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METHODS OF TEST FOR DETERMINATION OF PERMEABILITY OF NATURAL BUILDING STONES

(First Revision)

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Indian Standard

METHODS OF TEST FOR DETERMINATION OF PERMEABILITY OF NATURAL BUILDING STONES

(First Revision)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 12 October 1973, after the draft finalized by the Stones Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 Permeability of stone is of particular importance in structures which are intended to retain water or which are subjected to the action of high water pressure. Besides functional considerations, permeability is also intimately related to the durability of stone, specially its resistance against progressive deterioration under exposure to severe climate, and leaching due to prolonged seepage of water. The determination of the permeability characteristics of stone, therefore, assumes considerable importance. This standard was published in 1967. The revision has been prepared with a view to reviewing its provision in regard to pressure to which the permeability is to be tested, besides making it up-to-date.

0.3 In reporting the results of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960*.

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1. SCOPE

1.1 This standard covers the method for determining the permeability of natural building stones.

2. SELECTION OF SAMPLE

2.1 The sample shall be selected to represent a true average of the type or grade of stone under consideration.

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

2.2 The sample shall be selected by the purchaser or his authorized representative from the quarried stone or taken from the natural rock, as described in **2.2.1** and **2.2.2** and shall be of adequate size to permit the preparation of the requisite number of test pieces.

2.2.1 *Stones from Ledges or Quarries* — The ledge or quarry face of the stone shall be inspected to determine any variation in different strata. Differences in colour, texture and structure shall be observed. Separate samples of stone weighing at least 25 kg each of the specimens shall be obtained from all strata that appear to vary in colour, texture and structure. Pieces that have been damaged by blasting, driving wedges, heating, etc, shall not be included in the sample.

2.2.2 *Field Stone and Boulders* — A detailed inspection of the stone and boulders over the area where the supply is to be obtained shall be made. The different kinds of stone and their condition at various quarry sites shall be recorded. Separate samples for each class of stone that would be considered for use in construction as indicated by visual inspection shall be selected.

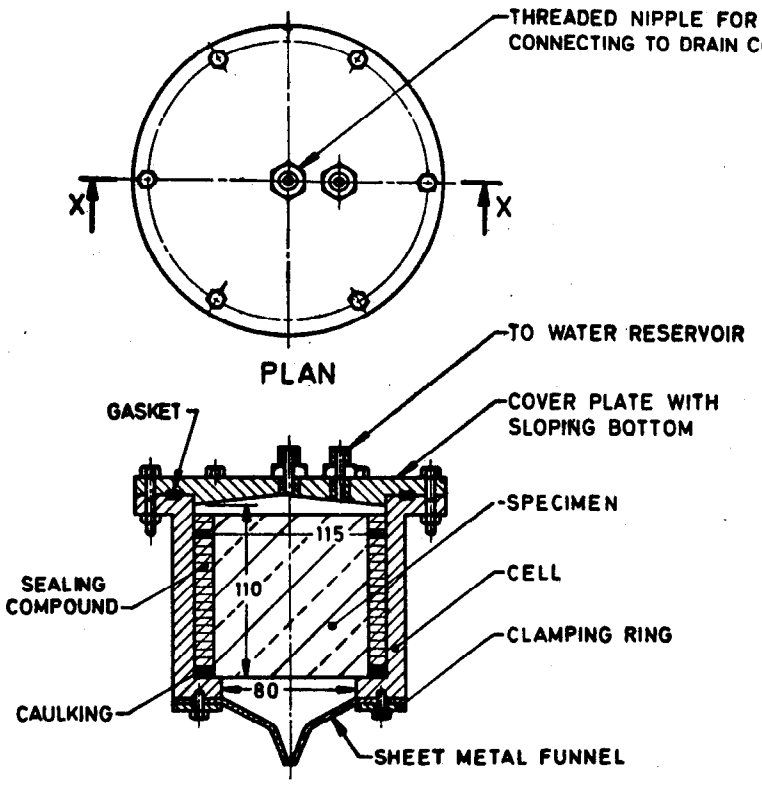
2.3 When perceptible variations occur in the quality of rock, the purchaser shall select as many samples as are necessary for determining the range in properties.

3. APPARATUS

3.1 Permeability Cell — The permeability cell shall consist of a metal cylinder with a ledge at the bottom for retaining the specimen, a flange at the top, a removable cover plate and a sheet metal funnel which can be securely bolted to the cell. Gunmetal or other suitable corrosion resistant metal shall be used for fabrication of the cell and cover plate which shall be designed to safely withstand the maximum test pressure. A rubber or neoprene O-ring or other suitable gasket, seated in matching grooves, shall be used between the cell and the cover plate to render the joint water-tight. Typical details of the permeability cell together with pertinent dimensions for use with test specimens of 100 mm diameter are shown in Fig. 1.

3.2 Water Reservoir — A suitable reservoir may consist of a length of metal pipe, 50 to 100 mm in diameter and about 500 mm long. The reservoir shall be fitted with a graduated side arm gauge-glass, and the necessary fittings and valves for admitting water and compressed air and for draining, bleeding and connection to the permeability cell, as shown in Fig. 2.

NOTE — The choice of reservoir dimensions is necessarily a matter of compromise between the accuracy with which the water entering the specimen can be measured and the adequacy of the capacity. The ideal combination would be the smallest diameter and sufficient length to provide a capacity for at least 24 hours of continuous operation. Lengths greater than about 500 mm may be difficult to handle.



All dimensions in millimetres.

FIG. 1 PERMEABILITY CELL

3.3 Pressure Lines — Heavy duty armoured rubber hose or suitable metal tubing or any other equally suitable hose or pipe shall be used for the various high pressure connections. All joints shall be properly made to render them leakproof.

4. ACCESSORIES

4.1 Supply of Compressed Air — Suitable arrangements shall be made for supplying compressed air at the relevant pressure (*see* **6**) to the permeability cell assemblies. Compressed air cylinders or alternatively a compressor of adequate capacity may be used. Suitable and sensitive regulating valves for holding the pressure within ± 2 percent range of the pressure set at initially on the setup and the companion pressure gauge of nearly same sensitivity shall be provided. Several cells at different operating pressures may be served by a common source as shown in **Fig. 2.**

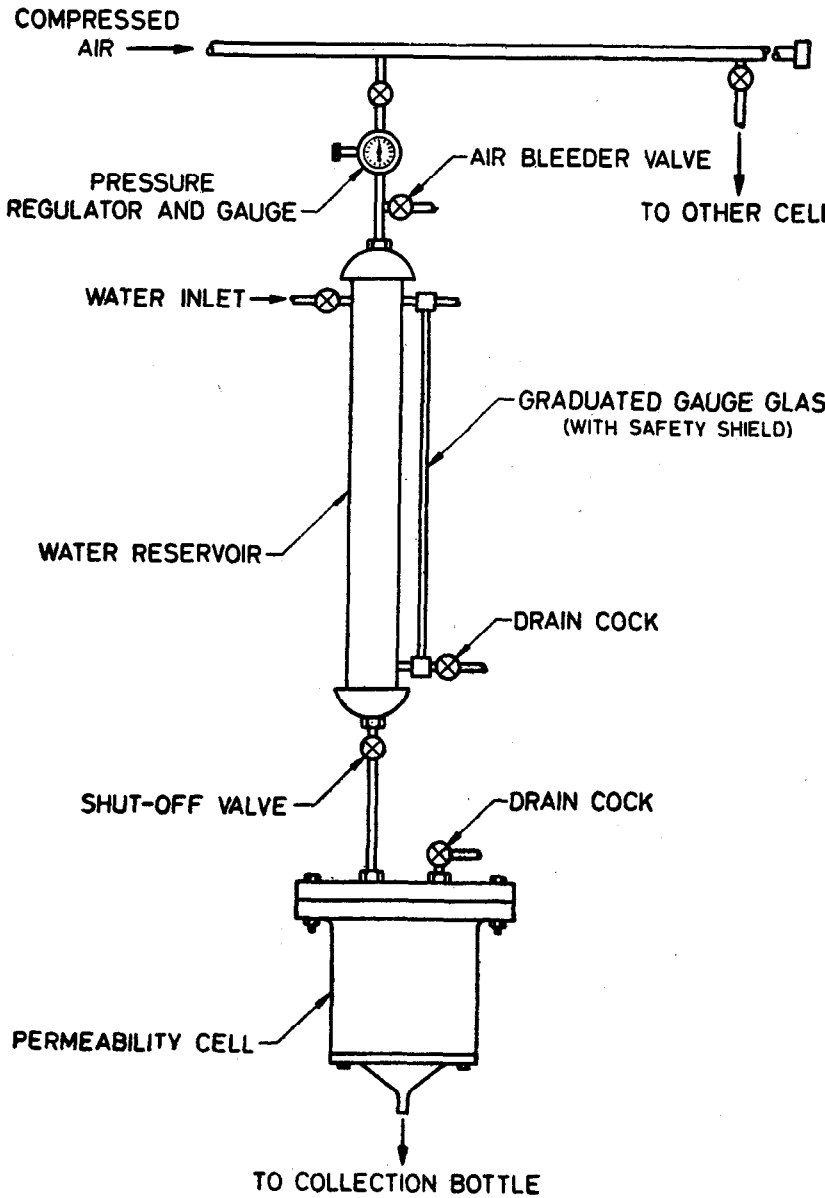


FIG. 2 ARRANGEMENT FOR CONDUCTING PERMEABILITY TEST

4.2 Supply of De-aired Water — An adequate supply of clean de-aired water shall be available for use in the permeability tests. Water may be easily de-aired for this purpose by boiling and cooling. De-aired water may be stored in closed containers, which should, as far as possible, be kept full. Unnecessary agitations and contact with air shall be avoided.

5. TEST SPECIMENS

5.1 Size of Specimens — The specimens shall be cylindrical in shape 100 mm long and 100 mm in diameter. Three test specimens shall constitute a set.

5.2 The specimens shall be cut from the samples with core drills or in any other way which will not induce incipient fracture, but shall not be chipped or broken off with a hammer. After cutting, the ends of the specimens shall be ground plane with water and carborunder or emery, on a cast iron lap until the cylinders are of the size mentioned in **5.1**. The specimen shall be cut with the axis at right angles to the planes of stratification. Wherever possible, polishing of drilled cores should be done by electrical polishing machines for efficient and quick polishing.

5.3 The ends of the cylinders shall be plane surfaces at right angles to the axis of the cylinder.

6. PRESSURE HEAD

6.1 The standard test pressure head to be applied to the water in the reservoir should be 1·1 times the hydraulic head to which the stones under test will be actually subjected.

7. PROCEDURE

7.1 Calibrating the Reservoir — Each reservoir shall be calibrated under 1·10 times the actual pressure to 0·9 times the actual pressure.

7.1.1 With the reservoir drain-cock and the shut-off valve between the reservoir and the cell closed, and with the air bleeder valve shut, the reservoir shall be filled with water. The reservoir drain-cock shall then be opened to flush out any air and closed again. The reservoir shall be refilled to a point above the zero mark of the gauge-glass scale; the bleeder valve shall be closed and the desired air pressure applied. The drain-cock shall be carefully opened to bring the water to the zero mark and quickly closed. Water shall then be drawn off and caught in 250 ml increments in a graduated jar and the level in the gauge-glass read on the scale. The calibration constant for the reservoir shall be expressed in millilitres per division of the scale.

7.2 Sealing the Specimen — The specimen shall be surface-dried and the dimensions measured to the nearest 0·5 mm. It shall then be centred in the cell, with the lower end resting on the ledge*. The annullar space between the specimen and the cell shall be tightly caulked to a depth of about 10 mm using a cotton or hemp cord soaked in a suitable molten sealing compound. The rest of the space shall be carefully filled with the molten sealing compound, level with the top of the specimen. Any drop in the level due to cooling shall be made up, using a heated rod to remelt the solidified compound before pouring fresh material over it. A mixture of 3 parts of resin and 5 parts of paraffin wax by mass is one which may be used for effective seal.

7.3 Testing the Seal — It is essential that the seal is water-tight. This may be checked very conveniently by bolting on the top cover plate, inverting the cell and applying an air pressure of 1 to 2 kgf/cm^2 from below. A little water poured on the exposed face of the specimen is used to detect any leaks through the seal which would show up as bubbles along the ledge. In case of leaks the specimen shall be taken out and resealed.

7.4 Assembling the Apparatus — After a satisfactory seal has been obtained, the funnel shall be secured in position and the cell assembly connected to the water reservoir, as illustrated in Fig. 2. With the air-bleeder valve, the valve between the reservoir and the cell, and the drain-cock in the cell open, de-aired water shall be allowed to enter the reservoir. When water issues freely through the drain-cock, it shall be closed and the water reservoir filled. The reservoir water inlet and air bleeder valves shall then be closed.

7.5 Running the Test — With the system completely filled with water, the desired test pressure (*see* **6**) shall be applied to the water reservoir and the initial reading of the gauge-glass recorded. At the same time a clean collection bottle shall be weighed and placed in position to collect the water percolating through the specimen. The quantity of percolate and the gauge-glass readings shall be recorded at periodic intervals. In the beginning, the rate of intake is larger than the rate of outflow. As the point of steady state of flow is reached, the two rates tend to become equal and the outflow reaches a maximum and stabilizes. With further passage of time, both the inflow and outflow generally register a gradual drop. Permeability test shall be continued for about 100 hours after the steady state of flow has been reached and the outflow shall be considered as average of all the outflows measured during this period of 100 hours.

NOTE — The steady state of flow is defined as the condition in which the rates of inflow and outflow of water are equal. The point of steady state is defined as the time at which this condition is first reached.

*For getting a good perfect seal, preheating of the cylinder at low temperature of 30-35°C for 24 to 30 hours is recommended before test specimen is centred.

7.6 Test Temperature — The test shall preferably be carried out at a temperature of 27 ± 3°C.

7.7 Precautions — There are several precautions which shall be observed, before any dependable estimate of permeability can be obtained from the test data, of these the most important are as follows:

a) The seal around the specimen shall be effective. Leakage through it can give rise to entirely misleading results. Obtaining a good seal is a matter of experience and only a general guidance can be provided.

b) It is important that the air content of the water entering the specimen should not exceed about 0·2 percent. Excessive amounts of dissolved air can result in air locks in the specimen and apparent reduction in permeability. Periodical samples shall be drawn from the cell drain-cock and the dissolved air determined. The system shall be drained and replenished with fresh de-aired water, as soon as the air content exceeds the above limit.

c) The flow should be permitted to attain the steady state before the coefficient of permeability is calculated. Examination of the inflow and outflow rate data or suitable graphs of the same may be used to determine the establishment of the steady state.

d) The observation of outflow from the specimen is liable to be influenced by evaporation of the percolate during collection. The collection bottle may be housed in a humid chamber, or alternatively, blank observations on a similar bottle containing water should be made and the necessary correction for evaporation loss applied. The inflow measurement provides an additional check.

8. CALCULATION

8.1 The quantity percolating in the steady period indicates an equilibrium state. Computation of coefficient of permeability shall be based on this rate.

8.2 The coefficient of permeability shall be calculated from the following formula:

$$K = \frac{Q}{A\,T\,\frac{H}{L}}$$

where

K = coefficient of permeability in cm/sec;

Q = quantity of water in millilitres percolating over the entire period of test after the steady state has been reached;

A = area of the specimen face in cm^2;

T = time in seconds over which Q is measured; and

$\frac{H}{L}$ = ratio of the pressure head to thickness of specimen, both expressed in the same units.

9. REPORT

9.1 The following information shall be included in the report on each specimen:

a) Identification mark of the specimen,

b) Duration of test,

c) Size of specimen,

d) Test pressure,

e) Test temperature,

f) Coefficient of permeability at test temperature,

g) Corrected coefficient of permeability at standard temperature, and

h) Whether permeability increased or decreased with time and at what rate.

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