व्यापक परिचालन मसौदा

हमारा संदर्भः सीईडी 48/टी-28   **25 नवंबर 2024**

तकनीकी समिति: रॉक मैकेनिक्स विषय समिति**, सीईडी 48**

प्राप्तकर्ता :

क) सिविल इंजीनियरी विभाग परिषद्, सीईडीसी के सभी सदस्य

ख) सीईडी 48 के सभी सदस्य

ग) रूचि रखने वाले अन्य निकाय

प्रिय महोदय/महोदया,

निम्नलिखित भारतीय मानक का मसौदा संलग्न है:

प्रलेख संख्या	शीर्षक
सीईडी 48 (26974)WC	**शैल सामग्री के जलांश, सरंध्रता, घनत्व एवं संबंधित गुण धर्मों का प्रयोगशाला निर्धारण — परीक्षण की पद्धति का भारतीय मानक मसौदा** (IS 13030 का *पहला पुनरीक्षण*) ICS 91.100.30

कृपया इस मानक के मसौदे का अवलोकन करें और अपनी सम्मतियाँ यह बताते हुए भेजे कि यदि यह मानक के रूप में प्रकाशित हो तो इस पर अमल करने में आपके व्यवसाय अथवा कारोबार में क्या कठिनाइयाँ आ सकती हैं ।

सम्मतियाँ भेजने की अंतिम तिथि : **26 दिसंबर 2024**

सम्मति यदि कोई हो तो कृपया अधोहस्ताक्षरी को उपरिलिखित पते पर संलग्न फोर्मेट में भेजें या manoj@bis.gov.in पर ईमेल कर दें ।

यदि कोई सम्मति प्राप्त नही होती है अथवा सम्मति में केवल भाषा सम्बन्धी त्रुटि हुई तो उपरोक्त प्रलेख को यथावत अंतिम रूप दिया जाएगा। यदि सम्मित तकनीकी प्रकृति की हुई विषय समिति के अध्यक्ष के परामर्श से अथवा उनकी इच्छा पर आगे की कार्यवाही के लिए विषय समिति को भेजे जाने के बाद प्रलेख को अंतिम रूप दे दिया जाएगा ।

यह प्रलेख भारतीय मानक ब्यूरो की वैबसाइट www.bis.gov.in पर भी उपलब्ध हैं।

धन्यवाद ।

भवदीय,

(द्वैपायन भद्र)
प्रमुख (सिविल इंजीनियरी)

संलग्नक : उपरिलिखित

DRAFT IN WIDE CIRCULATION

Ref: CED 48/T-28   **25 December 2024**

TECHNICAL COMMITTEE: Rock Mechanics Sectional Committee, CED 48

ADDRESSED TO:

   a) All Members of Civil Engineering Division Council, CEDC
   b) All Members of CED 48
   c) All others interests.

Dear Sir/Madam,

      Please find enclosed the following document:

Doc No.	Title
CED 48 (26974)WC	**Draft Indian Standard** **Laboratory Determination of Water Content, Porosity, Density and Related Properties of Rock Material — Method of Test** (*First Revision* of IS 13030) ICS 91.100.30

      Kindly examine the draft standard and forward your views stating any difficulties, which you are likely to experience in your business or profession, if this is finally adopted as National Standard.

      Last Date for comments**: 26 December 2024**

      Comments if any may please be made in the attached format and mailed to the undersigned at the above address or preferably through e-mail to manoj@bis.gov.in.

      In case no comments are received or comments received are of editorial nature, you may kindly permit us to presume your approval for the above document as finalized. However, in case of comments of technical in nature are received then it may be finalized either in consultation with the Chairman, Sectional Committee or referred to the Sectional Committee for further necessary action if so desired by the Chairman, Sectional Committee.

      The document is also hosted on BIS website **www.bis.gov.in.**

      Thanking you,

                                                                                           Yours faithfully,

                                                                            (**Dwaipayan Bhadra**)
                                                                           Head (Civil Engineering)

Encl: As above

FORMAT FOR SENDING COMMENTS ON BIS DOCUMENTS

(Please use A-4 size sheet of paper only and type within fields indicated. Comments on each clause/sub-clause/table/fig etc. be started on a fresh box. Information in column 3 should include reasons for the comments and suggestions for modified working of the clauses when the existing text is found not acceptable. Adherence to this format facilitates Secretariat's work) (Please e-mail your comments to manoj@bis.gov.in)

Doc. No.: CED 48 (26974)WC

Title: **Draft Indian Standard Laboratory Determination of Water Content, Porosity, Density and Related Properties of Rock Material — Method of Test**
(*First Revision* of IS 13030) ICS 91.100.30

LAST DATE OF COMMENT: **26 December 2024**

NAME OF THE COMMENTATOR/ORGANIZATION: _____

Sl. No.	Clause/Para/Table/ Figure No. Commented	Comments/Modified Wordings	Justification of the Proposed Change

BUREAU OF INDIAN STANDARDS

DRAFT FOR COMMENTS ONLY

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Draft Indian Standard

**LABORATORY DETERMINATION OF WATER CONTENT,
POROSITY, DENSITY AND RELATED PROPERTIES OF
ROCK MATERIAL — METHOD OF TEST**

(*First Revision* of IS 13030)
ICS 91.100.30

Rock Mechanics	Last date of Comments:
Sectional Committee, CED 48	**26 December 2024**

FOREWORD

(*Formal clauses will be added later*)

The presence of pores in fabric of a rock material decreases its strength and increases its deformability. A small volume fraction of pores can produce an appreciable mechanical effect.

Information on the porous nature of rock materials is frequently omitted from petrological descriptions but is required if these descriptions are to be used as a guide to mechanical performance. Sand stones and carbonate rocks in particular occur with a wide range of porosities and hence of mechanical character; igneous rocks that have been weakened by weathering processes also have typically high porosities.

Most rocks have similar grain densities and therefore have porosity and dry density values that are highly correlated. A low-density rock is usually highly porous. It is often sufficient, therefore, to quote values for porosity alone but a complete description requires values for both porosity and density.

Different methods of determination of density and porosity described in the standard are suitable for different types of rocks and sample. While method using saturation and caliper technique and using saturation and buoyancy technique are suitable for regular and irregular shape of sample respectively of those rocks which do not appreciably swell or disintegrate when immersed in water, the method using mercury displacement and grain specific gravity technique is suitable for irregular shape of such rock which are liable to swell or disintegrate when immersed in water.

These methods are based on the suggested method of International Society of Rock Mechanics.

This Standard was first published in 1991. This revision of the standard has been brought out based on the experience gained in use of the standard since its last revision. In this revision, the following major modifications have been mode:

    a) Guidelines for testing of rock containing gypsum or other minerals having loosely bound water of hydration or rock containing significant amounts of organic material has been included;

    b) Elaborated and clarified the procedure for obtaining the constant mass, in view of the difficulty present due to voids in the rocks;

    c) Consideration has been included in view of the fact that the voids present in the rock are not fully interconnected, so actual volume of voids is difficult to obtain; and

    d) Reference of Indian Standards has been updated.

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.

Draft Indian Standard

**LABORATORY DETERMINATION OF WATER CONTENT,
POROSITY, DENSITY AND RELATED PROPERTIES OF
ROCK MATERIAL — METHOD OF TEST**

(First Revision)

1 SCOPE

This standard gives the procedure for the test to evaluate water content, porosity, density and related properties of rock material. The following test methods have been covered:

a) Determination of the water content of rock sample;
b) Determination of porosity and density using saturation and caliper technique;
c) Determination of porosity and density using saturation and buoyancy; and
d) Determination of porosity and density using mercury displacement and grain specific gravity technique.

2 DEFINITIONS AND SYMBOLS

2.1 Symbols

For the purpose of this standard unless otherwise defined in the text, the following symbols shall apply:

M_g = Mass of grain (the solid component of the sample);
V_g = Volume of grain;
M_w = Mass of pore water;
V_w = Volume of pore water;
ρ_w = Density of water; and
V_a = Volume of pore air.

2.2 Definitions

For the purpose of this standard, physical properties pertinent to the methods of test shall be described as follow.

2.2.1 *Bulk Sample Mass* — $M = M_s + M_w$

2.2.2 *Bulk Sample Volume* — $V = V_s + V_v$

2.2.3 *Degree of Saturation* — $S_r = \frac{V_w}{V_v} \times 100$ (percent)

2.2.4 *Density or Bulk Density or Mass Density* — $(\rho) = \frac{M}{V} = \frac{M_s + M_w}{V}$ kg/m³

2.2.5 *Dry Density —* $\rho d = \frac{M_s}{V}$ kg/m^3

2.2.6 *Dry Relative Density —* (dry specific gravity) $G_d = \frac{\rho_d}{\rho_w}$

2.2.7 *Pore (Voids) Volume —* $V_v = V_w + V_a$

2.2.8 *Porosity —* $n = \frac{V_v}{V} \times 100$ (percent)

2.2.9 *Relative Density —* (mass specific gravity) $G_m = \frac{\rho}{\rho_w}$

2.2.10 *Saturated Density —* $\rho_{sat} = \frac{M_s + V_v \cdot \rho_w}{V}$ kg/m^3

2.2.11 *Saturated Relative Density —* (saturated specific gravity) $G_{sat} = \frac{\rho_{sat}}{\rho_w}$

2.2.12 *Solid Density or Density of Rock Material —* $\rho_s = \frac{M_s}{V_s}$ kg/m^3

2.2.13 *Solid Relative Density —* (solid specific gravity) $G_s = \frac{\rho_s}{\rho_w}$

2.2.14 *Unit Weight —* $\gamma = \rho \times g$ N/m^3

2.2.15 *Void Ratio —* $e = \frac{V_v}{V_s}$

2.2.16 *Water Content —* $w = \frac{M_w}{M_s} \times 100$ (percent)

3 TEST SAMPLE

A representative sample for testing should generally comprise several rock lumps, each in order of magnitude larger than the largest grain or pore size. Micro fissures of similar size to that of a rock will cause erratic results, their presence should be noted and if possible, the lump size increased or reduced to specifically include or exclude the influence of such fissures.

The following should be taken in to consideration while preparation and testing of sample for methods given in this Indian Standard:

  a) In the actual testing it is difficult to achieve fully saturated or fully dried condition for the rock specimen, as the voids in most of the rocks are not interconnected, because of which neither 100 percent voids can be filled with water nor can be taken out. Therefore, the assessment of volume of voids, through any of the methods mentioned in this Indian Standard, cannot be actual volume of voids available in the rock specimen, it is always apparent volume of void;
  b) In case of rock containing gypsum or other minerals having loosely bound water of hydration or rock containing significant amounts of organic material the sample should be dried to constant mass at a temperature of 60 °C ± 3 °C; and

c) Wherever, the saturating and drying processes are involved, it needs to be ensured that the sample is fully saturated/dried to the extent possible. This can be ensured by determining the difference of weight is not more ± 0.1 percent in three consecutive readings.

4 DETERMINATION OF THE WATER CONTENT OF A ROCK SAMPLE

4.1 Object

This method of test covers the procedure of determining the mass of water contained in a rock sample as a percentage of the oven dry sample mass.

4.2 Apparatus

a) An oven capable of maintaining a temperature of 105 °C ± 3 °C for a period of at least 24 h;
b) A sample container non-corrodible material including an airtight lid;
c) A desiccator to hold sample container during cooling; and
d) A balance of adequate capacity, capable of weighing to an accuracy of 0.01 percent of the sample mass.

4.3 Procedure

4.3.1 The container with its lid is cleaned and dried, and its mass m_1 is determined.

4.3.2 A representative sample comprised at least 10 lumps each having either a mass of at least 50 g or a minimum dimension of ten times the maximum grain size, whichever is greater, is selected. For *in-situ* water content determination sampling, storage and handling precautions should be such that water content remains within 1 percent of the *in-situ* value.

4.3.3 The sample is placed in the container, the lid replaced and the mass m_2 of the sample plus container determined.

4.3.4 The lid is removed and the sample dried to constant mass at a temperature of 105 °C ± 3 °C.

4.3.5 The lid is replaced and the sample allowed to cool in the desiccator for 30 min. The mass m_3 of sample plus container is determined.

4.4 Calculation and Reporting of Results

4.4.1 The water content shall be calculated from the following formula:

$$\text{Water content,} \, w = \frac{\text{Power water mass } M_w}{\text{Grain mass } M_s} \times 100 \text{ (percent)}$$

$$= \frac{m_2 - m_3}{m_3 - m_1} \times 100 \text{ (percent)}$$

where
     m_1 = Mass in g of the container with its lid at room temperature;
     m_2 = Mass in g of the container with its lid and the sample at room temperature; and
     m_3 = Mass in g of the container with its lid and the sample after drying.

4.4.2 The water content should be reported to the nearest 0.1 percent stating whether this corresponds to *in-situ* water content, in which case precautions taken to retain water during sampling and storage should be specified.

5 POROSITY AND DENSITY DETERMINATION USING SATURATION AND CALIPER TECHNIQUES

5.1 Object

5.1.1 This method of test covers the procedure for determining the porosity and dry density of rock samples in the form of specimen of regular geometry.

5.1.2 The method is applicable only to non-friable coherent rocks that can be machined and do not appreciably swell or disintegrate when they are oven dried or are immersed in water. The method is suitable when regularly shaped specimens are required for other test purposes.

5.2 Apparatus

a) An oven capable of maintaining a temperature of 105 °C ± 3 °C for a period of at least 24 h;
b) A desiccator to hold specimen during cooling;
c) A measuring instrument such as vernier or micrometer caliper, capable of reading specimen dimensions to an accuracy of 0.1 mm;
d) Vacuum saturation equipment such that the specimen can be immersed in water under a vacuum of less than 0.8 kPa (0.008 kg/cm^2) for a period of at least 1 h;
e) A sample container of non-corrodible material, including an airtight lid; and
f) A balance of adequate capacity for determining the mass of a specimen to an accuracy of 0.01 percent of the specimen mass.

5.3 Procedure

5.3.1 Select at least three specimens from a representative sample of material. Machine each specimen to conform closely to the geometry of a right cylinder or prism. The minimum size of each specimen should either be such that its mass is at least 50 g (for an average density rock a cube with sides of 27 mm will have sufficient mass) or such that its minimum dimension is at least ten times the maximum grain size, whichever is the greater.

5.3.2 Repeat the following procedure for each of the specimen in the sample:

a) Determine the external dimension and then bulk volume V of each specimen with the vernier or calipers. Measurement should be accurate to 0.1 mm. An average of three separate measurement should be obtained for each dimension;
b) Place the specimen in an oven and dry at 105 °C ± 3 °C. For this test method specimens should be of sufficient coherence not to require containers, but these should be used if the rock is at all friable or fissible. The specimen is deemed to be dry when the difference between successive determinations of mass of the cooled specimen at intervals of 4 h does not exceed 0.1 percent of the original mass of the specimen;
c) Remove the specimen from the oven and place in a desiccator to cool;

d) Determine the dry mass, M_s, of the specimen;

e) Immerse the specimen in a container of water and place the container with the specimen in a vacuum of less than 0.8 kPa for a period of one hour with periodic agitation to remove trapped air;

f) Determine the water temperature, t, to the nearest degree centigrade;

g) Remove the specimen from the container and surface dry it using a moist cloth. Care should be taken to remove only surface water and to ensure that no fragments are lost; and

j) Determine the saturation mass, M_{sat}, of the specimen.

5.4 Calculations

a) For each specimen calculate the pore volume, V_v, by the following formula:

$$V_v = \frac{M_{sat} - M_s}{\rho_w}$$

where

ρ_w = density of water at temperature, t.

b) For each specimen calculate the bulk volume, V, from the external dimensions;

c) For each specimen calculate the dry density, ρ_d, by the following formula:

$$\rho_d = \frac{M_s}{V} \ (kg/m^3)$$

d) For each specimen calculate the porosity, n, by the following formula:

$$n = \frac{V_v}{V} \times 100 \ (percent)$$

e) Calculate average values of porosity and dry density for the sample.

5.5 Reporting of Results

a) Report the individual dry density and porosity values for each specimen in the sample, together with the average values of dry density and porosity for the sample. Density values should be given to the nearest 10 kg/m^3 and porosity values to the nearest 0.1 percent;

b) Report that the bulk volume was obtained by measurement of dimension by caliper or vernier and the pore volume was obtained by water saturation;

c) Record any change in the shape and size of the rock specimen during wetting or drying; and

d) Record the following general information:
1) Project title;
2) Sampling technique and sample identifications number;
3) Dates of sampling and of testing; and
4) Lithological description of the rock samples.

6 POROSITY AND DENSITY DETERMINATION USING SATURATION AND BUOYANCY TECHNIQUES

6.1 Object

This method of test covers the procedure for determining the porosity and the dry density of a rock sample in the form of lumps or aggregate of irregular shape-geometry. It may also be applied to a sample in the form of specimens of irregular geometry.

6.1.1 The method should only be used for rocks that do not appreciably swell or disintegrate when oven-dried and immersed in water.

6.2 Apparatus

a) An oven capable of maintaining a temperature of 105 °C ± 3 °C for a period of at least 24 h;
b) A sample container of non-corrodible material, including an air-tight lid;
c) A desiccator to hold sample container during cooling;
d) A vacuum vessel such that the sample can be immersed in water under a vacuum of less than 0.8 kPa for a period of at least 1 h;
e) A balance of adequate capacity, capable of weighing to an accuracy of 0.01 percent of the sample weight; and
f) An immersion bath and a wire basket or perforated container, such that the sample immersed in water can be freely suspended from the stirrup of the balance to determine the saturated-submerged weight. The basket should be suspended from the balance by a fine wire so that only the wire intersects the water surface in the immersion bath.

6.3 Procedure

a) A representative sample comprising at least 10 lumps of regular or irregular geometry, each having either a mass of at least 50 g or a minimum dimension of at least 10 times the maximum grain size, whichever is the greater, is selected. The sample is washed in water to remove dust;
b) The sample is saturated by water immersion in a vacuum of less than 0.8 kPa for a period of at least 1 h, with periodic agitation to remove trapped air;
c) Determine the temperature, t, of the water in the immersion bath to the nearest degree centigrade;
d) Determine the mass, M_1, of the basket submerged in the immersion bath;
e) Transfer the sample under water to the basket in the immersion bath. Determine the saturated-submerged mass, M_2, of the basket plus sample to an accuracy of 0.01 percent of the sample mass;
f) Determine the mass, M_3, of a clean, dry sample container and lid;
g) Remove the sample from the immersion bath and surface dry the sample with a moist cloth, care being taken to remove only surface water and to ensure that no rock fragment are lost. Transfer the sample to the sample container and replace the lid. Determine the mass, M_4, of the saturated surface dry sample plus container;
h) Remove the lid and place the container with contents and lid in the oven and dry at 105 °C ± 3 °C. The sample is deemed to be dry when the difference between successive determination of mass of the cooled sample at interval of 4 h does not exceed 0.1 percent of the original mass of the sample;
j) Replace the lid, remove the container from the oven and place the whole in the desiccator to cool for 30 min; and
k) Determine the dried mass, M_5, of the container with the oven dry sample.

6.4 Observations

Sample No.   **Date**

Temperature of water, t, in Centigrade

Sl No.	*Determination No.*	(1)	(2)	(3)
(1)	(2)	(3)	(4)	(5)
i)	Saturated-submerged mass of basket alone, M_1 in kg			
ii)	Saturated-submerged mass of basket + specimen, M_2 in kg			
iii)	Mass of container and lid, M_3 in kg			
iv)	Saturated surface dry mass of the sample plus container, M_4 in kg			
v)	Dried mass of the container with sample, M_5 in kg			

6.5 Calculations

a) Calculate the saturated-submerged mass, M_{sub}, of the sample:

$$M_{\text{sub}} = M_2 - M_1 (\text{kg})$$

b) Calculate the saturated-surface-dry mass, M_{sat}, of the sample:

$$M_{\text{sat}} = M_4 - M_3 \ (\text{kg})$$

c) Calculate the dry mass (Grain Weight) M_s, of the sample:

$$M_s = M_5 - M_3 \ (\text{kg})$$

d) Calculate the bulk-volume, V, of the sample by the following formula:

$$V = \left(\frac{M_{\text{sat}} - M_{\text{sub}}}{\rho_w}\right) (\text{m}^3)$$

ρ_w = density of water at temperature t

e) Calculate the pore volume, V_v, of the sample by following formula:

$$V = \left(\frac{M_{\text{sat}} - M_s}{\rho_w}\right) (\text{m}^3)$$

f) Calculate porosity, n, of the rock sample by the following formula :

$$n = (V_v / V) \times 100 \ (\text{percent})$$

$$\text{or} = \left(\frac{M_{\text{sat}} - M_s}{M_{\text{sat}} - M_{\text{sub}}}\right) \times 100 \ (\text{percent})$$

g) Calculate the dry density, Pa, of the rock sample by the following formula:

$$\rho_\mathrm{d} = \frac{M_\mathrm{s}}{V}\,(\mathrm{kg/m^3})$$

6.6 Reporting of Result

a) Report the porosity and dry density values or the sample to the nearest 0.1 percent and 10 kg/m^3 respectively;
b) Report that the bulk volume was obtained by a buoyancy technique and that the pore volume was obtained by water saturation; and
c) Report the following general information:
   1) Project title;
   2) Sampling technique and sample identification numbers;
   3) Date of sampling and testing; and
   4) Lithological description of the rock samples.

7 POROSITY AND DENSITY DETERMINATION USING MERCURY DISPLACEMENT AND GRAIN SPECIFIC GRAVITY TECHNIQUES

7.1 Object

a) This method of test covers the procedure for determining the porosity and the density of a rock sample in the form of lumps or aggregate of irregular geometry; and
b) This is particularly suitable if the rock material is liable to swell or disintegrate if immersed in water. The test is also applicable to regularly shaped rock specimens or to coherent rock materials but other techniques are usually found more convenient in these cases.

7.2 Apparatus

a) An oven capable of maintaining a temperature of 105 °C ± 3 °C for a period of at least 24 h. It should have forced ventilation exhausting to outside atmosphere;
b) Specimen containers of non-corrodible material, including airtight lids;
c) A desiccator to hold specimen containers during cooling;
d) A balance of adequate capacity, capable of mass determination to 0.01 percent of sample mass;
e) A mercury-displacement volume measuring apparatus capable of measuring specimen volume to 0.5 percent;
f) Grinding equipment to reduce the sample to a pulverized powder less than 150 mm in grain size;
g) A calibrated volumetric flask and stopper (conveniently 50 cm^3);
h) A constant temperature water bath;
j) A vacuum apparatus capable of maintaining a vacuum with a pressure of less than 0.8 kPa; and
k) A soft brush of camel hair or of similar softness.

7.3 Procedure

a) A representative sample is selected comprising at least ten rock lumps, the shape and size of lumps suiting the capabilities of the volume measuring apparatus. The minimum size of each lump should preferably be either such that its mass exceeds 50 g or such that its minimum dimension is at least 10 times the maximum grain size, whichever is the greater. Specimen and swelling or fissible rock should be sampled and stoned to retain water content to within 1 percent of its *in-situ* value prior to testing;

b) Repeat the following procedure for each of the specimens in the sample:

  1) Brush each specimen to remove loose material and measure its volume, V, by mercury displacement;

  2) Carefully remove mercury adhering to the sample, ensuring that no rock fragment are lost;

  3) Determine the mass, M_1, of a suitable clean, dry, container and its lid;

  4) Place the specimen in the container, replace the lid and determine the mass, M_2 of the container plus specimen at initial water content; and

  5) Remove the lid and the specimen is oven dried to constant mass at a temperature of 105 °C ± 3 °C allowed to cool for 30 min in a desiccator. The mass, M_3, of container plus oven dry specimen is determined.

c) Crush all the rock specimens and grind to a grain size not exceeding 150 mm. A number of representative sub-samples of about 15 g of the pulverized material are selected and oven-dried;

d) Determine the mass, M_4, of a clean, dry volumetric flask plus stopper to an accuracy of 0.001 g;

e) Fill the flask with a liquid such as kerosene that is non-reactive with the rock;

f) Bring the flask to equilibrium temperature in the constant temperature bath and adjust the liquid level accurately to the 50 cm^3 graduation. Remove the flask from the constant temperature bath, insert the stopper and clean and dry the outside of the flask;

g) Determine the mass, M_5, of the flask and liquid to an accuracy of 0.01 percent of the total mass;

h) Empty and dry the flask and add the representative 15 g sub-sample of dry pulverized rock with the aid of a funnel;

j) Determine the mass, M_6, of flask, sample and stopper to an accuracy of 0.001 g;

k) The flask and sub-sample are evacuated for about 20 min and sufficient fluid added to thoroughly wet the sample. Further fluid is then added and the flask is carefully evacuated to remove air. The flask is replaced in the constant temperature water bath and the liquid level adjusted accurately to the 50 cm^3 graduation;

m) The stoppered flask with its contents is allowed to cool and its mass, G, is determined to 0.01 percent of the total mass; and

n) Steps (e) to (m) are repeated for each subsample of pulverized material.

7.4 Precautions

a) It is preferable to use self-indicating silica gel as the desiccant;

b) Metallic mercury is a toxic material and should be handled with considerable care. It is principally absorbed via the respiratory tract as elemental mercury vapour but there is also some absorption through the gastro-intestinal tract. Spillages are difficult to clean up completely owing to the propensity of the substance, if left, to divide into miniscue globules, which can generate unacceptably high levels of mercury vapour in the atmosphere of a room. Tests should be carried out in fume cupboard to avoid accumulation of vapour, and mercury spillages

should be liberally sprinkled with powdered sulphur which takes up the metallic mercury to form the less volatile sulphide; and

c) The density of some non-reactive liquids may vary appreciably. It is essential that a consistent source of liquid is used for each test and that volumes are adjusted in the constant temperature bath.

7.5 Observations

Sample No.				Date	

Sl No.	*Specimen No.*	(1)	(2)	(3)
(1)	(2)	(3)	(4)	(5)
i)	Bulk volume of specimen by mercury displacement, V, in m^3			
ii)	Mass of dry container plus lid, M_2 in kg			
iii)	Mass of the container and sample, + lid, M_2 in kg			
iv)	Mass of the container and oven dried sample, + lid, M_3 in kg			
v)	Mass of the dry flask (volumetric) and stopper, M_4 in kg			
vi)	Mass of volumetric flask plus liquid stopper, M_5 in kg			
vii)	Mass of flask, stopper and sample, M_6 in kg			
viii)	Mass of flask, sample liquid + stopper, M_7 in kg			
ix)	Wet mass of sample $= M_2 - M_1$ (kg)			
x)	Dry mass of sample $M_s = M_3 - M_1$ (kg)			
xi)	Mass of water in the sample $= M_2 - M_3$ (kg)			
xii)	Moisture content $w = \dfrac{M_2 - M_3}{M_2 - M_s} \times 100$ (percent)			

7.6 Calculations

a) Calculate the grain density, ρ_s, of the pulverized rock material by the following formula:

$$\rho_s = \frac{M_6 - M_4}{V_f\left[1 - \left(\frac{M_7 - M_5}{M_5 - M_4}\right)\right]} \ (\text{kg/m}^3)$$

where

V_f, = Calibrated volume, in m^3 of the volumetric flask.

b) For each specimen in the sample calculate the following:

1) Dry density, ρ_d, by the following formula:

$$\rho_d = \frac{M_s}{V}$$

2) Porosity, n, by the following formula:

$$n = \left[\frac{\rho_s - \rho_d}{\rho_s}\right] \times 100 \ (\text{percent})$$

c) From the values for the individual specimens, calculate the average dry density, porosity, moisture content and grain density for the sample.

7.7 Reporting of Results

a) Report the individual dry density, porosity and moisture content values for each specimen in the sample together with the average values of dry density, porosity and moisture content for the sample. Density values shall be given to the nearest 10 kg/m^3, porosity values to the nearest 0.1 percent and moisture content values to the nearest 0.1 percent;

b) Report that the bulk volume was obtained using a mercury displacement technique, and that the porosity was calculated from grain volume, measurement using a pulverization technique;

c) Record any gross change in the shape or competence of the rock specimens during drying; and

d) Record the following general information:
   1) Project title,
   2) Sampling technique and sample identification number,
   3) Dates of sampling and of testing, and
   4) Lithological description of the rock sample.