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(Reaffirmed 1998)

भारतीय मानक

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Indian Standard

CODE OF PRACTICE FOR INSTALLATION, MAINTENANCE AND OBSERVATION OF INSTRUMENTS FOR PORE PRESSURE MEASUREMENTS IN EARTH DAMS AND ROCKFILL DAMS — ELECTRICAL PORE PRESSURE CELLS VIBRATORY WIRE TYPE

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NEW DELHI 110002

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Price Group 4

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards on 29 March 1990, after the draft finalized by the Hydraulic Structures Instrumentation Sectional Committee had been approved by the River Valley Division Council.

The soil mass is composed of solid soil particles and voids filled with water and air. The constructed embankment will always contain a certain volume of air and water within the voids. The air is compressible while water is highly incompressible. Hence when embankment settles due to compaction by rolling, or due to self weight, the void space contract. This causes pressure in the pore fluid comprising air and water. Thus the intergranular pressure is reduced due to opposing pore pressure and therefore the shear strength depends upon intergranular pressure.

Pore pressure is also caused due to the seepage of water through an embankment. The initial energy head of percolating water at entrance into the dam is greater than the energy heat at any point in the interior. The difference represents the loss of energy due to friction forces of percolation. The potential of the water decreases as it seeps through the dam. Pore pressure due to percolation is determined by subtracting the corresponding elevation from the flow potential at that point being considered. Thus pressure at any point in a dam at any time is the function of compaction, consolidation and seepage. Procedures for testing the pore pressure cells both in the laboratory and in the field before installation are under formulation.

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 '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 — ELECTRICAL PORE PRESSURE CELLS VIBRATORY WIRE TYPE

1 SCOPE

1.1 This standard covers the details of installation, observation and maintenance of electrical pore pressure cells (vibrating wire type) installed in earth and rockfill dams for measuring the pore pressures in the embankment and the foundation.

2 REFERENCES

2.1 The following Indian Standard is a necessary adjunct to this standard:

IS No.	*Title*
10034 : 1982	Code of practice for selection, splicing, installation and providing protection to the open ends of cables used for connecting resistance type measuring devices in concrete and masonry dams.

3 INSTALLATION EQUIPMENT

3.1 Electrical Pore Pressure Cells

The electrical pore pressure cell has a stainless steel diaphragm behind a porous filter element. The diaphragm is deflected by the pore water pressure against one face; the deflection being proportional to the applied pressure. The deflection of the diaphragm is measured by means of various electrical transducers, most common among them being unbounded resistance strain gauge and vibrating wire strain gauge. Electrical piezometers have very small time lags and are very sensitive. Hence these are especially suited in the circumstances when the fluctuations in pore pressures are very quick or in case of dynamic observations.

3.1.1 *Vibration Wire Type Pore Pressure Cells*

The basic principle of the vibrating-wire strain gauge is that the change in natural frequency of vibration of a stretched wire depends on the change of the tension in the wire. In practice, a gauge-wire is stretched between two points on a structural member or transducer element used to sense the physical quantities that are to be determined

3.1.1.1 When the gauge-wire is caused to oscillate, it will vibrate at its resonate or natural frequency of vibration which is dependent on the tension in the wire. If strains are induced in the element on which the gauge is mounted, the distance between the support posts will change. Accordingly, the tension in the gauge-wire and its natural frequency of vibration will also be changed. Thus the change in frequency of the gauge wire is a measure of the strain in the sensing element of the transducer.

3.1.1.2 The main components of such an instrument are, porous filter element diaphragm, vibrating wire, electro-magnet and connecting cable. The pretensioned vibrating wire is such connected to the body of the cell and the diaphragm, that the tension of the wire changes due to the deflection of the diaphragm only. Due to pore water pressure, the diaphragm is deflected and the natural frequency of the measuring wire is altered. The mechanical oscillation of the wire is converted to electrical frequency signal by an electro-magnet and this electrical frequency is transmitted through the cable to the receiver unit and correlated to the pore pressure. The frequency of the wire is independent of variations in voltages, currents and resistance. There are several types of electrical piezometers and the main difference lies in the transducer package, the porous element and the arrangement of the body of the piezometer.

3.1.1.3 The pore pressure cell should be structurally isolated from the surrounding concrete/earth so that no apparent pore pressure are indicated due to straining of the body of the instrument.

3.2 Cable

The electrical type pore pressure cells shall be supplied with conductors of required length (*see* **3.2.1**) attached to the instrument as agreed by the supplier and the purchaser. The cable type depends on the different makes of the instruments and for the details and specifications, the catalogue of the manufacturer may be referred to. In most installations the cable is recommended to be further protected.

When used in adverse environments, cables armoured with steel wires, having two layers of insulation with petroleum jelly filling to prevent water seepage may be used. It is also recommended that the use of a junction box to connect several individual cables terminating in the junction box and a steel armoured, jelly filled multi-core cable of 10, 20, 40 conductors capability may be used to connect these to a termination switch box installed in the terminal house.

3.2.1 *Cable Connections*

The connection between the pore pressure cell and the cable of required length to connect to the readout unit is generally done in the factory itself and in exceptional cases when the cable is too short or has been damaged, the cable connections are done at site. In such a case care should be taken to get pressure-tight connections using sealing compound. The splicing shall be done in accordance with IS 10334 : 1982.

3.2.2 *Insulation Tests*

After completion of the cable connections, test the pore pressure cell for insulation by means of an ohmmeter, the value shall not be less than 500 megaohms at 12 V. There must be no electrical connection between each of the conductors and the metal braiding or the body of the pore pressure cell. After this the pore pressure cell shall be checked for proper functioning. These tests should be performed immediately after the sealing resin has been applied.

3.2.3 *Identification of Cable Ends*

After connecting the cable to the pore pressure cell the free end of the cable should be marked or identified with permanent marks by use of a minimum of 3 tags at a maximum spacing of 10 m over the entire exposed length of cable with non-corrosive metal tags engraved or embossed with appropriate transducer numbers. Permanent identification is necessary to prevent errors in identifying the pore pressure cells.

3.2.4 *Cable Termination Arrangement*

The number of cable joints should be minimised, using continuous lengths wherever possible. The cable shall be of sufficient length to reach the permanent readout station. In case of necessity of joining the cables, proper splicing kit shall be used. The cables should be looped where they cross an interface and at joints, to reduce the strain in cables and joints due to differential movement. When there are sufficient pore pressure cells to be installed which can justify use of an instrument house, the cables have to be lead through an entry duct connected to a suitable terminal unit. If many pore pressure cells are grouped together closely and the terminal unit is relatively far, then suitable junction boxes shall be used for connecting individual cables from the transducers to a multicore cables, which in turn connected to the terminal unit.

3.3 Installation of Pore Pressure Cells in the Drill Holes

3.3.1 Pore pressure cells are installed in bore holes drilled, below the foundations or through already completed embankments. The minimum diameter of bore holes shall be 100 mm for cell diameter up to 35 mm and 150 mm for cell diameter above 35 mm and up to 45 mm separate bore holes shall be drilled for each cell. Casing of these holes is usually required to maintain the holes during installation, depending on local conditions and the type of equipment available. The casing should be removed after the pore pressure cell is placed in position.

3.3.1.1 Procedure for installation of pore pressure cells in drill holes.

a) Remove the high air entry filter from the cell and boil it in clear water for five minutes to saturate the filter with water.

b) Reassemble the pore pressure cell under cool water by assembling the same in a bucket of clean water. The bucket should be large enough to allow pore pressure cell to be reassembled and the placement of the cell inside the cloth bag in submerged condition.

c) Place a cloth bag in the bucket of water mentioned above and place some clean sand in the bag, place the pore pressure cell in the bag and pack the sand above it as shown to get the assembly as indicated in Fig. 1.

d) Tie the top of the bag by a suitable string and place the same into the bronze metal screen keeping the assembly submerged in water.

e) Take zero reading at this time to check proper functioning of the cell.

f) Clean the drill hole and fill up the bottom 300 mm of hole with clean saturated sand.

If the hole has been provided with the casing, fill up the sand up to required depth and remove the casing from the bottom 300 mm prior to backfill operation.

g) Lower the cell assembly into the hole up to the top of the sand. Test the pore pressure cell whether it is working satisfactorily, if yes, continue with the steps below.

h) Pour additional clean saturated sand to fill the hole up to 300 mm above the top of the cloth bag.

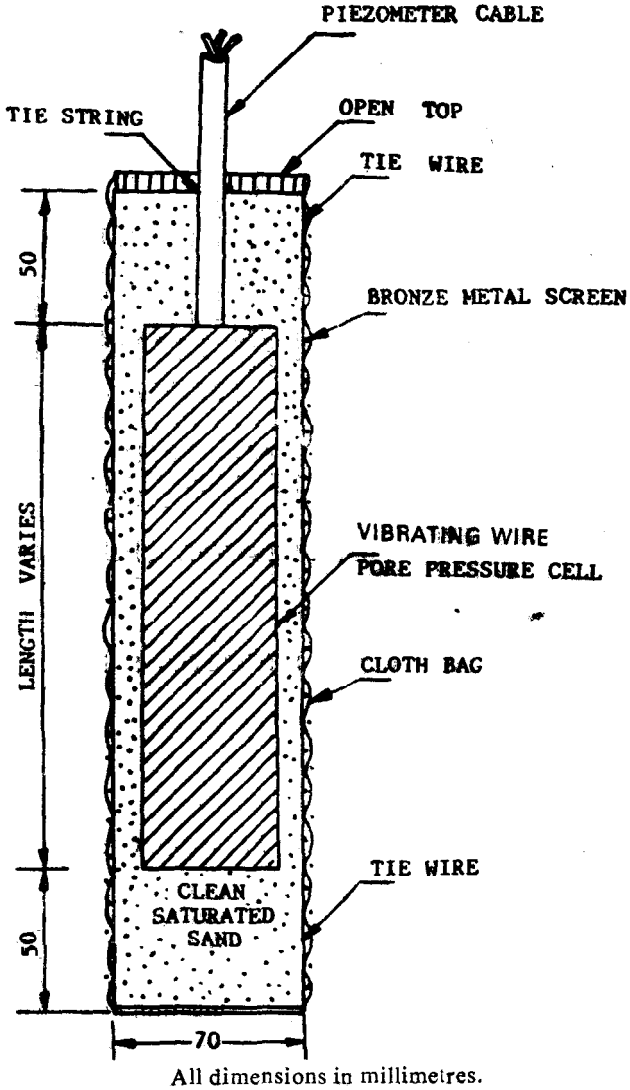
i) Follow the backfilling as shown in Fig. 2.

3.3.2 *Installation of Pore Pressure Cell in Embankment*

Pore pressure cells are placed in embankment in shallow trenches laid at right angles to the main trenches which carry the connecting cable from all the cells. The main trenches are offset 300 to 600 mm from the location of cells. Main trenches are usually 450 to 600 mm wide and the depth should provide for a minimum of 100 mm of selected material over the connecting cables and a 300 mm thick protective cushion of selected fine material in the bottom of the trenches, below the connecting cables. A minimum of 450 mm of embankment material should then be placed to complete the backfill to existing embankment level.

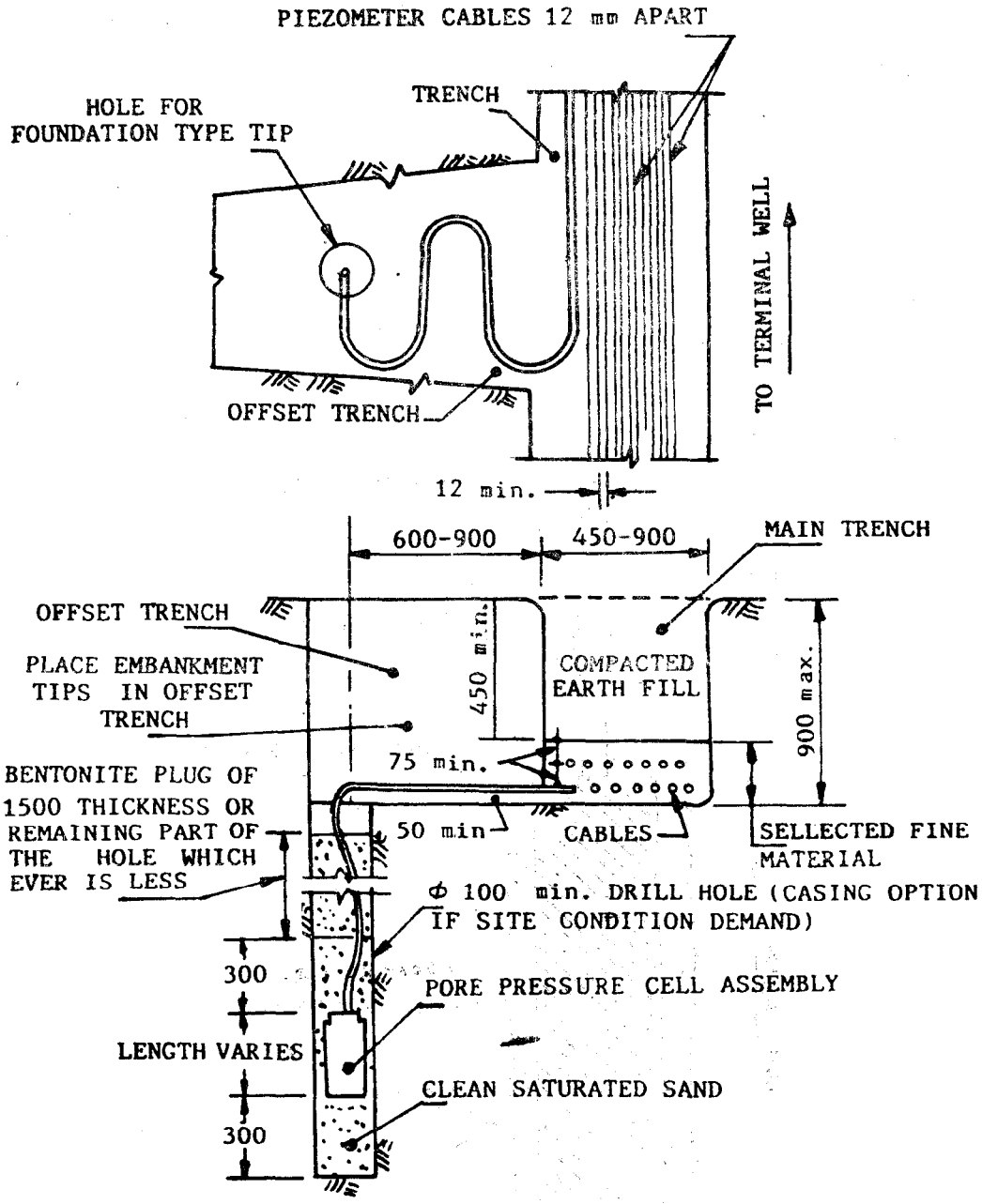
3.3.2.1 Procedure for installation of pore pressure cells in embankment:

a) Remove the high air entry filter from the cell and boil it in water for five minutes to saturate the filter with water.



All dimensions in millimetres.

FIG. 1 PORE PRESSURE CELL ASSEMBLY FOR INSTALLATION IN DRILL HOLES



All dimensions in millimetres.

FIG. 2 TYPICAL INSTALLATION OF PORE PRESSURE CELL IN DRILL HOLES

b) Reassemble the pore pressure cell in a bucket of cool water under submerged conditions.

c) Take zero reading at this time to check proper functioning of the cell.

d) Carry the cell to its desired location in submerged condition.

e) Place 100 mm thick layer of selected fine material of the same type as that of the surrounding embankment and compact.

f) Place the pore pressure cell at its designed location as shown in Fig. 3.

g) Place selected fine embankment material up to a thickness of 300 mm over the pore pressure cell taking care so as to avoid

large sized particles which can damage the pore pressure cell or the cable.

h) Test the pore pressure cell for satisfactory operation.

j) Backfill the rest of the trench with typical fill material and compact the same by manual tamping.

3.3.3 *Laying of Cables*

The cable shall be laid in main trenches, where bed is cleared of sharp edge objects and replaced with selected material, in slight wave lines. The trench shall then be filled with selected fine material up to a depth of 300 mm and hand compacted. The main cable trenches should be provided with a cross cut-off trench filled with 1 : 3 soil bentonite mixture to prevent formation of a possible seepage path in the body of the earth/rockfill dam. Heavy machinery shall not be allowed to pass within 2 000 mm of the instrument and before 2 000 mm covering height over the instrument.

At locations where the cable passes in transition zones of the embankment, differential settlement of fill materials may shear the cable, adequate provision shall be made by providing extra loose length of cable in that portion.

While routing of cables through rockfill, the main trenches carrying cables shall be filled with coarse to fine sand completely passing 5 mm seive. The relative spacing between individual layers of cables as shown in Fig. 4 may be maintained. The graded material surrounding the main trench shall be provided with properly graded layers to prevent migration of sand filling in the main trench.

The cables shall be protected against prolonged exposure to sun and mechanical damage. It is, therefore, necessary that the cable is properly covered at all times.

3.3.4 *Cable Ends*

The free ends of the installed cable shall be terminated immediately in water-tight connections. Entry of moisture through open ends of cable can ultimately result in making the pore pressure cell inoperative.

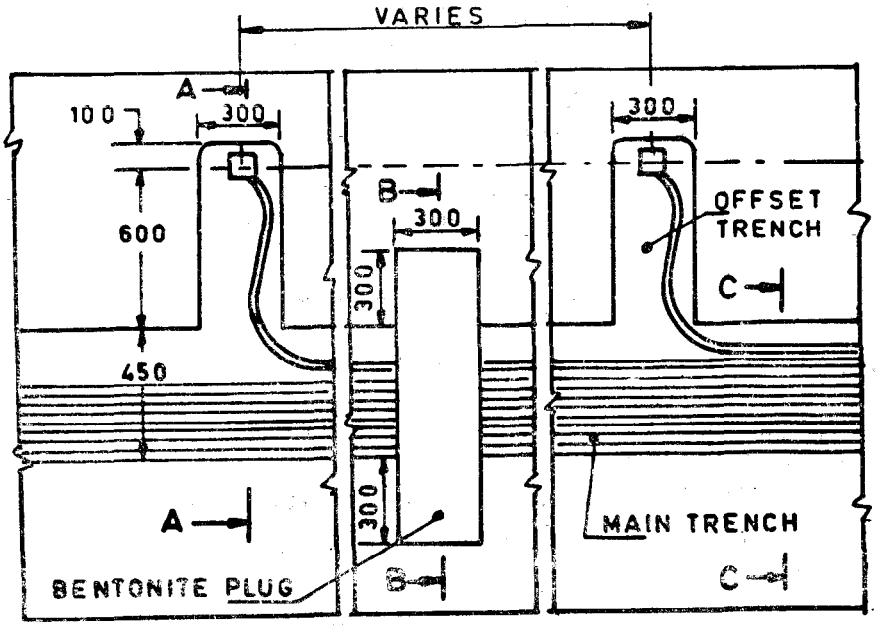
3.3.5 *Precautions Against Atmospheric Over-Voltages*

Suitable over-voltage protection shall be provided to safeguard the transducer and the terminal unit from atmospheric over-voltages.

4 OBSERVATIONS

4.1 Initial Reading

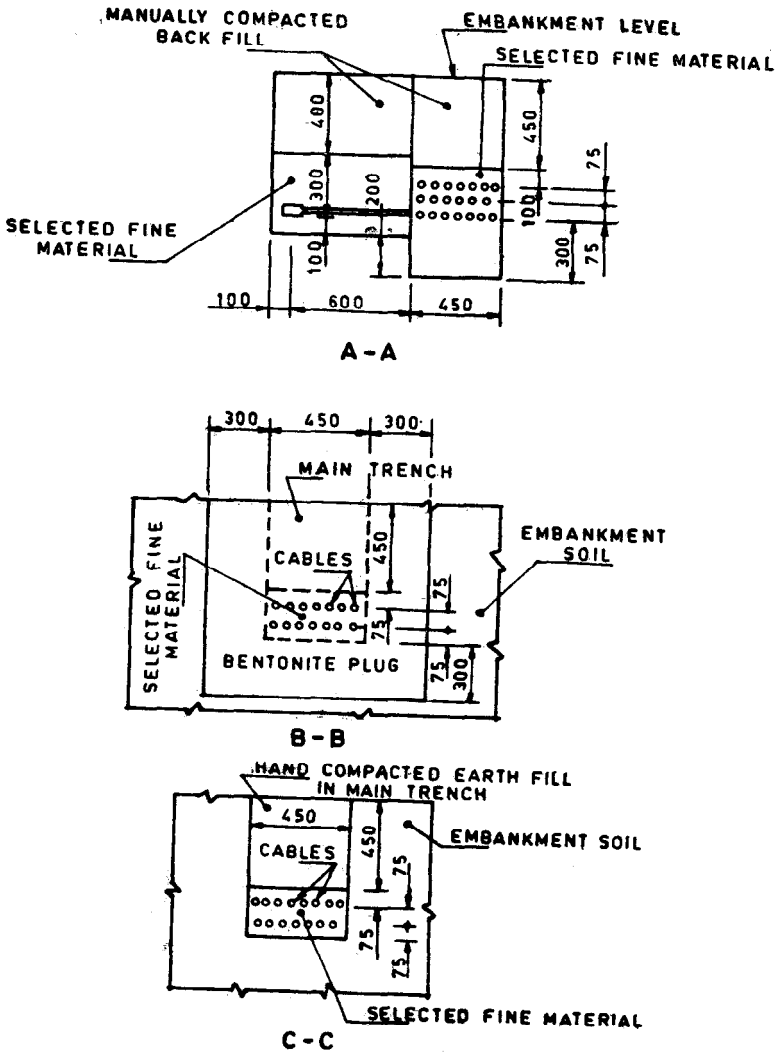
4.1.1 After the installation of each piezometer



All dimensions in millimetres.

Bentonite Plug (A mixture of 5% Bentonite (by Volume) and 95% Embankment Material Should be Placed '15' Metre Intervals, or Midway Between the Piezometer Tips Whenever Distance is Smaller)

FIG. 3 TYPICAL INSTALLATION OF PORE PRESSURE CELL IN EMBANKMENT (*Contd*)



All dimensions in millimetres.

FIG. 3 TYPICAL INSTALLATION OF PORE PRESSURE CELL IN EMBANKMENT

stabilizing near the piezometer tip will take some time depending on soil permeability, pore pressure gradient, etc. A judgement in each case is necessary to decide when piezometer readings can take place. Normally the pore pressure will be stable within 48 hours of installation. A reading at this stage shall be taken and shall be recorded as the initial reading.

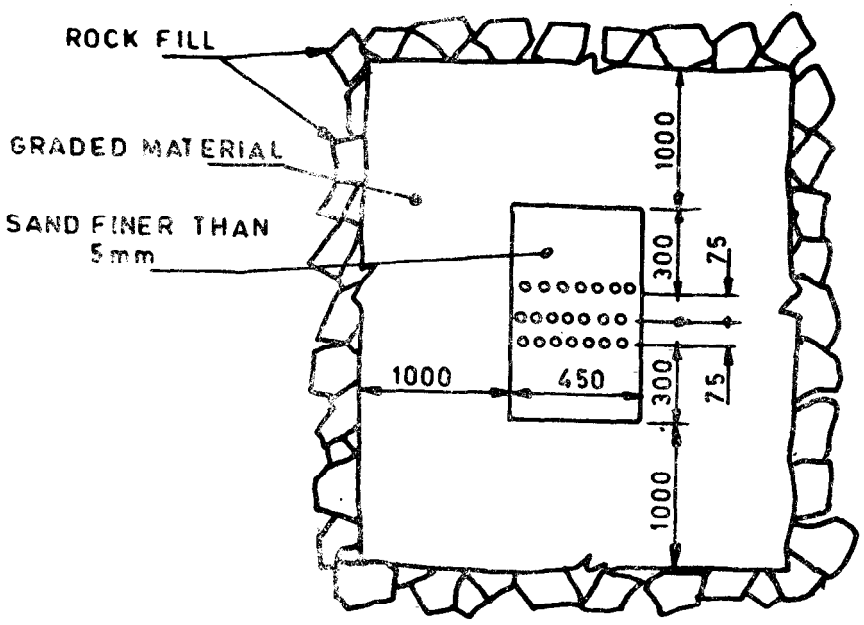
4.1.2 The pore pressure cell is temperature compensated, that is, temperature fluctuations of the surrounding soil will not affect the measuring result, provided the entire cell is in a state of temperature balance (the measuring wire should be at the same temperature as the body of the cell).

4.2 Recording of Observation

Different systems of recording observations of vibrating wire type instruments are available. For recording observations instruments of the manufacturers of the respective makes should be referred to.

4.3 Frequency of Observation

Pore pressure readings shall be taken at every 15 days interval during construction and at monthly intervals during shut down. After



All dimensions in millimetres.

FIG. 4 LAYING CABLES THROUGH ROCKFILL

construction, during initial reservoir filling, the readings shall be taken for every 3 m rise or fall of the reservoir or at monthly intervals. After two years, the readings should be taken at every 3-monthly intervals except during rainy season when readings should be taken at monthly intervals.

5 PRESENTATION OF DATA

5.1 The data from piezometric observations shall be duly processed and the following graphs prepared:

a) Pore pressure, reservoir level and embankment height versus time;

b) Pore pressure versus total stress; and

c) The distribution of the above parameter along with geometry of the place with the contours and cross sections.

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