

PERMEABILITY OF CONCRETE

1. Objective: 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.

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. The test permits measurement of the water entering the specimen as well as that leaving it.

2. Apparatus Required:

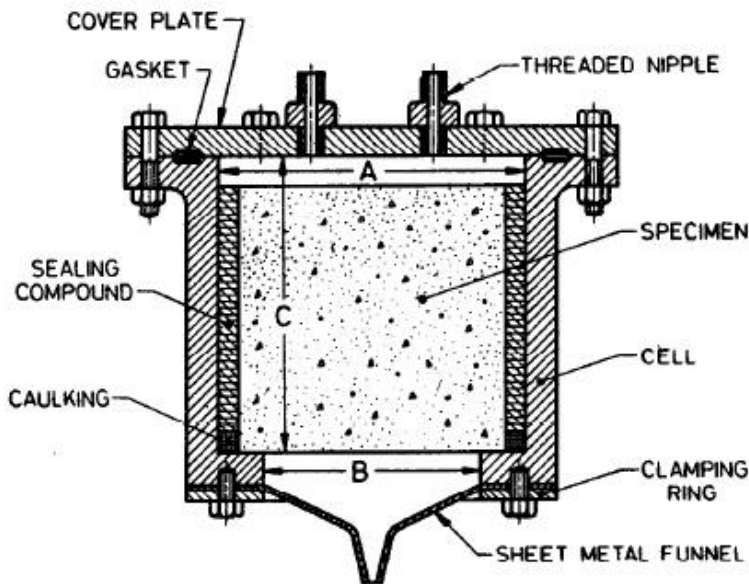


Fig. 1: Concrete Permeability Apparatus

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. 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.

Specimen Diameter (mm)	Dimension of Cell, A (mm)	Dimension of Cell, B (mm)	Dimension of Cell, C (mm)
100	115	80	110
150	170	120	160
300	330	260	320

Table 1: Typical Details of Permeability Cell



Fig. 1: Water Reservoir in Permeability Apparatus

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.

3. Reference: IS 3085:1965 Methods of Test for Permeability of Cement Mortar and Concrete (Seventh revision). Reaffirmed- Dec 2016.

4. Procedure:

A. Preparation of Test Specimen:

1. 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.

2. 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 trovelling 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.

B. Pressure Head:

1. The standard test pressure head to be applied to the water in the reservoir should be 10 kg/cm². This may, however, be reduced up to 5 kg/cm² 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 kg/cm² for relatively less permeable specimens and where sealing could be ensured to be fully effective.

2. 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 milliliters per division of the scale.

C. Sealing of Test 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.

D. 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/cm² 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.

E. 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. 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.

F. Running the Test:

1. With the system completely filled with water, the desired test pressure 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.

2. Test shall preferably be carried out at a temperature of 27°C +/- 2°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°C increase of temperature above the standard temperature, results in 10 percent increase in the coefficient of permeability and vice versa.

5. Calculation: The Coefficient of Permeability shall be calculated as follows:

$$K = Q / (A * T * H / L)$$

where,

K= Coefficient of permeability (cm/sec),

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

A= area of the specimen face in cm²,

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

H/L= ratio of the pressure head to thickness of specimen, both expressed in the same units.

6. Precautions:

1. 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.

2. 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.

3. 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 strata.

4. 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.

5. 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.