भारतीय मानक

Indian Standard

IS 4838 : 2024

प्राकृतिक पारगम्यता का निर्धारण बिल्डिंग स्टोन्स — परीक्षण पद्धतियाँ

(दूसरा पुनरीक्षण)

Determination of Permeability of Natural Building Stones — Methods of Test

(Second Revision)

ICS 91.100.15

भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS
मानक भवन, 9 बहादुर शाह ज़फर मार्ग, नई दिल्ली - 110002
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI - 110002
www.bis.gov.in www.standardsbis.in

June 2024 **Price Group 5**

Stones Sectional Committee, CED 06

FOREWORD

This Indian Standard (Second Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Stone Sectional Committee had been approved by the Civil Engineering Division Council.

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, especially 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 first published in 1967 and revised in 1973. The first revision had been prepared with a view to reviewing its provision with regard to the pressure to which the permeability is to be tested, besides making it up-to-date.

The major modifications in this revision are as follows:

a) The scope has been modified to clarify that the standard covers only the laboratory method of determining permeability;

b) Definition of coefficient of permeability has been added;

c) The definition of bleeding, as relevent in a permeability cell, has been added;

d) The figure of permeability cell has been modified;

e) The need to polish the samples has been removed and instead, the samples have been permitted to be directly cut in the required size;

f) The maximum variation in pressure during the test has been curbed at 5 percent; and it has been added that the apparatus should be able to withstand at least 1.1 times the standard pressure;

g) It has mandated that the water used for the test shall be de-aired and free of air bubbles; and

h) The test condition of the sample shall also be mentioned along with the result.

This standard contributes to the United Nations Sustainable Development Goal 11 ‘Sustainable cities and communities’ towards strengthening the efforts to protect and safeguard the world’s cultural and natural heritage.

The composition of the Committee responsible for formulation of this standard is given in Annex A.

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 : 2022 ‘Rules for rounding off numerical values (*second revision*)’. 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

DETERMINATION OF PERMEABILITY OF NATURAL BUILDING STONES — METHODS OF TEST

(Second Revision)

1 SCOPE

This standard covers a laboratory method for determining the coefficient of permeability of natural building stones.

2 TERMINOLOGY AND DEFINITIONS

2.1 Bleeding — The slow escape or admission of air provided for in a mechanical system (as for equalizing pressure).

2.2 Coefficient of Permeability — The discharge velocity through a unit area of a material under a unit hydraulic gradient.

3 SELECTION OF SAMPLE

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

3.2 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 3.2.1 and 3.2.2 and shall be of adequate size to permit the preparation of the requisite number of test pieces.

3.2.1 *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.

3.2.2 *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.

3.3 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.

4 APPARATUS

4.1 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. Typical details of the permeability cell together with pertinent dimensions for use with test specimens of 100 mm diameter are shown in Fig. 1. The apparatus shall be capable of withstanding a pressure of at least 1.1 times the standard pressure to be applied as per 7.

4.2 Water Reservoir

A suitable reservoir may consist of a length of metal pipe, 50 mm 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.

4.3 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 leak-proof.

5 ACCESSORIES

5.1 Supply of Compressed Air

Suitable arrangements shall be made for supplying compressed air at the relevant pressure (*see* 7) to the permeability cell assemblies. Compressed air cylinders or alternatively a compressor of adequate capacity may be used. Suitable and sensitive regulating valves and pumps for holding the pressure within ± 5 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.

5.2 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.

6 TEST SPECIMENS

6.1 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.

6.2 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. The sample shall be cut to the required size as per **6.1**. The specimen shall be cut with the axis at right angles to the planes of stratification or as per indented application.

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

7 PRESSURE HEAD

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, subject to a minimum of 5kg/cm^2.

8 PROCEDURE

8.1 Calibrating the Reservoir

Each reservoir shall be calibrated under 1.10 times the actual pressure to 0.9 times the actual pressure. 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.

8.2 Sealing the Specimen

The specimen shall be surface-dried and the dimensions measured to the nearest 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 packed 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 re-melt 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.

8.3 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 kgf/cm^2 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.

8.4 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.

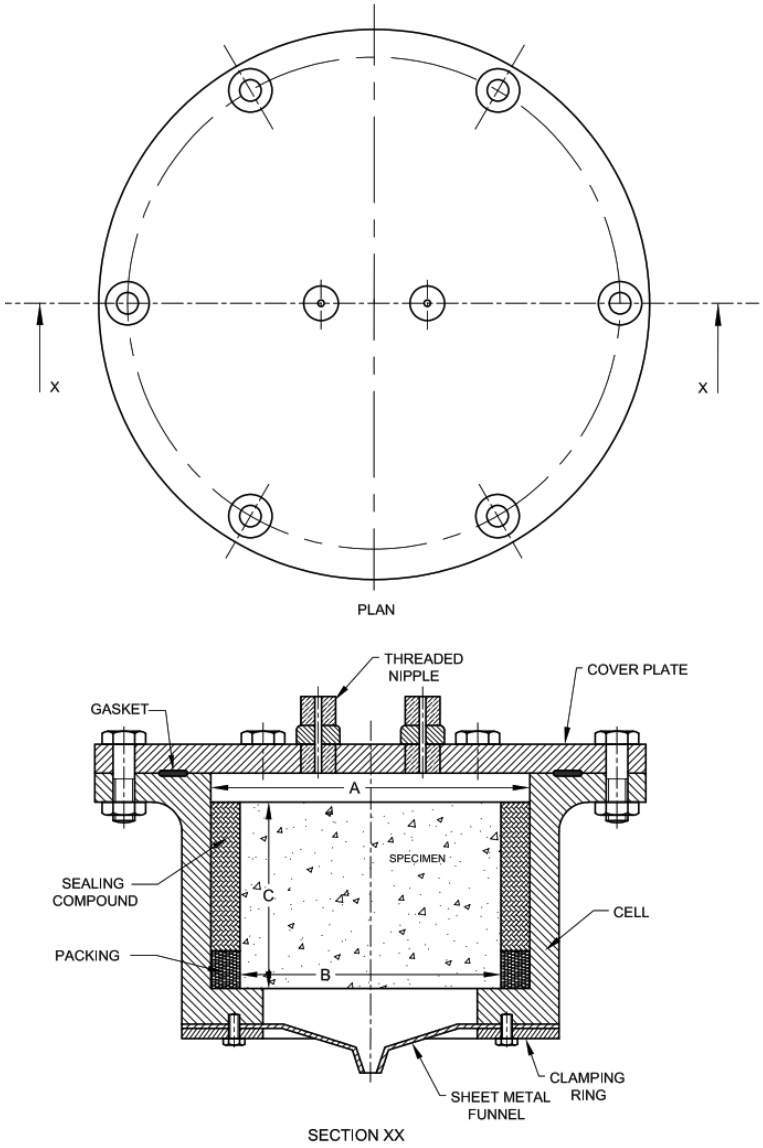

FIG. 1 TYPICAL DETAILS OF PERMEABILITY CELL

Key

A	115 mm
B	110 mm
C	80 mm

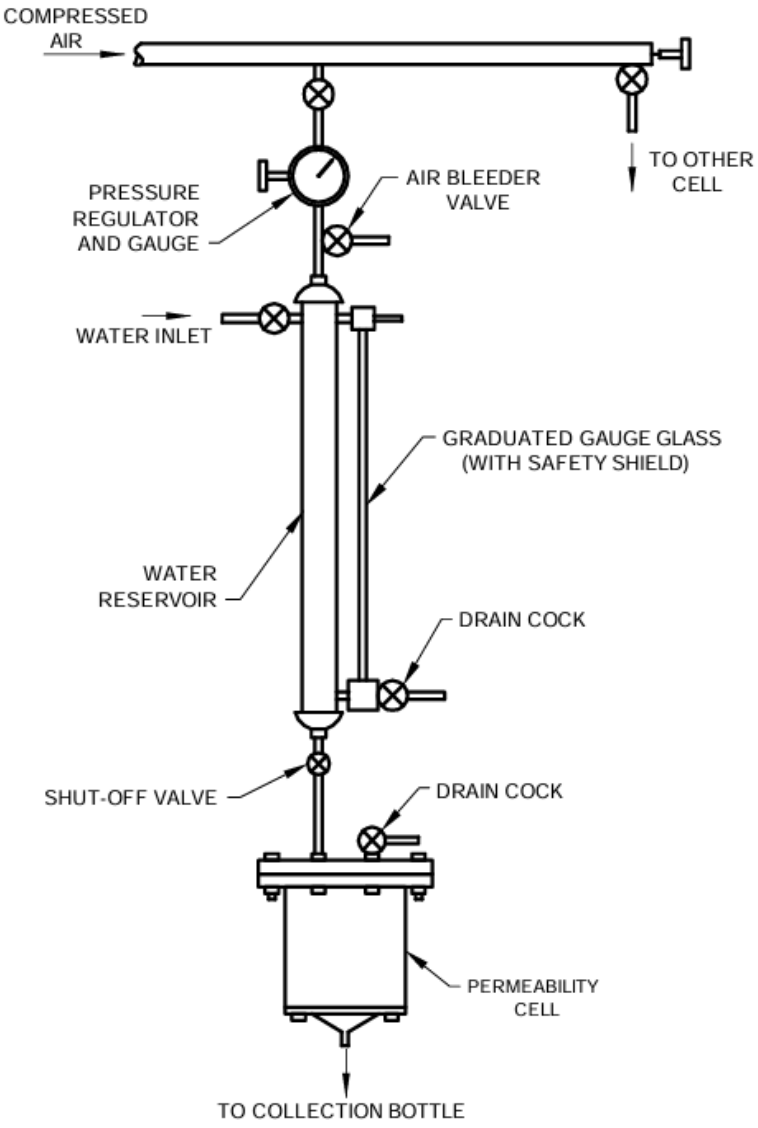

FIG. 2 ARRANGEMENT FOR CONDUCTING PERMEABILITY TEST

8.5 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 h, 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 h.

NOTES

1 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.

2 For getting a good perfect seal, preheating of the cylinder at low temperature of 30 ºC to 35 ºC for 24 h to 30 h is recommended before test specimen is centred.

8.6 Test Temperature

The test shall preferably be carried out at a temperature of 27 ºC ± 3 ºC.

8.7 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 shall be ensured that the water used is de-aired and is free of air bubbles. Excessive amounts of dissolved air can result in air locks in the specimen and apparent reduction in permeability;

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; and

e) There shall be standby arrangement for constant pressure supply. Pressure variation during testing period shall not exceed ± 5 percent.

9 OBSERVATION AND CALCULATION

The following measurements shall be recorded:

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

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

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

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

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

9.2 The coefficient of permeability (k in cm/s) shall be calculated from the following formula:

$$k = \frac{Q}{AT\frac{H}{L}}$$

10 REPORT

10.1 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;
h) Whether permeability increased or decreased with time and at what rate;
j) Test condition of sample parallel to bedding/perpendicular to bedding/ bedding not defined; and
k) Individual and average result reported in 3 significant figures.

ANNEX A

(*Foreword*)

COMMITTEE COMPOSITION

Stone Construction Sectional Committee, CED 06

Organization	*Representative(s)*
Indian Institute of Technology Delhi, New Delhi	DR SHASHANK BISHNOI **(*Chairperson*)**
AIMIL Limited, New Delhi	SHRI ROHITASH BARUA
Central Public Works Department, New Delhi	SHRI K. P. SINGH SHRI PRASHANT SINGH (*Alternate*)
Central Soil and Materials Research Station, New Delhi	SHRI U. S. VIDYARTHI SHRI SACHIN GUPTA (*Alternate*)
Centre for Development of Stones, Jaipur	SHRI MUKUL RASTOGI
Development and Research Organization for Nature, Arts and Heritage, Gurugram	SHRI SANJAY DHAR
Directorate of Geology and Mining, Lucknow	SHRI NAVEEN KUMAR DAS SHRI R. P. SINGH (*Alternate*)
Geological Survey of India, Kolkata	DR DHRUBAJYOTI CHAKRABORTY SHRI RABISANKAR KARMAKAR (*Alternate*)
Indian Institute of Technology Bombay, Mumbai	DR SWATHY MANOHAR
Indian Institute of Technology Delhi, New Delhi	DR DEEPANSHU SHIROLE SHRI AMIT KUMAR (*Alternate*)
Indian Institute of Technology Madras, Chennai	DR MANU SANTHANAM DR ARUN MENON (*Alternate*)
National Council for Cement and Building Materials, Faridabad	DR D. K. PANDA SHRI RICHA MAZUMDER (*Alternate*)
National Institute of Technology Calicut, Kozhikode	DR A. K. KASTURBA DR JAYACHANDRAN K. (*Alternate*)
School of Planning and Architecture, New Delhi	DR S. K. KHANNA DR SHUVOJIT SARKAR (*Alternate* I) SHRI MEHAR KUMAR KANDIPILLI (*Alternate* II)
Shriram Institute for Industrial Research, Delhi	DR MUKESH GARG DR RAMAN DHYANI (*Alternate*)
Stone Technology Centre, Jaipur	SHRI K. VIKRAM RASTOGI
Tamil Nadu Minerals Limited, Chennai	SHRI HENRY ROBERT SHRI S. THANGAPANDIAN (*Alternate* I) SHRI M. RAMESHBABU (*Alternate* II)
Unique Geocivil Services Private Limited, Surat	SHRI HITESH DESAI SHRI NEHAL DESAI (*Alternate*)
In Personal Capacity (*6/KA 16 Jawahar Nagar, Jaipur - 302004*)	SHRI PRADEEP AGARWAL
In Personal Capacity (*13-A Ram Nagar, Roorkee - 247667*)	DR RAJNI LAKHANI
In Personal Capacity (*Flat 119, Amulya Fortune Apartments, Road No 1, Opp. Union Bank, Madhavapuri Hills, Chandanagar, Hyderabad - 500050*)	SHRI K. SITARAMANANJEYULU

Organization	*Representative(s)*
BIS Directorate General	SHRI DWAIPYAN BHADRA, SCIENTIST 'E'/DIRECTOR AND HEAD (CIVIL ENGINEERING) [REPRESENTING DIRECTOR GENERAL (*Ex-officio*)]

Member Secretary
SHRIMATI DIVYA S.
SCIENTIST 'D'/JOINT DIRECTOR
(CIVIL ENGINEERING DEPARTMENT), BIS

Working Group for the Revision of IS 4348

Organization	*Representative(s)*
Indian Institute of Technology Delhi, New Delhi	DR DEEPANSHU SHIROLE
Unique Geocivil Services Private Limited, Surat	SHRI HITESH DESAI
National Institute of Technology Calicut, Kozhikode	DR JAYACHANDRAN K.

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act*, 2016 to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

Copyright

Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the website-www.bis.gov.in or www.standardsbis.in.

This Indian Standard has been developed from Doc No.: CED 06 (24693).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones: 2323 0131, 2323 3375, 2323 9402 *Website*: www.bis.gov.in

Regional Offices:		*Telephones*
Central	: 601/A, Konnectus Tower -1, 6th Floor, DMRC Building, Bhavbhuti Marg, New Delhi 110002	2323 7617
Eastern	: 8th Floor, Plot No 7/7 & 7/8, CP Block, Sector V, Salt Lake, Kolkata, West Bengal 700091	2367 0012 2320 9474
Northern	: Plot No. 4-A, Sector 27-B, Madhya Marg, Chandigarh 160019	265 9930
Southern	: C.I.T. Campus, IV Cross Road, Taramani, Chennai 600113	2254 1442 2254 1216
Western	: Manakalya, 4th Floor, NTH Complex (W Sector), F-10, MIDC, Andheri (East), Mumbai 400093	283 25838

Branches : AHMEDABAD, BENGALURU, BHOPAL, BHUBANESHWAR, CHANDIGARH, CHENNAI, COIMBATORE, DEHRADUN, DELHI, FARIDABAD, GHAZIABAD, GUWAHATI, HARYNA, HUBLI, HYDERABAD, JAIPUR, JAMMU & KASHMIR, JAMSHEDPUR, KOCHI, KOLKATA, LUCKNOW, MADURAI, MUMBAI, NAGPUR, NOIDA, PARWANOO, PATNA, PUNE, RAIPUR, RAJKOT, SURAT, VIJAYAWADA.

Published by BIS, New Delhi