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*Indian Standard*

**METHOD OF TEST FOR  
PERMEABILITY OF CEMENT MORTAR  
AND CONCRETE**

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

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# *Indian Standard*

## METHOD OF TEST FOR PERMEABILITY OF CEMENT MORTAR AND CONCRETE

### 0. FOREWORD

**0.1** This Indian Standard was adopted by the Indian Standards Institution on 20 April 1965, after the draft finalized by the Cement and Concrete Sectional Committee had been approved by the Civil Engineering Division Council.

**0.2** Permeability of cement mortar or concrete is of particular significance in structures which are intended to retain water or which come into contact with water. Besides functional considerations, permeability is also intimately related to the durability of concrete, specially its resistance against progressive deterioration under exposure to severe climate, and leaching due to prolonged seepage of water, particularly when it contains aggressive gases or minerals in solution. The determination of the permeability characteristics of mortar and concrete, therefore, assumes considerable importance.

**0.3** As the test for the permeability of mortar or concrete falls outside the scope of IS : 516-1959\* and IS : 1199-1959† and in view of its great importance, the Sectional Committee took up the formulation of this standard.

**0.4** In the preparation of this standard, due weightage has been given to the need for international co-ordination among standards prevailing in different countries and the practices that are at present being followed in the country in this field.

**0.5** 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‡. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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\*Method of test for strength of concrete.

†Method of sampling and analysis of concrete.

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

## 1. SCOPE

**1.1** This standard covers the method for determining the permeability of cement mortar and concrete specimens either cast in the laboratory obtained by cutting out cores from existing structures.

## 2. PRINCIPLE

**2.1** The test consists in subjecting the mortar or concrete specimen of known dimensions, contained in a specially designed cell, to a known hydrostatic pressure from one side, measuring the quantity of water percolating through it during a given interval of time and computing the coefficient of permeability as described in **8.1**. The test permits measurement of the water entering the specimen as well as that leaving it.

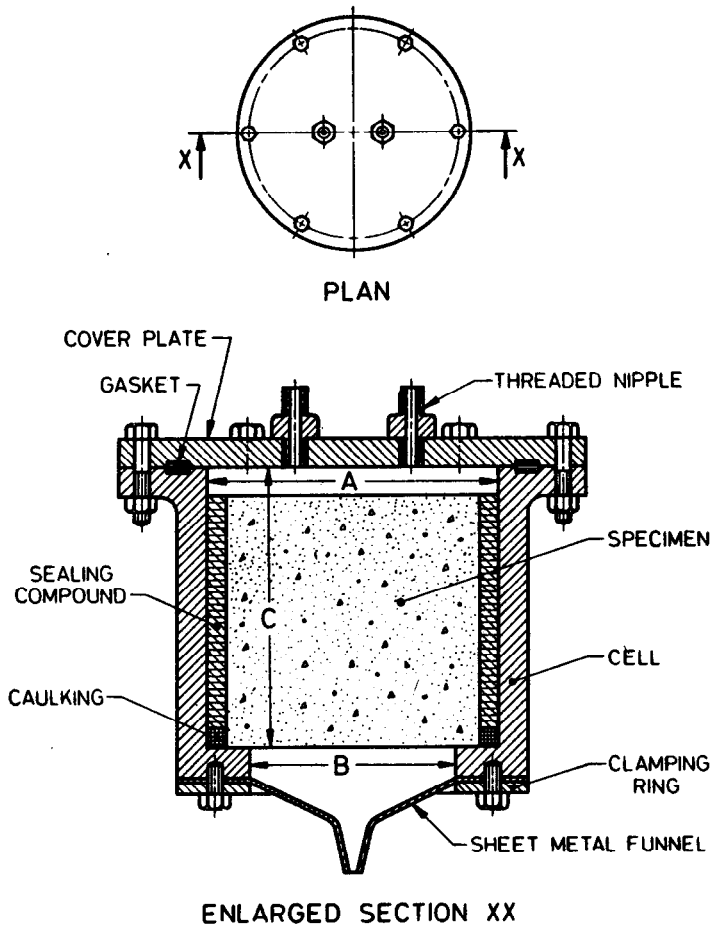
## 3. APPARATUS

**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, aluminium 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 various sizes, 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 much greater than about 500 mm may be difficult to handle.

**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.



SPECIMEN DIA mm	DIMENSION OF CELL, mm		
	A	B	C
100	115	80	110
150	170	120	160
300	330	260	320

FIG. 1 TYPICAL DETAILS OF PERMEABILITY CELL

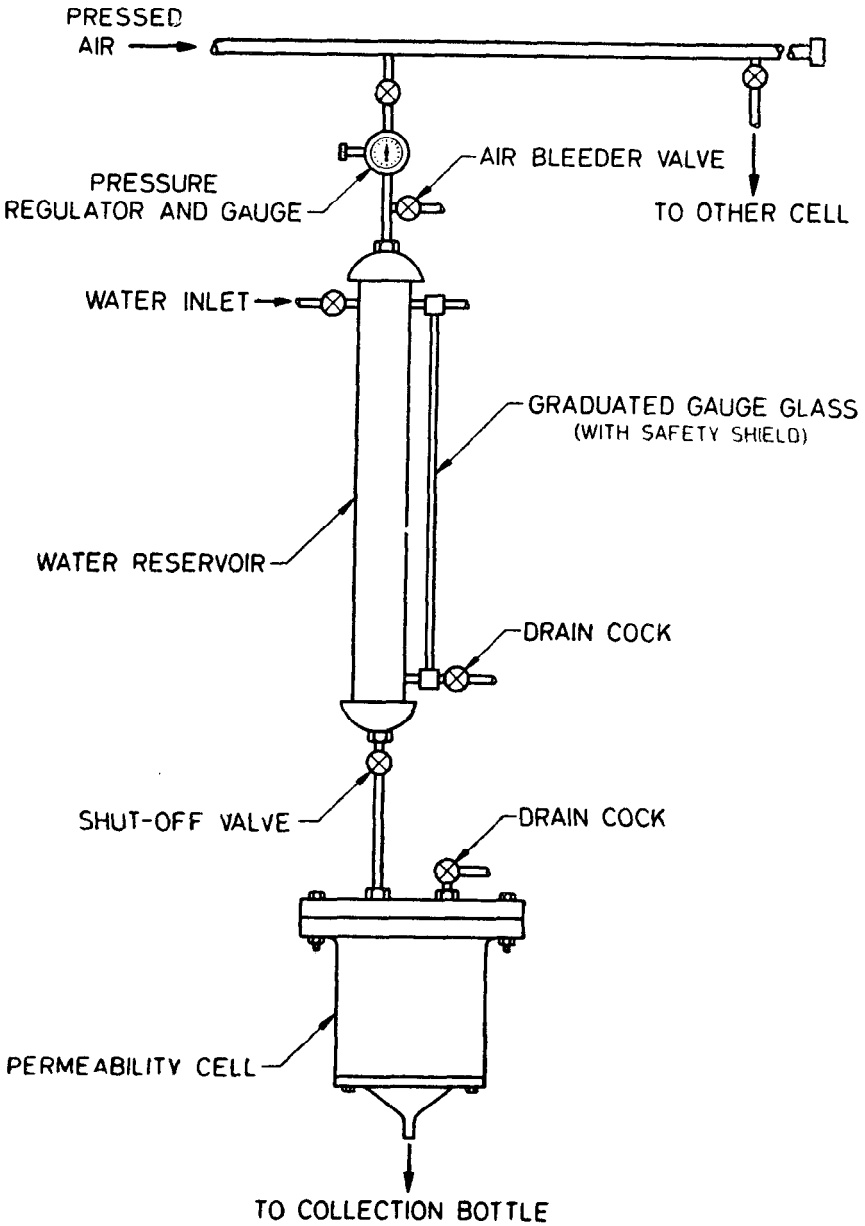


FIG. 2 PERMEABILITY TEST SET-UP (SCHEMATIC)

#### 4. ACCESSORIES

**4.1 Supply of Compressed Air** — Suitable arrangements shall be made for supplying compressed air at  $5 \text{ kg/cm}^2$  to  $15 \text{ kg/cm}^2$  (see 6) to the permeability cell assemblies. Compressed air (or nitrogen) cylinders or alternatively a compressor of adequate capacity may be used. Suitable regulating valves and pressure gauges shall be provided. Several cells at different operating pressures may be served by a common source as shown in Fig. 2.

**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 with height equal to the diameter. The standard size of specimen shall have diameter (and height) of 150 mm. In the case of specimens containing aggregates whose nominal size does not exceed 20 mm, the diameter (and the height) of the specimen may be reduced to 100 mm. In the case of specimens containing aggregates whose nominal size exceeds 40 mm, the diameter (and the height) of the specimen should not be less than about four times the nominal size of the aggregate.

**5.2 Casting and Curing** — The mortar or concrete mix shall be cast in split moulds of the required size, with a removable collar of about half the height set on the top. The material shall be compacted either by hand rodding or vibration, as proposed to be done during construction. The collar shall then be removed and the mould shall be struck off level with a straight-edge using a sawing motion without further travelling or finishing, which might raise the fines to the surface. The specimen shall be cured for 28 days unless otherwise specified by the engineer-in-charge.

#### 6. PRESSURE HEAD

**6.1** The standard test pressure head to be applied to the water in the reservoir should be  $10 \text{ kg/cm}^2$ . This may, however, be reduced up to  $5 \text{ kg/cm}^2$  in the case of relatively more permeable specimens where steady state of flow is obtained in a reasonable time, and may be increased up to  $15 \text{ kg/cm}^2$  for relatively less permeable specimens and where sealing could be ensured to be fully effective.

#### 7. PROCEDURE

**7.1 Calibrating the Reservoir** — Each reservoir shall be calibrated under



the operating pressures of 5 kg/cm<sup>2</sup> to 15 kg/cm<sup>2</sup> (see 6) as indicated below:

With the reservoir drain-cock and the shut-off valve between the reservoir and the cell closed, and with the air bleeder valve open, 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 Preparing the Specimen** — The specimen shall be thoroughly cleaned with a stiff wire brush to remove all laitance. The end faces shall then be sand-blasted or lightly chiselled.

**7.3 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 annular 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 bees-wax and rosin, applied smoking hot, forms an effective seal. The proper proportions are best chosen by trial. Other suitable materials are stearine pitch, marine glue, and various asphaltic compounds.

**7.4 Testing the Seal** — It is essential that the seal is watertight. 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 kg/cm<sup>2</sup> 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.

**7.5 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.

**7.6 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 water intake is larger than the rate of outflow. As the steady state of flow is approached, 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 stage at which the outflow and inflow of water become equal for the first time.

**7.7 Test Temperature** — The test shall preferably be carried out at a temperature of  $27^{\circ} \pm 2^{\circ}\text{C}$ . In case arrangements are not available for maintaining the above temperature, a record shall be maintained of the actual temperature. An approximate correction may be made on the basis that each  $5^{\circ}\text{C}$  increase of temperature above the standard temperature, results in 10 percent increase in the coefficient of permeability and *vice versa*.

**7.8 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

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should be made and the necessary correction for evaporation loss applied. The inflow measurement provides an additional check.

- e) It is very important that the specimen surface is carefully prepared by sand blasting or chiselling, as even a thin highly impervious skin can result in considerable underestimation of the permeability.

### 8. CALCULATION

8.1 The coefficient of permeability shall be calculated as follows:

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

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<sup>2</sup>;

$T$  = 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) Particulars of mix,
- c) Age at commencement of the test,
- d) Duration of test,
- e) Size of specimen,
- f) Test pressure,
- g) Test temperature,
- h) Coefficient of permeability at test temperature, and
- j) Corrected coefficient of permeability at standard temperature.

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