भारतीय मानक

मिट्टी तथा पाषाण भरित बाँधों में पोर दाब मापन के लिए उपकरणों के संस्थापन, रखरखाव और प्रेक्षण की रीति संहिता

भाग 1 छिद्रिल ट्यूब दाबमापी

(दूसरा पुनरीक्षण)

Indian Standard

CODE OF PRACTICE FOR INSTALLATION, MAINTENANCE AND OBSERVATION OF INSTRUMENTS FOR PORE PRESSURE MEASUREMENTS IN EARTH DAMS AND ROCKFILL DAMS

PART 1 POROUS TUBE PIEZOMETERS

(Second Revision)

ICS 93.160

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

March 2002 **Price Group 5**

Hydraulic Structures Instrumentation Sectional Committee, WRD 16

FOREWORD

This Indian Standard (Part 1) (Second Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Hydraulic Structures Instrumentation Sectional Committee had been approved by the Water Resources Division Council.

When load is applied to a soil mass, part of it is carried by the soil particle skeleton and remaining part by the air and water entrapped between the soil particle skeleton. The load is distributed in direct proportion to the relative stiffness of the individual phases. The pores between the soil particles are very small and may be partly filled with water. Therefore, the pressure in the air and water, which fills the pore space will be different. The effective stress, related to these known stresses, is crucial in soil engineering for analyzing its deformation behaviour. The porous tube piezometer is a device for measuring pore water pressures primarily in a foundation though it can also be used to measure pore pressure in an embankment. It is more sensitive to foundation pressures or ground water fluctuations and is more resistant to plugging due to silting than the conventional observation well which it replaces. The porous tube piezometer can be installed at any location, being an independent installation. Since it can be installed after completion of construction, there is no hindrance to the construction of dam.

Proper installation of piezometers in earth fills and their foundations provide significant quantitative data indicating the magnitude and distribution of pore pressure and their variations with time. It also helps to know the pattern of seepage, zones of potential piping and effectiveness of seepage control measures. The data obtained from such piezometers serves the following purposes :

a) It indicates potentially dangerous conditions that may adversely affect the stability of a dam.

b) It helps to monitor the post-construction behaviour of dams and their foundations.

c) It provides basic data for improvement of design practices and criteria that will promote safer and more economical design and construction of earth and rock fill dams.

d) It enables evaluation of the effectiveness of grout curtain.

This standard was first published in 1974 and subsequently revised in 1992. In this revision, description of equipments, installation procedure, correction for time lag and data sheet for porous tube piezometer readings (Annex A) have been modified in the light of experience gained over the years.

There is no ISO standard on the subject. This standard has been prepared based on indigenous manufacturers data/practices prevalent in the field in India.

The composition of the Committee responsible for the formulation of this standard is given at Annex C.

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, should 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

CODE OF PRACTICE FOR INSTALLATION, MAINTENANCE AND OBSERVATION OF INSTRUMENTS FOR PORE PRESSURE MEASUREMENTS IN EARTH DAMS AND ROCKFILL DAMS

PART 1 POROUS TUBE PIEZOMETERS

(Second Revision)

1 SCOPE

1.1 This standard (Part 1) covers description of porous tube piezometer with connected accessories, the installation procedure and maintenance, method of taking observations, record and presentation of data for earth and rock fill dams.

1.1.1 The provisions of this code suitably modified may also be applicable to porous tube piezometer installations in earthen embankments.

2 DESCRIPTION AND WORKING OF THE APPARATUS

2.1 The intake point of the piezometer consists of a porous carborundum/alundum tube of annular cross-section. The bottom end of the porous tube is plugged with a suitable rubber stopper. The porous tube is set in a hole which is either drilled or jetted into the foundation/embankment to a predetermined elevation. The porous tube is surrounded by sand and has a riser pipe extended to the surface.

2.2 The pressure of the pore water surrounding the porous tube causes a flow of water through the pores of the porous tube which rises in the riser pipe. The elevation of water in the riser pipe is determined by a suitable device lowered from the top of the pipe.

2.3 A typical assembly of the porous tube piezometer is shown in Fig. 1.

3 EQUIPMENT

3.1 Porous Tube

This is a porous carborundum or alundum tube of annular cross-section, 37 mm outer dia × 6 mm wall thickness and about 60 cm long. It may be of shorter lengths also depending on the height of the structure. The length of the porous tube and the sand backfill (*see* Fig. 1) may be varied with the sub-surface conditions encountered at site. The porosity of the porous tube should be chosen considering the nature of the soil.

3.2 Stopper

This is a rubber plug used to seal the bottom end of the porous tube.

3.3 Top Adaptor

This is a rubber bush having a central hole with diameter equal to outer dia of the stand pipe for passing into the porous tube and is used for plugging the top end of the porous tube.

3.4 Standpipe

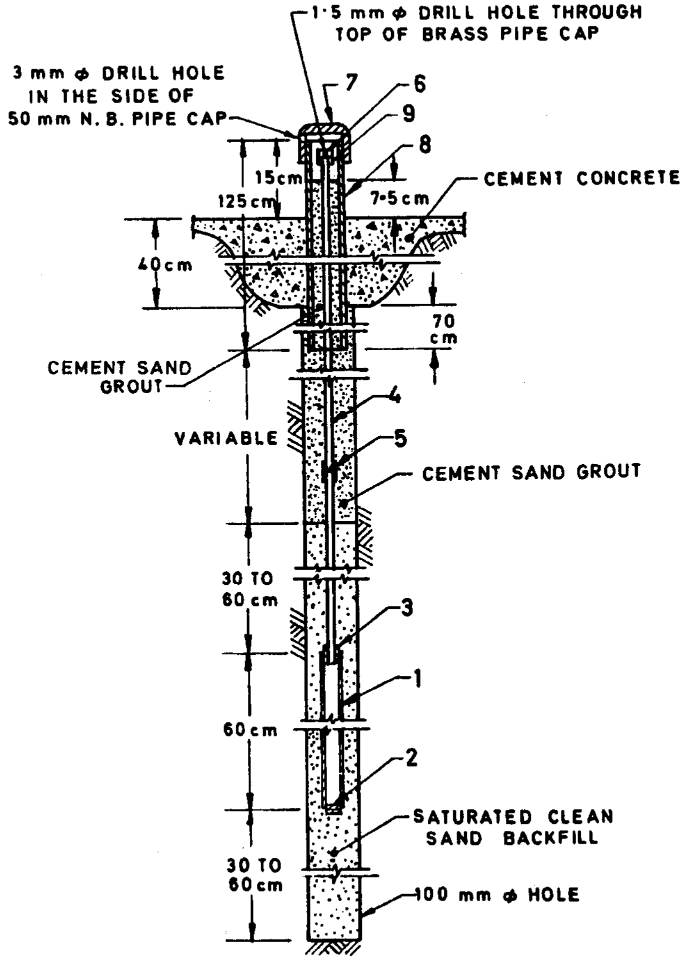
This is a durable rigid PVC pipe of an outside diameter of 12 mm and wall thickness of 1.5 mm. Maximum available lengths shall be used to minimize joints. In case of water level sounder of 8 mm dia or more the diameter of the tubing may be increased, provided the consequent increase in response time is acceptable for the intended use.

3.5 Joints for PVC Pipe

These are required for jointing the available lengths of PVC pipes. The joints should be of suitable type to ensure no leakage and should be smooth and flush inside to prevent lodging of air bubbles and smooth passing of the sounder. The joiner or coupler for PVC pipes may be made of rigid PVC having internal diameter same as of the PVC pipes. Suitable adhesive/resin may be used for joining lengths of PVC tubing.

4 WATER LEVEL SOUNDER

4.1 It comprises of two insulated wires passing through a probe of 6 mm diameter of suitable material. The lower ends of wires shall be bare for contact with water. The water level sounder is required to be lowered from the surface into the PVC tube with the help of the connecting graduated cable for taking observations. Suitable markings should be given on the cable preferably at 0.5 m intervals with an arrangement to



LIST OF PARTS

Sl No.	*Name of Item*	*Material*
1.	37 mm dia × 6 mm thick wall and 60 cm long porous tube	Carborundum or Alundum
2.	Stopper	Rubber
3.	Top adaptor	Rubber
4.	Pipe 12 mm in OD × 1.5 mm wall	PVC
5.	Pipe joint	PVC
6.	12 mm brass hexagonal pipe cap	Brass
7.	50 mm nominal bore pipe cap	G/I
8.	50 mm nominal bore steel pipe	G/I
9.	Male connector	Brass

NOTES

1 Suitable protective fencing around each installation shall be built at top.

2 Water level sounder used for observations shall be capable of being lowered into 9 mm ID plastic tubing.

3 The 50 mm casing pipe may also be used for extending the 12 mm plastic pipe through fill where necessary.

FIG. 1 TYPICAL ASSEMBLY OF POROUS TUBE PIEZOMETER measure levels to an accuracy of 2 mm. The length of the wires should be commensurate with depth up to which the observations are required to be made. The sounder unit should be battery operated, complete with reel/spool, cable extension rod of 0.5 m length, leather carrying case, tripod stand and dummy probe with nylon cord of 50 m length. The unit should also be equipped with battery operated indicator and buzzer.

5 INSTALLATION PROCEDURE

5.1 The various phases and steps involved in the installation of porous tube piezometer are briefly described in subsequent clauses (*see also* Fig. 2).

5.1.1 *Phase 1 — Advancing and Cleaning of Hole*

A minimum of 100 mm diameter cased hole is advanced to about 30 to 60 cm below the planned elevation of the porous tube by jetting or accepted drilling procedure. For a drilled hole, clean water is circulated till the discharge from the hole becomes clear. For a jetted hole, the jet pipe is pulled a few centimetres from the bottom of hole to be used as intake. The casing is filled by reversing flow of clear water until the cloudiness disappears from the effluent. The pump is then stopped (*see* phase 1, Fig. 2).

5.1.2 *Phase 2 — Backfilling Below Porous Tube*

After the hole is cleaned, the casing is raised by 30 to 60 cm depending on the relative permeability of natural soil surrounding the hole (greater length for lower permeability and *vice versa*). The space created should be backfilled with clean saturated sand (excluding silt) satisfying the filter criteria with respect to the surrounding soil. However, if there is tendency for sloughing/caving in, the process of raising and backfilling with sand should be in increments of 15 cm or less. The backfilled sand should then be tamped with a bar or pipe before installation proceeds (*see* phase 2, Fig. 2).

5.1.3 *Phase 3 — Saturation of Porous Tube and Elimination of Air*

The porous tube is either soaked in warm water for several hours or boiled in water for 15 min before it is ready for installation. The length of porous tube along with the projecting top adaptor/plug is measured. The assembled apparatus including the stand pipe, after testing against leakage, is then immersed in the hole filled with clear water so that its top is about 1 m below the water surface. The stand pipe is then connected to a small tank and using reversible pump, water is drawn through porous tube into the tank. The process is continued till air is completely eliminated from the system, taking care that some depth of water remains over the top of porous tube (*see* phase 3, Fig. 2).

5.1.4 *Phase 4 — Positioning of Porous Tube Assembly*

The assembled porous tube apparatus is then lowered into the hole, maintaining a small positive pressure in the tank to cause an outward flow of water from the tip. This will prevent movement of fines into the porous tube. The original elevation at the middle point of porous tube is then measured to the nearest 1 cm. This will be the elevation at which pre-pressure reading is planned (*see* phase 4, Fig. 2).

5.1.5 *Phase 5 — Backfilling of Sand Around Porous Tube*

With the assembled porous tube assembly resting on sand at the bottom of hole, the casing is withdrawn approximately 30 to 60 cm above its top in small increments, depending on the condition of the wall of hole. The saturated sand is poured in to the hole on each withdrawal upto a minimum of 30 cm above the top of porous tube (*see* phase 5, Fig. 2).

5.1.6 *Phase 6 — Completion of Installation*

The casing is then pulled in small increments, approximately 1 m or as the hole permits. The hole is backfilled with workable cement sand grout 1 : 4 which is then puddled with tamping bar maintaining the stand pipe at the center of hole during each increment. This process is continued till about 125 cm length of casing remains within the hole.

The casing is then cut-off about 15 cm above the ground surface. The annular surface between the stand pipe and casing pipe is filled with grout to within 7.5 cm of top of casing pipe. The stand pipe is cut flush with top of casing pipe and is covered with the removable metallic pipe cap. The concrete is then placed near the top, all around the casing pipe. The system is protected against damage by means of tripod or fence made of pipe sections or reinforcement steel and fixed into the ground (*see* phase 6, Fig.2).

5.1.7 *General Instructions*

a) Casing to be filled with water in phases 1 to 5.

b) Diameter of the holes and the length of sand backfill below the piezometer may be varied with sub-surface conditions encountered.

c) Water level sounder used for observations shall be capable of being lowered into the plastic tubing without any problem.

d) The 50 mm casing pipe may also be used for extending the 12 mm standpipe through fill where necessary.

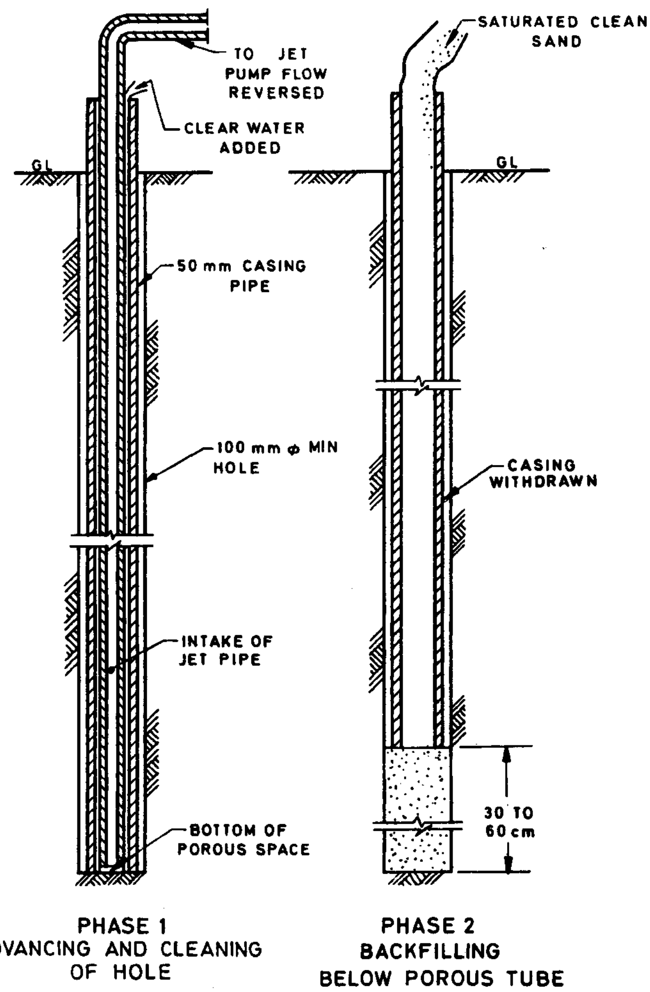


FIG. 2 INSTALLATION PROCEDURE FOR POROUS TUBE PIEZOMETER — *Continued*

6 OBSERVATIONS

6.1 The casing pipe and then the plastic standpipe are uncapped and the water level sounder is lowered into the standpipe. The depth, where the sounding device gives indication of contact with ground water should be read off from the marked cable. This is the level up to which water is standing in the standpipe.

Distance between half metre marks on the cable could be scaled off by a metre scale graduated to every 2 mm. Knowing the distance from top of the installation to the water surface in the standpipe, the elevation of water surface can be determined. The difference of the elevation of the water surface and the elevation of the mid-point of the porous tube gives the pore pressure of water in metres.

7 FREQUENCY OF OBSERVATIONS AND RECORDING OF DATA

7.1 Frequency of Observations

Pore pressure readings should be taken at every 15 days interval during construction and at monthly intervals during shut down. After construction, during the filling and depletion of the reservoir, the piezometer should be read for every 3 m rise or fall of the lake level. For the first five years after completion, fortnightly observations should be taken if the rate of change of water level is slower than 3 m per fortnight. After five years observations may be taken monthly. During rainy seasons more frequent readings may be recorded, if necessary.

7.2 Recording of Observed Data

The readings taken should be recorded in a suitable form. A proforma recommended for this purpose is given in Annex A. A separate register should be maintained for each porous tube piezometer. A recommended proforma for the register is given in Annex B.

7.2.1 *Corrections for Time Lag*

The porous tube piezometer gives normally correct reading when water levels on the upstream and downstream face of the dam are almost steady. However, when there are large fluctuations in upstream and downstream water levels, say during raising or falling of the reservoir water level during flood or when reservoir is pounded up for supply of water to the canal for irrigation or for generation of power. During this time, the piezometer readings are likely to be affected due to the response time or the time lag. This problem also arises when the installation gets choked. Therefore, it is important to know the time lag.

The time lag can be assessed by considering the permeability of the filling material and of the porous tube.

Assessment of the time lag is normally done, a month after installation of porous tube in order to establish original conditions and once every six months to ascertain the extent of choking of installation. If the time lag becomes extremely high, the piezometer should be taken as completely choked. It should then be reactivated if possible as mentioned in **10.1** or a new piezometer installed by its side.

8 PRESENTATION OF DATA

The data from piezometric observations should be duly processed and the graphs prepared for pore pressure, reservoir level and height of overburden *versus* time.

9 PRECAUTIONS FOR ERECTION

9.1 During erection, the end of standpipe should be kept closed by caps to avoid foreign matter finding its way into the pipes, making observations of water level unreliable, if not impossible.

9.2 Stand pipes should be kept vertical to facilitate lowering of the sounding device for observations.

9.3 Each installation in structure should be given a distinct number and these numbers should be stamped on the caps at the end of the standpipes and on the platform where these are located.

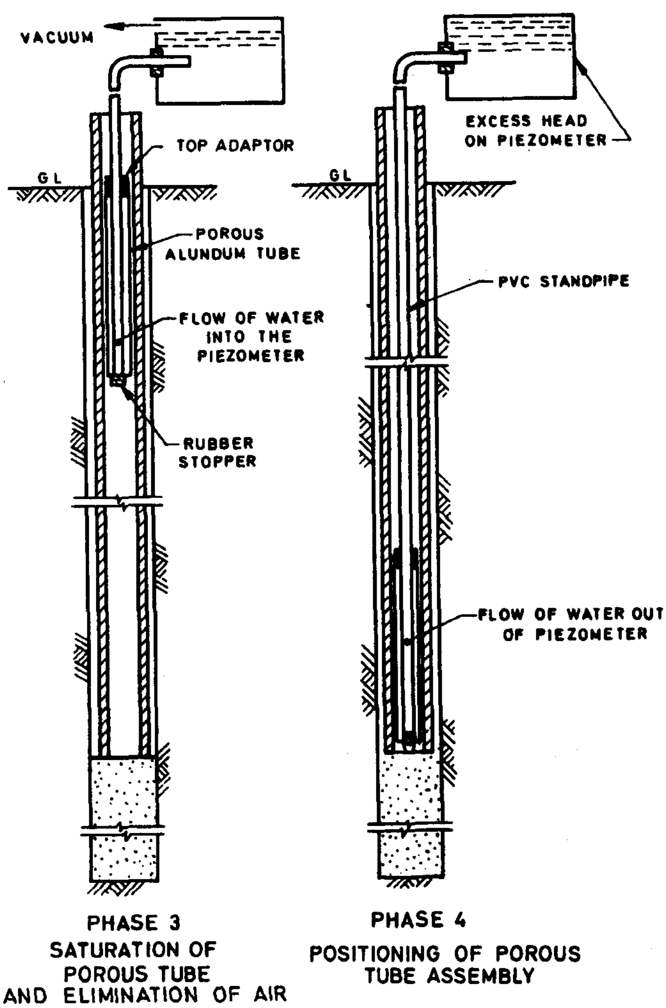


FIG. 2 INSTALLATION PROCEDURE FOR POROUS TUBE PIEZOMETER — *Continued*

10 MAINTENANCE OF INSTALLATION

10.1 Every two months each standpipe should be tested for any clogging. Clogging or sedimentation can be controlled by raising the water level in the pipe by adding air-free water from the top of the pipe thereby allowing outward flow of water with sediments from the periphery of the porous tube. Compressed air, however, should not be used to revive a piezometer as this would fill the pores of the tube with air, which would be impossible to remove. It is essential that air should be prevented from entering the pores of the tube at all times as the presence of air will lead to gross errors in the readings.

10.2 All missing screw caps on tops of the standpipes and casing pipes should be replaced with their original numbers stamped.

10.3 The top levels of the standpipes should be checked by an accurate levelling instrument, in case any change in levels is suspected.

10.4 The protective fencing around the installation should be maintained in good order and replaced, if need be.

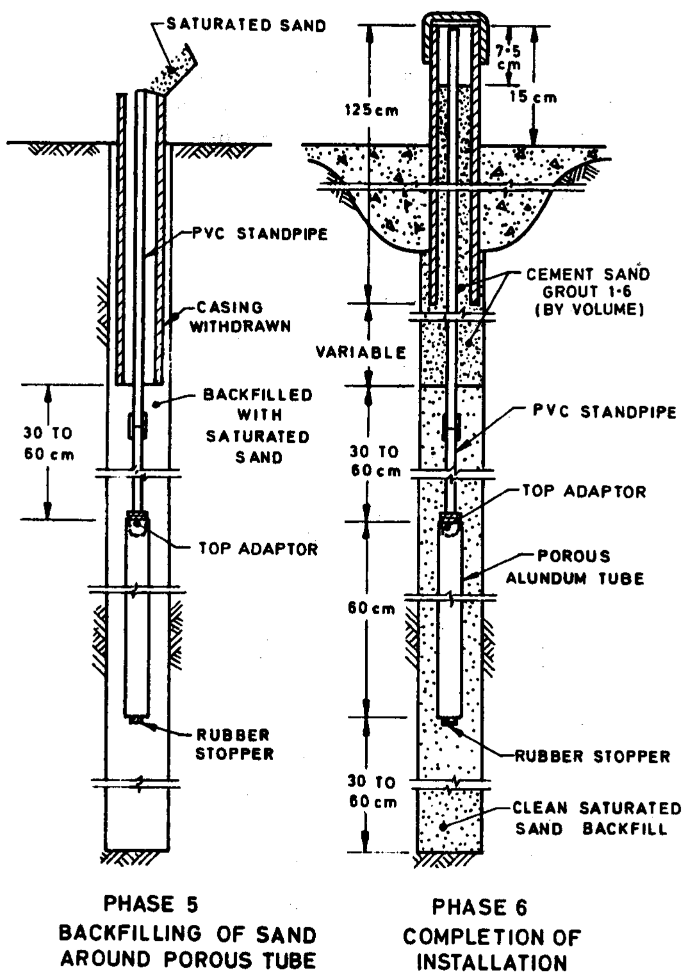


FIG. 2 INSTALLATION PROCEDURE FOR POROUS TUBE PIEZOMETER

ANNEX A

(*Clause* 7.2)

DATA SHEET FOR POROUS TUBE PIEZOMETER READINGS

Dam : .... Date of Observation : ....

Project : .... Observer : ....

Ref Drawing : .... Sheet : .... of ....

Plan Elevation : .... Top of Embankment : ....

Reservoir Water El : .... Tail Water El : ....

Piezometer No.	*Location*		*Original Elevation Porous Tube*	*Elevation-Top of Riser Tube*		*Settlement of Top of Riser Tube*	*Current Elevation of Porous Tube*	*Depth of Water Surface from Top of Riser Tube*	*Elevation of Water in Piezometer*	*Pore Pressure*
	Station	Offset		Original	Current					
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)

NOTES

1 Record offset by distance U/S or D/S from dam axis.

2 Elevation of porous tube to be taken at mid-point on length of porous tube.

3 Record all elevations and distances to an accuracy of 5 mm.

4 Use minus sign (—) to indicate heave.

ANNEX B

(*Clause* 7.2)

REGISTER FOR POROUS TUBE PIEZOMETER OBSERVATIONS

Dam : .... Piezometer Tip No. : ....

Project : .... Date of Installation of Tip : ....

Strata Around Tip : Location of Tip ....

.... Station : ....

Offset : ....

Original El : ....

Date of Observation	*Embankment Level*	*Reservoir Elevation*	*Tail Water Elevation*	*Elevation of Water in Piezometer*	*Pore Pressure*	*Remarks*
(1)	(2)	(3)	(4)	(5)	(6)	(7)

ANNEX C

(*Foreword*)

COMMITTEE COMPOSITION

Hydraulic Structures Instrumentation Sectional Committee, WRD 16

Organization	*Representative(s)*
National Hydro Electric Power Corporation Limited, Faridabad	SHRI BRIJENDRA SHARMA (***Chairman***)
AIMIL Ltd, New Delhi	SHRI M. D. NAIR SHRI J. C. BAWEJA *(Alternate)*
Bhakra Beas Management Board, Nangal	DIRECTOR (DAM SAFETY) EXECUTIVE ENGINEER *(Alternate)*
Central Board of Irrigation and Power, New Delhi	SHRI. S. P. KAUSHISH SHRI T. S. MURTHY *(Alternate)*
Central Building Research Institute, Roorkee	SHRI J. N. VAISH SHRI Y. PANDEY *(Alternate)*
Central Water Commission, New Delhi	DIRECTOR INSTRUMENTATION DIRECTOR ERDD (N & W) *(Alternate)*
Central Water and Power Research Station, Pune	SHRI R. K. KONDAYYA SHRI A. C. GANGAL *(Alternate)*
Damodar Valley Corporation, Dhanbad	CHIEF ENGINEER (CIVIL) SUPERINTENDING ENGINEER (CIVIL) *(Alternate)*
Irrigation Department, Government of Punjab, Chandigarh	CHIEF ENGINEER DIRECTOR (DAM) *(Alternate)*
Irrigation Department, Government of Andhra Pradesh, Hyderabad	DIRECTOR SUPERINTENDING ENGINEER (DAMS) *(Alternate)*
Irrigation Department, Government of Maharashtra, Nasik	CHIEF ENGINEER AND DIRECTOR
Irrigation Department, Government of Uttar Pradesh, Roorkee	CHIEF ENGINEER (DAM DESIGN) DIRECTOR *(Alternate)*
Karnataka Power Corporation Limited, Bangalore	CHIEF ENGINEER (CIVIL DESIGNS) PROJECT ENGINEER DESIGNS *(Alternate)*
Kerala State Electricity Board, Thiruvananthapuram	CHIEF ENGINEER (CIVIL) EXECUTIVE ENGINEER *(Alternate)*
Narmada and Water Resources Department, Government of Gujarat, Vadodara	DIRECTOR
National Hydroelectric Power Corporation Ltd, Faridabad	SHRI D. KARKUN SHRI Y. K. CHOUBEY *(Alternate)*
Sardar Sarovar Narmada Nigam Ltd, Gandhi Nagar	S. E. (NPHW CIRCLE)
Vasi Shums and Co Private Ltd, Mumbai	SHRI Z. M. KARACHIWALA
Public Works Department, Government of Tamil Nadu, Chennai	SHRI M. DURAIRAJ JOINT CHIEF ENGINEER *(Alternate)*
University of Roorkee, Roorkee	DR NAYAN SHARMA
BIS Directorate General	SHRI S. S. SETHI, Director and Head (WRD) [Representing Director General (*Ex-officio*)]

Member-Secretary

SHRI KULDEEP SIROHI

Deputy Director (WRD), BIS

This Indian Standard has been developed from Doc : No. WRD 16 (270).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110 002
Telephones : 323 01 31, 323 33 75, 323 94 02

Telegrams: Manaksanstha
(Common to all offices)

Regional Offices :	Telephone
Central : Manak Bhavan, 9 Bahadur Shah Zafar Marg NEW DELHI 110002	323 76 17 323 38 41
Eastern : 1/14 C. I. T. Scheme VII M, V. I. P. Road, Kankurgachi KOLKATA 700 054	337 84 99, 337 85 61 337 86 26, 337 91 20
Northern : SCO 335-336, Sector 34-A, CHANDIGARH 160 022	60 38 43 60 20 25
Southern : C. I. T. Campus, IV Cross Road, CHENNAI 600 113	254 12 16, 254 14 42 254 25 19, 254 13 15
Western : Manakalaya, E9 MIDC, Marol, Andheri (East) MUMBAI 400 093	832 92 95, 832 78 58 832 78 91, 832 78 92

Branches : AHMADABAD. BANGALORE. BHOPAL. BHUBANESHWAR. COIMBATORE. FARIDABAD. GHAZIABAD. GUWAHATI. HYDERABAD. JAIPUR. KANPUR. LUCKNOW. NAGPUR. NALAGARH. PATNA. PUNE. RAJKOT. THIRUVANANTHAPURAM.

Printed at New India Printing Press, Khurja, India