IS 7356 (Part 1) : 1992
(Reaffirmed 1998)

भारतीय मानक

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

भाग 1 छिद्रिल ट्यूब दाबमापी

(पहला 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

(First Revision)

UDC 624·131·387 : 627·824·2/· 3 : 681·121·843

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NEW DELHI 110002

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FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Hydraulic Structures Instrumentation Sectional Committee had been approved by the River Valley Division Council.

When load is applied to a soil mass, part is carried by the mineral skeleton and part by fluids, the load being distributed in direct proportion to the relative stiffness of the individual phases. Because the pores between the individual soil particles are very small and may be only partly filled with water, the pressures in the air and water which filled the pore spaces will be different. The effective stress is related to these known stresses is crucial in soil engineering because the distribution of deformation behaviour of the soil.

Installations 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 and also patterns of seepage, zones of potential piping, and effectiveness of underseepage control measures. Piezometers properly installed in earth dams and correct evaluation of pore pressure will:

a) Indicate potentially dangerous conditions that may adversely affect the stability of a dam and its appurtenant structures;

b) Help monitor, after construction, the behaviour of dams and their foundations and appurtenant structures;

c) Provide 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 and appurtenant structures; and

d) Enables evaluation to be made of the effectiveness of grout curtain.

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. These tips may not indicate the correct pressures where there is no sufficient flow of water into the standpipe of the piezometer, as for example in partially saturated soils.

Even though foundation pore pressures can be measured by the conventional twin tube hydraulic type foundation piezometers, there are locations not easily accessible to these piezometers, in view of the depths at which the tips are required to be installed and of the necessity of terminal facilities. The porous tube piezometer can be installed at such locations being an independent installation. Because of its simplicity, and reliability, the porous tube piezometer can be used by taking advantage of the drainage tunnels and grouting culverts to provide permanent access to the top of the holes. Since porous tube piezometers can be installed after completion of construction, obstruction to construction equipment can also be avoided.

This standard was first published in 1974. This revision has been prepared to incorporate certain changes found necessary in the standard in the light of the comments received from the users. The major changes in this revision are in description of equipments i. e. porous tube, stopper with rubber seal, top adaptor. The accuracy of water well sounder has also been reduced to 2 mm. The need for the installation of porous tube piezometers have been added.

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

(First 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 dams.

1.1.1 The provisions of the code suitably modified may be also 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 to a predetermined elevation to intercept ground water or pore pressure in the foundation. The porous tube is surrounded by sand and has a plastic riser pipe extended to the surface.

2.2 The pressure of the pore water surrounding the porous tube causes a flow through the piezometer until the pressures are equalized by the head of water in the standpipe (plastic tube). The elevation of water in the plastic tube is determined by an electrical sounding device lowered from the ground surface.

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

3 EQUIPMENT

3.1 Porous Tube

This is a porous carborandum or alundum tube of annular cross-section, 37 mm outer dia × 6 mm wall thickness and about 60 cm long. Alternatively porous tubes of shorter lengths may be coupled together with proper tie rods and rubber gasket seals to form a piezometer tip or could be used in shorter lengths 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 subsurface conditions encountered at site. The porosity of the porous tube should be chosen according to site conditions.

3.2 Stopper and Coupler

The bottom end of the porous tube is sealed with suitable rubber plug. When shorter lengths are coupled together a brass stopper having a suitable rubber seal should be used to seal the ends.

3.3 Top Adaptor

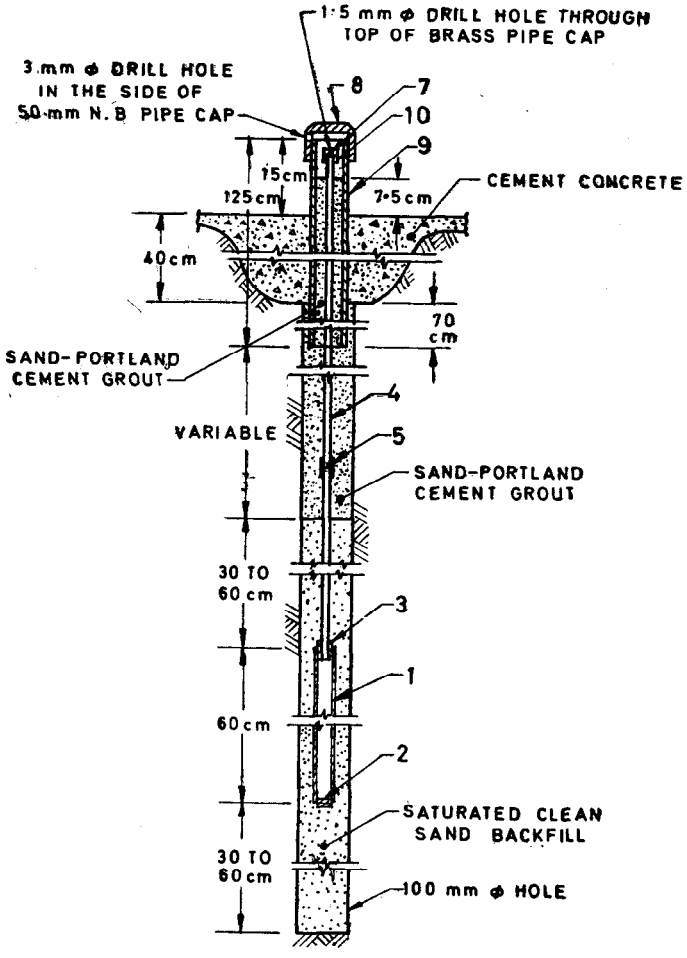
It is required to be fitted on the upper end of the porous tube assembly to connect the standpipe to the porus tube.

3.4 Standpipe

Durable rigid PVC tubing having an outside diameter of 12 mm and a wall thickness of 1·5 mm in maximum available lengths. The diameter of the tubing may be increased, if necessary, in view of the difficulty experienced in passing the sounder used, provided the consequent increase in response time is acceptable for the intended use.

3.5 Joint for PVC Tubing

These are required for jointing the available lengths of PVC tubing. The joints should be of suitable type to ensure no leakage and should



LIST OF PARTS

Sl No.	*Name of Item*	*Material*	*Sl No.*	*Name of Item*	*Material*
1.	37 mm × 6 mm wall porous tube 60 cm long	Carborandum or Alundum	6.	Water level sounder with accessories (not shown)	—
2.	Rubber stopper	Rubber	7.	12 mm brass hexagonal head pipe cap	Brass
3.	Rubber bushing	Rubber	8.	50 mm nominal bore pipe cap	G/I
4.	PVC tubing 12 m in OD × 1·5 mm wall	PVC	9.	50 mm nominal bore steel pipe	G/I
5.	Tubing joint	—	10.	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 tubing through fill where necessary.

FIG. 1 ASSEMBLY OF POROUS TUBE PIEZOMETER

be smooth and flush inside to prevent lodging of air bubbles and smooth passing of the sounder. The joiner or coupler for PVC tubing may be made of rigid PVC having internal diameter of the rubber tubing. Suitable adhesive/resin may be used for jointing lengths of PVC tubing.

4 WATER LEVEL SOUNDER

4.1 The water level sounder is required to be lowered from the surface into the plastic tube with the help of the connecting cable for taking observations. It comprises of two insulated wires bared at the contact end which passes through a weighted probe of any suitable material. Suitable markings should be given on the cable preferably at every 0·5 m intervals and should have an additional arrangement to measure with 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 unit should be battery operated, complete with reel/spool of cable extension rod of 0·5 m, leather carrying case, tripod stand and dummy probe with nylon cord of 50 m. The unit should also carry battery operated indicator and buzzer.

5 INSTALLATION PROCEDURE

5.0 The procedure given is for installation of porous tube piezometers in drill holes where it is considered necessary to provide porous tube piezometers within the embankment. Where the standpipes are expected to pass through embankments and concrete structures, necessary provision for extending the standpipes to successive higher elevations should be made as the construction operations progress.

5.1 The successive steps involved in the installation of porous tube piezometer are described in **5.2** to **5.10** (*see also* Fig. 2).

5.2 A minimum 100 mm dia cased hole is advanced to about 30 to 60 cm distance below the planned elevation for the bottom of the porous tube by jetting or by other accepted procedures. Use of bentonite on drilling muds should not be permitted. Most of the casing is usually removed from the hole during installation of the apparatus but if the casing is expandable, a sufficient length should be pulled after installation of porous tube so that the sand-cement grout has direct contact, if possible, with an impermeable stratum.

5.3 After the casing has reached the designed depth in the 100 mm dia hole, the hole should be washed clean to the bottom. For a drilled hole, clean water should be circulated through the drilled bit until the discharge is clear. For a jetted hole the pump is reversed and the jet pipe pulled up a few inches from the bottom of the hole to be used as an intake. The casing should be kept filled by pouring in clear water, until all cloudiness disappears from the effluent (*see* phase 1, Fig. 2).

5.4 After the hole is cleaned, saturated sand should be poured into the casing to fill the bottom of the porous space. The length of the porous space to be filled with sand should depend upon the relative tightness of the natural soil surrounding the hole, that is, the lower the permeability, the greater the length of the hole for the intake area of the piezometer. The sand backfill should consist of clean sand, which should satisfy the filter requirements vis-a-vis the surrounding soil as closely as possible, without including any silt sizes. Unless the side walls of the holes have a tendency to cave in, the casing should be raised approximately by 60 cm before backfilling with saturated clean sand. The casing should be withdrawn in such a way that the surrounding soils is not disturbed. However, if there is a danger of sloughing, the casing should be withdrawn in increments of 15 cm or less after lifts of sand are placed to support the hole. The sand in the bottom of the hole should be tamped with a bar or a pipe, before installation proceeds (*see* phase 2, Fig. 2).

5.5 Next step is the lowering of the porous tube to its designated elevation. Before this is done, the required length of the tubing and the joints should be tested for leak proofness and then the porous tube and tube assembly should be immersed about a metre below the surface of water in the hole into the clear water, and the plastic stand pipe should be connected to a supply tank, a vaccum should be then applied to the tank to draw water through the porous tube to eliminate air from the system. If the length of tubing is too much to handle as a single length, shorter length can be first lowered into the borehole and subsequent lengths be jointed properly afterwards. To expedite saturation and removal of air from the porous tube, it should be soaked in warm water for several hours, or boiled in water for 15 min before installation (*see* phase 3, Fig. 2).

5.6 When lowering the assembled porous tube and plastic standpipe into the hole, a small positive pressure should be maintained in the tank to cause an outward flow of water from the tip. A pump of low capacity may also be used to draw water through the porous tube and to maintain a positive pressure while lowering the tip. This will prevent movement of fines into the porous tube. With the assembled porous tube resting on the sand in the bottom of the hole, the casing is withdrawn in

small increments, depending on the condition of the wall of the hole and saturated sand is poured into the hole to the level of the top of the porous tube.

5.6.1 The designed elevation for the porous tube is the elevation of the mid-point along the length of the tube. The length of the tube including the projecting rubber bushing should, therefore, be measured before the apparatus is lowered into the hole. Measurements for the original elevation of the porous tube should be taken to the nearest 1 cm. However, after the installation is completed, measurements for elevation on top of each installation and the water level in each pipe should be made to the nearest 5 mm (*see* phase 4, Fig. 2).

5.7 The casing should then be pulled approximately 30 to 60 cm and that portion of the hole backfilled with saturated sand. A minimum 30 cm of sand should be backfilled above the elevation of the top of the porous tube (*see* phase 5, Fig. 2).

5.8 The casing should then be pulled approximately one metre or as the hole permits and the hole backfilled with sand-portland cement grout having volume ratio one part cement to 4 parts sand. Sufficient water should be added to dry volumes to produce workable grout mix. The consistency of the plugging paste should be such that the fines do not penetrate the sand backfill. Tamping bar should be lowered into the hole at this stage to puddle the grout. Attempt should be made to maintain the PVC standpipe in the centre of the hole during each increment of the backfill procedure should continue till appear. One meter of the casing remains in the hole (*see* phase 6, Fig. 2).

5.9 The casing should be cut off at about 15 cm above the ground surface. The plastic standpipe should be cut off flush with the top of steel casing and capped with a removable pipe cover. The annular space between the steel casing and the plastic standpipe should be filled with grout to within approximately 5 cm from top of the pipe. The top of stand pipe casing pipe should now be individually covered with metallic pipe cap.

5.10 Upon completion of the installation, a protective tripod or fence made from sections of pipe or reinforcement steel should be constructed and set into the ground over the system to protect the installation from damage.

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 given 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 from an even half metre mark 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.

6.2 Measurements for original elevation of the porous tube should be taken to the nearest one centimetre. However, after the installation is completed, elevation on top of the installation and the water elevation in the standpipe should be made to the nearest 2 mm. The elevation of top of PVC pipe be checked at least once in a year to account for change in RL of top of PVC pipe due to settlement.

6.3 Sedimentation around the porous tube reduces the sensitivity of the piezometer. In order to retard this, the water level in the standpipe should be raised, thereby requiring an outward flow to achieve equilibrium. This should be done particularly when an increase in pore pressure around the tip is anticipated.

7 FREQUENCY OF OBSERVATIONS AND RECORDING OF DATA

7.1 Frequency of Observations

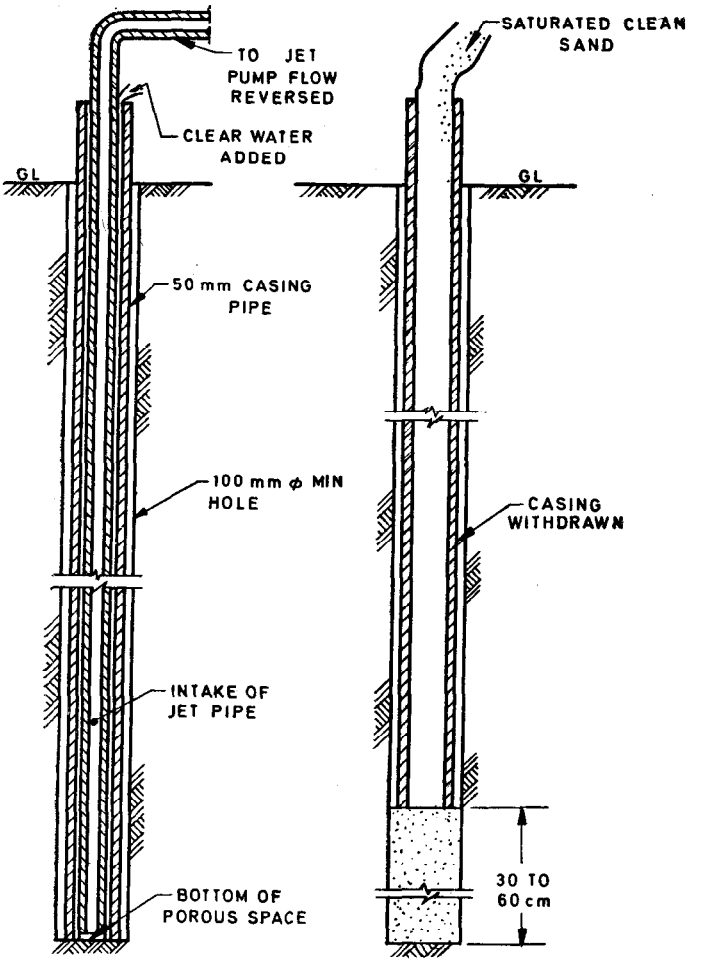
Pore pressure readings should be taken at every 15 days interval during construction and at monthly intervals during shut down. After construction, during the filling and depletion of the reservoir, the piezometer should be read for every 3 m rise or fall of the lake level. For the first five years after 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.

8 PRESENTATION OF DATA

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



Operations:

1. Advance a 100 mm dia minimum cased hole to the desired elevation by jetting or accepted drilling procedures.
2. For a drilled hole, circulate clean water/through the bit till the discharge is clear. For a jetted hole: (i) reverse the pump and pull jet pipe a few cm from bottom of hole to be used as intake, (ii) pour clear water keep it full.
3. Stop the pump when cloudiness disappears from the effluent.

1. Pull casing pipe by approx. 60 cm or in increments of 15 cm or less if there is a tendency of sloughing.
2. Pour saturated, clean sand to fill the bottom 30 to 60 cm of the hole depending upon the relative permeability of the natural soil surrounding the hole.

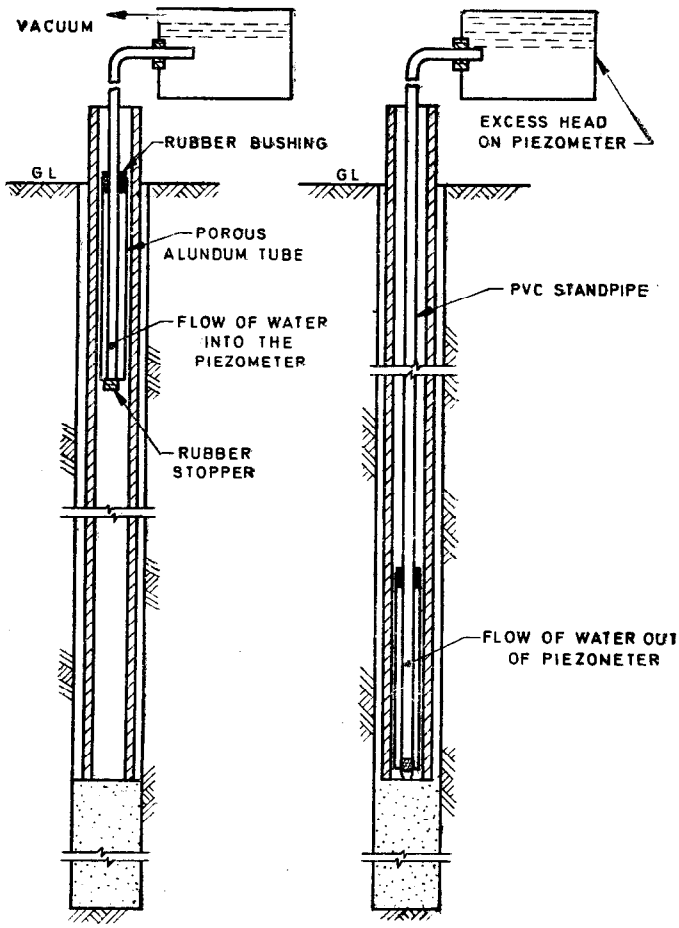
NOTES

1 Casing to be kept filled with water in phases 1 to 5.

2 Diameter of the hole and the length of sand back fill below the piezometer may be varied with subsurface conditions encountered.

3 For assembly and list of parts of porous tube piezometer installation, Fig. 1.

FIG. 2 INSTALLATION PROCEDURE FOR POROUS TUBE PIEZOMETER (*Continued*)

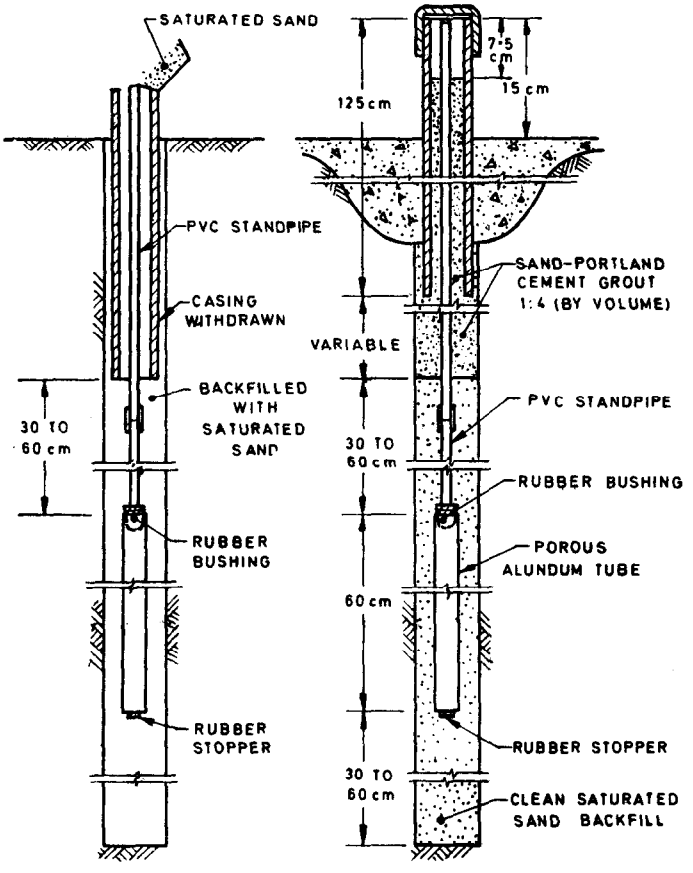


Operations:

1. Soak the porous (alundum) tube in warm water for several hours or boil in water for 15 min before installation.
2. Measure the length of the porous tube, including the projecting rubber bushing.
3. Immerse the porous tube about a metre below the surface of water in the hole into clear water.
4. Connect the PVC stand pipe to a small tank and draw water through the porous tube into the tank by using a reversed pump. Continue till air is completely eliminated from the system, taking care that some depth of water remains over the top of the porous tube.

1. Lower the apparatus into the hole to the desired elevation.
2. Maintain a small positive pressure in the tank while lowering to cause an outward flow of water from the tip.
3. Measure original elevation at the middle point of porous tube to the nearest 1 cm.

FIG. 2 INSTALLATION PROCEDURE FOR POROUS TUBE PIEZOMETER (*Continued*)



PHASE 5
BACKFILLING OF SAND AROUND POROUS TUBE

PHASE 6
COMPLETION OF INSTALLATION

Operations:

1. Withdraw casing 30 to 60 cm on top of porous tube in small increments, depending upon the conditions of the walls of the hole and pour saturated sand after each withdrawal.
1. Pull casing in small increments as before.
2. Back fill with workable sand-portland cement grout, having a volume ratio of one part cement to four parts sand.
3. Puddle the grout with a tamping bar.
4. Maintain standpipe in centre of hole during each increment of backfill.
5. Continue backfilling with sand-cement grout in small increments till approximately 125 cm of casing remains in the hole.
6. Cut off the casing about 15 cm above the ground surface.
7. Fill the annular space between stand pipe and the casing pipe with grout to within 75 cm of top of casing pipe.
8. Cut off the stand-pipe flush with the top of casing and cap with a removable pipe cover.
9. Place a metal pipe cap on the casing pipe.
10. Place concrete near the top as shown.
11. Instal a protective tripod or fence over the system.

FIG. 2 INSTALLATION PROCEDURE FOR POROUS TUBE PIEZOMETER

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 All 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.

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, thereby allowing outward flow of water with sediments from top of the pipe. 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 pipe should be replaced with their original numbers stamped.

10.3 The top levels of the standpipe should be checked up by an accurate levelling instrument, if any, change in levels is suspended to have occurred.

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

NOTE — When there are large fluctuations in upstream and downstream water levels, for instance during rising or falling floods or when the river is being ponded up, to feed supplies to canals or for generation of power, etc, the results are likely to be influenced by time lag. A rise in the upstream level will give relatively lower readings and vice-versa. When water levels are taken at regular intervals, due allowance should be made for such time lag and its effect taken into account. The time lag can be assessed by filling the standpipe with water and measuring the time of the water level to drop down to a constant level. This test should be performed when the levels on the upstream and the downstream are almost steady. The time lag should be measured by an average of three such trails. The time lag measurements may be done allowing about a month after installation for establishment of original conditions and once every six months to ascertain the extent of choking of the installation, if any, and to take into account the effect of time lag on the readings.

ANNEX A

(*Clause* 7.2)

DATA SHEET FOR POROUS TUBE PIEZOMETER READINGS

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

Project..... Observer .....

Ref for drawing..... Sheet.....of.....

Elevation..... Top of Embankment.....

Reservoir Water El..... Tail Water El[1]

Piezometer No.	Location		Original Elevation of Porous Tube	Elevation-Top of Riser Tube		Settlement of Top Riser Tube	Distance Top of Riser Tube to Water Surface	Elevation Water in Piezometer	Pore Pressure
	Station	Offset		Original	Current				

1. Record if appropriate
2. Record offset by distance U/S or D/S from crest of dam or axis of location by using co-ordinates
3. Taken as mid-point on length of porous tube.
4. Record all elevations and distance to 5 mm.
5. Use minus (—) to indicate heave.

ANNEX B

(*Clause* 7.2)

REGISTER OF POROUS TUBE PIEZOMETER OBSERVATIONS

Dam.....

Project.....

Strata Around Tip.....

Piezometer Tip No. .....

Date of Installation of Tip.....

.....

Location of the Tip.....

R. L. of the Tip.....

Offset from Axis of Dam.....

Date of Observation	Embankment Level	Reservoir Elevation	Tail Water Elevation	Elevation of Water in Piezometer	Pore Pressure	Remarks
		mm	m	m		

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Indian Standards are reviewed periodically and revised, when necessary and amendments, if any, are issued from time to time. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition. Comments on this Indian Standard may be sent to BIS giving the following reference:

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