Representing*
SHRI R. S. MELKOTE DEPUTY DIRECTOR (CSMRS) (*Alternate*)	Central Water Commission, New Delhi
SHRI T. K. NATARAJAN	Central Road Research Institute (CSIR), New Delhi
REPRESENTATIVE	Hindustan Construction Co Ltd, Bombay
RESEARCH OFFICER	Building & Roads Research Laboratory, Chandigarh
SHRI K. R. SAXENA	Engineering Research Laboratories, Hyderabad
SECRETARY DEPUTY SECRETARY (*Alternate*)	Central Board of Irrigation & Power, New Delhi
*DR SHAMSHER PRAKASH DR GOPAL RANJAN (*Alternate*)	University of Roorkee, Roorkee
SHRI H. D. SHARMA	Irrigation Research Institute, Roorkee
SUPERINTENDING ENGINEER EXECUTIVE ENGINEER (*Alternate*)	Public Works Department, Government of Tamil Nadu, Madras
SHRI B. T. UNWALLA SHRI T. M. MENON (*Alternate*)	Concrete Association of India, Bombay
SHRI H. C. VERMA SHRI V. K. VASUDEVAN (*Alternate*)	All India Instruments Manufacturers & Dealers Association, Bombay
SHRI D. AJITHA SIMHA, Director (Civ Engg)	Director General, ISI (*Ex-officio Member*)

Secretary

SHRI G. RAMAN
Deputy Director (Civ Engg), ISI

Site Exploration and Investigation for Foundations Subcommittee, BDC 23 : 2

Convener

SHRI R. S. MELKOTE	Central Water Commission, New Delhi

Members

DEPUTY DIRECTOR (CSMRS) (*Alternate* to Shri R. S. Melkote)	
PROF ALAM SINGH	University of Jodhpur, Jodhpur
DR A. BANERJEE	Cementation Co Ltd, Bombay
DEPUTY DIRECTOR RESEARCH (FE), RDSO ASSISTANT DIRECTOR RESEARCH (SOIL MECH), RDSO (*Alternate*)	Railway Board (Ministry of Railways)
SHRI R. C. DESAI	Asia Foundations and Construction (P) Ltd, Bombay
DIRECTOR RESEARCH OFFICER (*Alternate*)	Maharashtra Engineering Research Institute, Nasik
DIRECTOR GENERAL SHRI S. K. SHOME (*Alternate*) SHRI P. N. MEHTA (*Alternate*)	Geological Survey of India, Calcutta
EXECUTIVE ENGINEER (SM)	Public Works Department, Tamil Nadu

(*Continued on page* 16)

*Also represents Institution of Engineers (I).

Indian Standard

CODE OF PRACTICE FOR *IN-SITU* VANE SHEAR TEST FOR SOILS

(First Revision)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 28 February 1978, after the draft finalized by the Soil Engineering Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 The vane shear test is most appropriate for the determination of the shear strength of saturated clays, especially of the 'soft' to 'medium' consistency. The test is especially appropriate for determining the shear strength of sensitive soils which are highly susceptible to sampling disturbances.

0.3 The vane shear test consists of pushing a four-bladed vane in the soil and rotating it till a cylindrical surface in the soil fails by shear. The torque required to cause this failure is measured and this torque is converted to a unit shearing resistance of the cylindrical surface.

0.4 This standard was first published in 1967. In this revision several changes have been made taking into consideration the experience gained in conducting the test. The essential requirements of the torque applicator have been added. Maximum permissible area ratio of the vane has been related to the vane diameter. Torque applicators of two capacities have been specified; guidance has been given for the selection of the lesser capacity torque applicator in relation to the anticipated shear strength of the soil to be tested and the overall vane diameter. Opportunity has also been taken to give the requirements and examples in SI units.

0.5 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. This has been met by basing the standard on the following publications:

BS 1377 :1975 Methods of test for soils for civil engineering purposes. British Standards Institution.

ASTM D 2573-67T Field vane shear test in cohesive soils. American Society for Testing and Materials.

E-20 Inplace vane shear test. Earth Manual, United States Bureau of Reclamation.

0.6 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed for calculated, expressing the results 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.

1. SCOPE

1.1 This standard covers the procedure of conducting *in-situ* vane shear test in saturated cohesive deposits for determining their inplace shearing resistance. Two methods of the test, namely, testing from bottom of a bore-hole and by direct penetration from ground surface, are covered.

2. APPARATUS

2.1 For Test from Bottom of Bore-Hole

2.1.1 *Vane* — shall consist of four mutually perpendicular blades as illustrated in Fig. 1. The height of the vane shall be twice the overall diameter. It is recommended that the overall diameter of the vane should be 37·5, 50, 65, 75 or 100 mm. The design of the vane shall be such that it causes as little remoulding and disturbance as possible to the soil when inserted into the ground for a test. The blades shall be as thin as possible, consistent with the strength requirements. The vane should not deform under the maximum torque for which it is designed. The penetrating edge of the vane blades shall be sharpened having an included angle of 90°. The vane blades shall be welded together suitably either directly or to a central rod, the maximum diameter of which should preferably not exceed 12·5 mm. The area ratio of the vane shall be kept as low as possible and shall not exceed 18 percent for the 37·5 mm vane and 12 percent for the 50, 65, 75 and 100 mm diameter vanes. The area ratio may be calculated using the following formula:

$$A_r = \frac{8t\,(D-d) + \pi d^2}{\pi D^2} \times 100\,(\%)$$

where

A_r = area ratio in percent,

t = thickness of vane blades in mm,

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

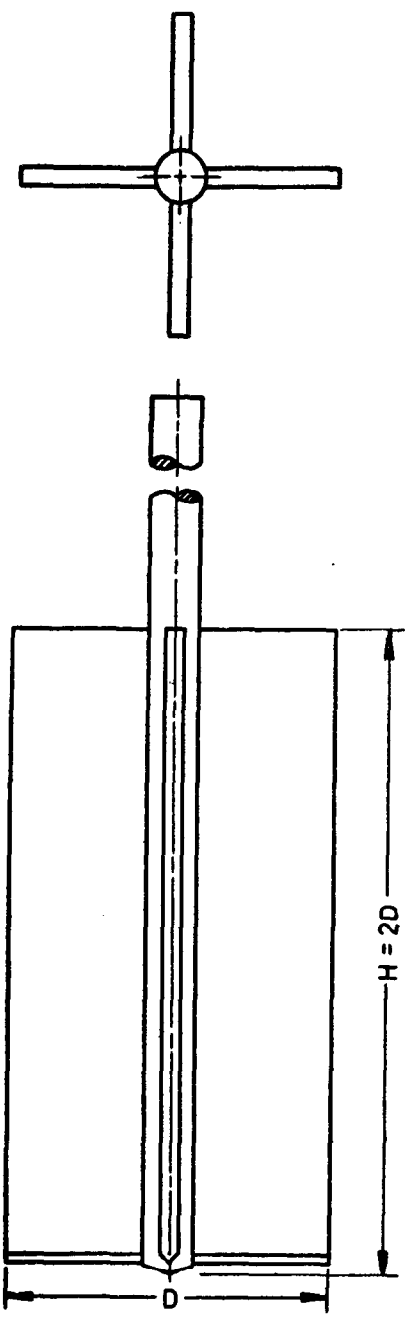

FIG. 1 GEOMETRY OF FIELD VANE

D = overall diameter of vane in mm, and

d = diameter of central vane rod including any enlargement due to welding in mm.

NOTE — The vane selected should be the largest size suitable for the general soil conditions at a site.

2.1.1.1 The vane rod (the rod to which the vane blades are fixed) may be enclosed in a suitably designed sleeve from just above the blades and throughout the length it penetrates the soil to exclude the soil particles and the effects of soil adhesion. This sleeve shall commence above the blades at a distance equivalent to about two diameters of the vane rod.

NOTE — The vanes shall be frequently checked for straightness.

2.1.2 *Torque Applicator* — The torque applicator shall have a clamping device to rigidly secure it to the anchor casing and shall have an attachment to securely hold the string of rods connecting the vane.

2.1.2.1 The instrument shall be capable of applying a torque to the vane through the string of rods and to measure the same. It should also have a device to read the angular rotation of the upper end of the extension rod. The torque applicator shall be provided with speed control so that the rate of rotation may be maintained at 0·1°/s. Friction exerted by the torque applicator should be of neglible magnitude and shall be checked periodically. Depending upon the estimated shear strength of the soil, the following table (Table 1) may be used as a guide for the selection of torque applicator of capacity 60 N.m (600 kgf.cm).

TABLE 1 SELECTION OF TORQUE APPLICATOR

Estimated shear strength in kN/m² (kgf/cm²)	10 (0·1)	20 (0·2)	30 (0·3)	40 (0·4)	50 (0·5)	60 (0·6)	70 (0·7)
Vane size (dia) suitable for use with 600 kgf.cm torque applicator	All sizes	All sizes except 100 mm	All sizes except 100 mm	All sizes except 100 mm and 75 mm	All sizes except 100 mm and 75 mm	37·5 and 50 mm sizes	37·5 and 50 mm sizes

2.1.2.2 The capacity and accuracy of the instrument shall be one of the following as may be specified by the purchaser:

a) Measure torque up to 60 N.m (600 kgf.cm) to an accuracy of 1 N.m (10 kgf.cm), or

b) Measure torque up to 200 N.m (2 000 kgf.cm) to an accuracy of 2·5 N.m (25 kgf.cm).

2.1.3 *Rod System* — The string of torque rods connecting the vane to the torque applicator called the rod system may be of the quick coupling type or of the threaded type. The length of the rods shall preferably be 1 m with a few of smaller lengths. These rods shall have sufficient diameter such that their elastic limit is not exceeded when the vane is stressed to its capacity (*see* Note). The threaded rods shall be so coupled that the shoulders of the male and female ends shall meet to prevent any possibility of the coupling tightening when the torque is applied during the test. If a vane housing is used, the torque rods shall be equipped with well-lubricated bearings where they pass through the housing. These bearings shall be provided with seals to prevent soil from entering them. The torque rods shall be guided so as to prevent friction from developing between the torque rods and the walls of casing or boring.

NOTE — If torque *versus* rotation curve is to be determined, it is essential that the torque rods be calibrated (prior to the use in the field). The amount of rod twist (if any) shall be established in degree per metre per unit torque. This correction becomes progressively more important as the depth of test increases the calibration shall be made at least to the maximum depth of testing anticipated.

2.1.4 *Dummy Rod* — of dimensions equal to that of the vane rod of the vanes used.

2.1.5 *Guides for Rod* — of suitable type provided with ball bearing arrangement so as to enable the rod to rotate freely (*see* Note).

NOTE — During the test, it is essential that the rods and vane are placed centrally in the bore-hole. For this purpose guides shall be used at an interval in depth of not more than 5 m.

2.1.6 *Drilling Equipment* — The equipment used shall provide a clean hole of the required diameter for insertion of the vane to ensure that the vane test is performed on undisturbed soil.

2.1.7 *Jacking Arrangement* — for pushing the shoe and vane (where required).

NOTE — The apparatus shall be checked and calibrated as and when required.

2.2 For Tests by Direct Penetration from Ground Surface

2.2.1 *Vane* — as specified in **2.1.1**. In addition the vane shall be suitably protected by a shoe (*see* Fig. 2).

2.2.2 *Rod System* — as specified in **2.1.3** and of suitable type.

2.2.3 *Extension Pipes* — about one metre in length with coupling on the outer face to case the hole.

2.2.4 *Torque Applicator* — as specified in **2.1.2.**

NOTE — The apparatus shall be checked and calibrated as and when required.

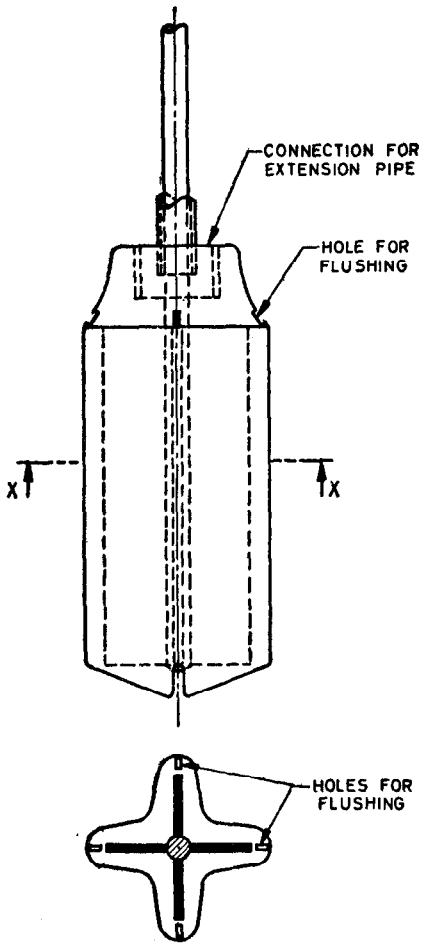

FIG. 2 TYPICAL VANE PROTECTING SHOE

3. PROCEDURE OF TESTING

3.1 Tests from Bottom of Bore-Hole

3.1.1 Sink the bore-hole up to the depth required and extend the casing up to the full depth. If the casing is loose, secure it so that it does not move during the tests. Fix the torque applicator anchor plate to the casing.

3.1.2 Connect the vane of suitable size (*see* **2.1.1**, Note) to the rods and lower it to the bottom of the bore-hole, putting guides at suitable intervals but not more than about 5 m as the rods are extended. Push the vane with a moderate steady force up to a depth of five times the diameter of the bore-hole below the bottom of the bore-hole or shoe. Take precautions to make sure that no torque is applied to the torque rods during the thrust. No hammering shall be permitted. Fix the torque applicator with frame to the anchor plate and connect the rods to it. Tighten the torque applicator to the frame properly. A diagrammatic vane test arrangement for test from bottom of bore-hole is shown in Fig. 3.

3.1.3 Allow a minimum period of five minutes after insertion of the vane. Turn the gear handle so that the vane is rotated at the rate of 0·1°/s. Note the maximum torque reading attained. If necessary, note the torque indicator dial gauge readings at half-minute intervals and continue rotating the vane until the reading drops appreciably from the maximum.

3.1.4 Just after the determination of the maximum torque, rotate the vane rapidly through a minimum of ten revolutions. The remoulded strength should then be determined (*see* **3.1.3**) within one minute after completion of the revolutions.

3.1.5 Remove the vane testing assembly, continue boring, and collect soil sample from the level of the vane testing for laboratory analysis to ascertain whether the deposit will behave as a purely cohesive soil.

3.1.6 In case where a sleeve is not provided for the vane rod and the soil is in contact with the rod, determine the friction between the soil and the vane rod by conducting tests at appropriate depths using the dummy rod corresponding to that of the vane used in the test. The test should be conducted as with the vane except that the vane is replaced by dummy rod. The test should be conducted in an adjacent bore-hole at the same depth at which the vane tests were conducted. The dummy rod should be pushed into the ground to the same distance as the vane rod at that depth.

3.2 Test by Direct Penetration from Ground Surface

3.2.1 Lock the vane in-place inside the protecting shoe and jack or drive it to the required depth. Care shall be taken to see that the rods remain tight while the vane is lowered. Place guides about every 3 m to centralize and reduce friction between the rods and extension pipes.

3.2.2 When the vane and protecting shoe have penetrated to the required depth, push the vane steadily, without twisting, a distance of 5 times the diameter of the shoe, into the undisturbed soil below the protecting shoe. Rotate the vane till the soil fails as in **3.1**. A diagrammatic vane test arrangement for testing by direct penetration from ground surface is given in Fig. 4.

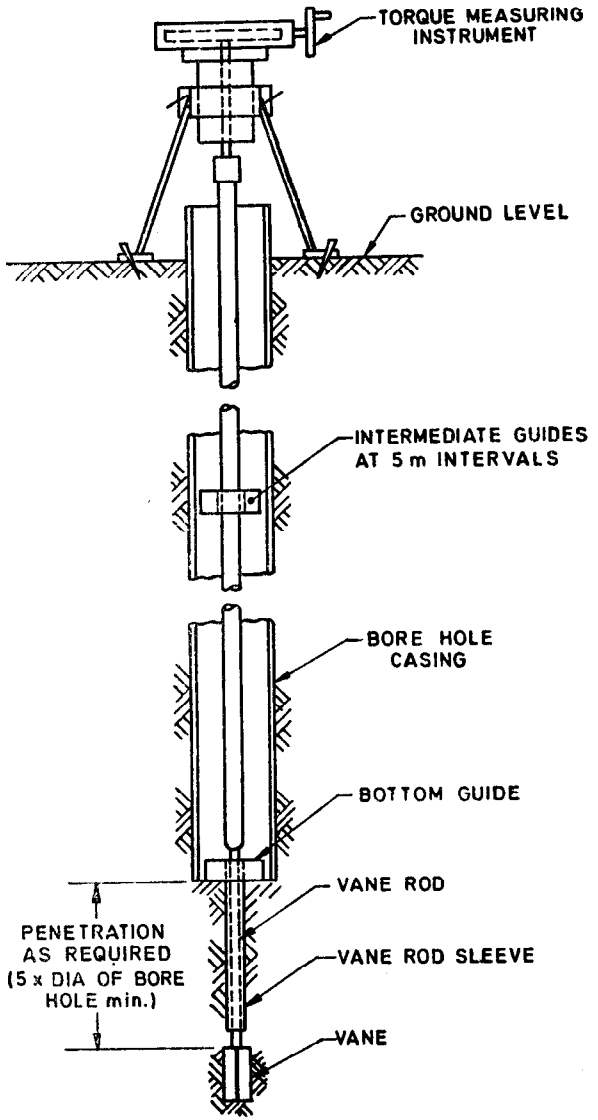

FIG. 3 DIAGRAMMATIC VANE TEST ARRANGEMENT (FOR TEST FROM BOTTOM OF BORE-HOLE)

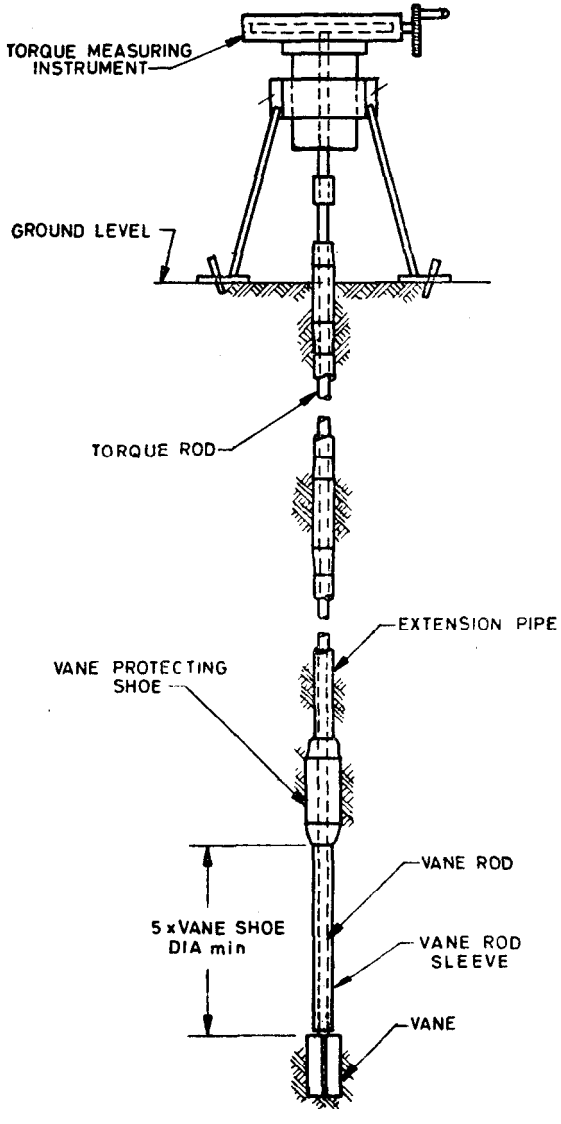

FIG. 4 DIAGRAMMATIC VANE TEST ARRANGEMENT
(TEST BY DIRECT PENETRATION FROM GROUND SURFACE)

3.2.3 Remove the torque measuring instrument and pull back the vane fully into its protecting shoe before advancing for another test or before being removed from the ground taking precautions that the vane is not damaged by the shoe.

3.2.4 In the case where soil is in contact with the torque rods, determine the friction between the soil and the rod by means of torque tests conducted on similar rods at similar depths with no vane attached. Conduct the rod friction test at least once on each site; this shall consist of a series of torque tests at varying depths. A dummy should be used instead of the vane if the vane rod is not provided with a sleeve.

4. RECORDS

4.1 Records of vane shear test shall be maintained in a suitable form including details given in Appendix A, which gives a recommended proforma for the record of results.

5. COMPUTATIONS

5.1 For vane testing instruments that do not read the torque directly a calibration curve to convert the readings to Newton Metre (centimetre-kilogram) of torque shall be provided. These calibration curves shall be checked periodically.

5.2 For a rectangular vane, calculate the shear strength of the soil using the following formula (*see* Note 1):

$$S = \frac{M}{\pi\left(\frac{D^2H}{2} + \frac{D^3}{6}\right)} \times 10^6 \qquad \left[S = \frac{M}{\pi\left(\frac{D^2H}{2} + \frac{D^3}{6}\right)} \times 10^3 \right]$$

where

S = shear strength in kN/m² (kgf./cm²);

M = torque, to shear the soil in N.m (kgf. cm) (corrected for vane rod and torque rod resistance, if any);

D = overall diameter of vane in mm (*see* Note 2); and

H = height of vane in mm (*see* Note 2).

NOTE 1 — This formula is based on the assumptions that (a) Shearing strength in the horizontal and vertical directions are the same. (b) At the peak value, shear strength is equally mobilized at the end surface as well as at the centre and that both the top and the bottom ends of the vane take part in shearing the soil. (c) It is assumed that the shear surface is cylindrical and has a diameter equal to the diameter of the vane.

NOTE 2 — It is important that the dimensions of the vane are checked periodically to ensure that the vane is not distorted or worn. Actual values should be used in the calculation.

5.2.1 If $H = 2D$, then the formula given in **5.2** reduces to

$$S = \frac{3M}{11D^3} \times 10^6 \quad (S \text{ in kN/m}^2)$$

$$S = \frac{3M}{11D^3} \times 10^3 \quad (S \text{ in kgf/m}^2) \text{ (}\textit{See}\text{ Notes 1 and 2 of 5.2).}$$

APPENDIX A

(*Clause* 4.1)

PROFORMA FOR FIELD VANE SHEAR TEST

GENERAL

Project:

Bore-hole No.: (if any)

Date of test:

Drilling or testing foreman:

Supervising engineer:

DETAILS OF BORING (IF ANY)

Location:

Reference elevation:

or

Ground elevation:

Method of making the hole:

Cased/uncased:

Level of water in the bore-hole/ level of ground water at the time of test:

Notes on driving resistance:

Log of soil conditions:

DETAILS OF VANE TEST

Test from bottom of bore-hole:

Test by direct penetration from ground surface:

Vane test apparatus No.:

Vane Size:

Vane constant:

Diameter of dummy rod (if used):

Conversion factor for torque measuring equipment:

	Depth																				
	D	U	R	D	U	R	D	U	R	D	U	R	D	U	R	D	U	R	D	U	R
Depth of vane tip below bottom of bore hole or vane shoe																					
Time to failure																					
Maximum reading on torque measuring equipment																					
Maximum torque																					
Number of revolutions for remoulding																					
Shear strength of undisturbed soil, kN/m² (kgf/cm²)																					
Shear strength of remoulded soil, kN/m² (kgf/cm²)																					
Sensitivity																					

D = test with dummy if used or any other test for the determination of friction of vane rod and/or torque rods.

U = test with vane in undisturbed soil.

R = test with vane in remoulded soil.

Record of deviation from standard procedure, if any, with reasons.

Time — Rotation Readings

Time in Minutes	Depth																				
	D	U	R	D	U	R	D	U	R	D	U	R	D	U	R	D	U	R	D	U	R
0																					
½																					
1½																					
2																					
2½																					
3																					
3½																					
4																					
4½																					
5																					
5½																					
6																					
6½																					
7																					
7½																					
8																					
8½																					
9																					
9½																					
10																					

D = test with dummy if used or any other test for the determination of friction of vane rod and/or torque rods.

U = test with vane in undisturbed soil.

R = test with vane in remoulded soil.

Record of deviations from standard procedure, if any, with reasons.

(*Continued from page* 2)

Members	*Representing*
SHRI T. K. NATARAJAN	Central Road Research Institute, New Delhi
SHRI H. C. VERMA	Associated Instruments Mfrs (I) Pvt Ltd, New Delhi
PROF T. S. NAGARAJ (*Alternate*)	
SHRI H. R. PRAMANIK	River Research Institute, Government of West Bengal
SHRI H. L. SAHA (*Alternate*)	
MAJ K. M. S. SAHASI	Engineer-in-Chief's Branch, Army Headquarters
SHRI O. P. BHATIA (*Alternate*)	
SHRI N. SEN	Roads Wing (Ministry of Shipping and Transport)
SHRI P. K. THOMAS (*Alternate*)	
SHRI M. M. D. SETH	Public Works Department, Government of Uttar Pradesh, Lucknow
SHRI D. SHARMA	Central Building Research Institute, Roorkee
SHRI V. S. AGGARWAL (*Alternate*)	
SUPERINTENDING SURVEYOR OF WORKS (I)	Central Public Works Department
REPRESENTATIVE	Hindustan Construction Co Ltd, Bombay

BUREAU OF INDIAN STANDARDS

Headquarters :

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

Telephones : 3 31 01 31, 3 31 13 75 Telegrams : Manaksanstha
(Common to all Offices)

Regional Offices :	*Telephone*
*Western : Manakalaya, E9 MIDC, Marol, Andheri (East) BOMBAY 400093	6 32 92 95
†Eastern : 1/14 C. I. T. Scheme VII M, V. I. P. Road, Maniktola, CALCUTTA 700054	36 24 99
Northern : SCO 445-446, Sector 35-C CHANDIGARH 160036	2 18 43 3 16 41
Southern : C. I. T. Campus, MADRAS 600113	41 24 42 41 25 19 41 29 16
Branch Offices :	
Pushpak,' Nurmohamed Shaikh Marg, Khanpur, AHMADABAD 380001	2 63 48 2 63 49
'F' Block, Unity Bldg, Narasimharaja Square, BANGALORE 560002	22 48 05
Gangotri Complex, 5th Floor, Bhadbhada Road, T. T. Nagar, BHOPAL 462003	6 27 16
Plot No. 82/83, Lewis Road, BHUBANESHWAR 751002	5 36 27
53/5 Ward No. 29, R. G. Barua Road, 5th Byelane, GUWAHATI 781003	—
5-8-56C L. N. Gupta Marg, (Nampally Station Road), HYDERABAD 500001	22 10 83
R14 Yudhister Marg, C Scheme, JAIPUR 302005	6 34 71 6 98 32
117/418B Sarvodaya Nagar, KANPUR 208005	21 68 76 21 82 92
Patliputra Industrial Estate, PATNA 800013	6 23 05
Hantex Bldg (2nd Floor), Rly Station Road, TRIVANDRUM 695001	52 27
Inspection Office (With Sale Point):	
Institution of Engineers (India) Building, 1332 Shivaji Nagar, PUNE 410005	5 24 35

*Sales Office in Bombay is at Novelty Chambers, Grant Road, Bombay 400007 89 65 28

†Sales Office in Calcutta is at 5 Chowringhee Approach, P. O. Princep Street, Calcutta 700072 27 68 00

Reprography Unit, BIS, New Delhi, India