RWANDA STANDARD

DRS 526

First edition

2023-mm-dd

Natural stone test methods — Determination of real and apparent density and total porosity

ICS 73.020; 91.100.15

Reference number

DRS 526: 2023

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Contents

Page

Foreword iv

1 Scope 1

2 Normative references 1

3 Principal 1

4 Terms and definitions 1

5 Symbols 2

6 Apparatus 3

7 Preparation of the specimens 3
7.1 Sampling 3
7.2 Test specimens 3
7.3 Drying the specimens 4

8 Test procedures 4
8.1 Open porosity and apparent density 4
8.2 Real density 4
8.2.1 General 4
8.2.2 Method A (pycnometer) 5
8.2.3 Method B (Le Chatelier volumenometer) 5

9 Expression of results 6
9.1 General 6
9.2 Apparent density 6
9.3 Open porosity 6
9.4 Real density 6
9.5 Total porosity 7

10 Test report 7

Foreword

Rwanda Standardsarepreparedby Technical Committees and approved by Rwanda Standards Board (RSB) Board of Directors in accordance with the procedures of RSB, in compliance with Annex 3 of the WTO/TBT agreement on the preparation, adoption and application of standards.

The main task of technical committees is to prepare national standards. Final Draft Rwanda Standards adopted by technical committees are ratified by members of RSB Board of Directors for publication and gazettment as Rwanda Standards.

DRS526was prepared by Technical Committee RSB/TC 9, *Civil engineering and building materials.*

In the preparation of this standard, reference was made to the following standard:

BS EN 1925:1999, Natural stone test method — Determination of real density, apparent density and of total and open porosity

The assistance derived from the above source is hereby acknowledged with thanks.

Committee membership

The following organizations were represented on the Technical Committee on *Civil engineering and building materials*(RSB/TC 9) in the preparation of this standard.

A+Construction Group Ltd

Africeramics Ltd

Consultants Engineers Group (CEG) Ltd

D&D Resources Ltd

Dutureheza Ltd

Enabel Rwanda

Greenpack Africa Ltd

Integrated Polytechnic Regional Centre (IPRC) - Musanze

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NP Construction Company (NPCC) Ltd

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Stonecraft Industries Ltd

University of Rwanda - College of Science and Technology (UR - CST)

Rwanda Standards Board (RSB) – Secretariat

Natural stone test methods — Determination of real and apparent density and total porosity

1 Scope

This Draft Rwanda standard specifies methods for determining the real density, apparent density, and open and total porosity of natural stone.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the editioncited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

DRS 515, *Natural stones— Terminology*

ISO 3507, *Laboratory glassware — Pyknometer*

3 Principal

After drying to constant mass, the apparent density and open porosity are determined by vacuum assisted water absorption and submerged weighing of specimens. The real density and total porosity require the specimen to be pulverised.

4 Terms and definitions

For the purposes of this standard, the terms and definitions given in DRS 515 apply.

4.1

apparent density (ρ_b)

ratio between the mass of the dry specimen and its apparent volume

4.2

apparent Volume

volume limited by the external surface of the specimen, including any voids

4.3

volume of the solid parts

difference between the apparent volume of the specimen and the volume of the voids (open and closed pores)

4.4

real density (ρ_r)

ratio between the mass of the dry specimen and the volume of its solid part

4.5

open porosity

ratio (as a percentage) between the volume of the open pores and the apparent volume of the specimen

4.6

total porosity

ratio (as a percentage) between the volume of pores (open and closed) and the apparent volume of the specime

5 Symbols

m_d mass of the dry specimen, in grams;

m_h mass of the specimen immersed in water, in grams;

m_s mass of the saturated specimen, in grams;

m_e mass of the specimen ground and dried (for the tests using the pycnometer or the volumenometer), in

grams;

m_1 mass of the pycnometer filled with water and the ground specimen, in grams;

m_2 mass of the pycnometer filled with water, in grams;

V_b apparent volume of the specimen, in millilitres;

V_o volume of open pores of the specimen, in millilitres;

V_s volume of liquid displaced by the mass me (volumenometer test);

ρ_b apparent density of the specimen, in kilograms per cubic metre;

ρ_r real density of the specimen, in kilograms per cubic metre;

ρ_{rh} density of water, in kilograms per cubic metre;

$\rho_o$open porosity of the specimen, as a percentage;

ρtotal porosity of the specimen, as a percentage.

6 Apparatus

6.1A ventilated oven which maintain a temperature (70 ± 5) °C.

6.2 An evacuation vessel which can maintain a pressure of (2,0 ± 0,7) kPa = (15 ± 5) mm Hg and allowgradual immersion of the contained specimens.

6.3A weighing instrument which has an accuracy of at least 0,01% of the mass to be weighed, alsocapable of weighing the specimen in water.

6.4A linear measuring device with an accuracy of at least 0,01%.

6.5 An ISO 3507 type 3 pycnometer having a nominal capacity of 50 ml.

6.6A La Chatelier type volumenometer consisting of a flat-bottomed flask with a tube graduated form 0 mlto 24 ml in 0,1 ml graduations.

6.7A sieve with a 0,063 mm mesh.

6.8A dessicator with dessicant.

7 Preparation of the specimens

7.1 Sampling

The sampling is not the responsibility of the test laboratory except where specially requested. At least six test specimens, representing the body of stone being tested, shall be selected.

7.2 Test specimens

The test specimens can be in the form of a cylinder, cube or prism and must be obtained by diamond sawing or coring. Their apparent volume calculated by geometrical measurements shall be at least 60 ml.

In addition, the surface area to volume ratio shall be between 0,08 mm-1 and 0,20 mm-1.

NOTE The specimens prepared for the determination of compressive or flexural strength can be used if they satisfy the surface/volume ratio.

7.3 Drying the specimens

The specimens are to be dried at (70 ± 5)°C until a constant mass is reached. This is assumed to have been attained when the difference between the two weighings at an interval of (24 ± 2) h is not greater than 0,1 % of the mass of the specimen.

The specimens shall be kept in a desiccator until room temperature is attained.

8 Test procedures

8.1 Open porosity and apparent density

Weigh each specimen (m_d), then put the specimens into an evacuation vessel and lower the pressure gradually to (2,0 ± 0,7) kPa = (15 ± 5) mm Hg.

Maintain this pressure for (2 ± 0,2) h in order to eliminate the air contained in the open pores of the specimens.

Slowly introduce demineralized water at (20 ± 5)°C into the vessel (the rate at which the water rises shall be such that the specimens are completely immersed not less than 15 min).

Maintain the pressure of (2,0 ± 0,7) kPa during the introduction of water.

When all the specimens are immersed, return the vessel to atmospheric pressure and leave the specimens under water for another (24 ± 2) h at atmospheric pressure.

Then, for each specimen:

— weigh the specimen under water and record the mass in water: m_h;

— quickly wipe the specimen with a dampened cloth and determine the mass $m_s$of the specimen saturated with water.

In the case of natural stones with visible cavities (e.g. travertine) the apparent volume is determined by measuring the dimensions of the specimens to the nearest millimetre.

8.2 Real density

8.2.1 General

For dense, low porosity stones the differences between real and apparent density, as well as between open porosity and total porosity, are very small. For these stones it is sufficient to determine the apparent density and the open porosity. In the case of control of supplies the decision of omitting the determination of the real density shall be agreed upon between the parties.

In this standard two methods for the determination of real density are described: the pycnometer (Method A) and Le Chatelier volumenometer (Method B).

The first method is more accurate but requires a very long time. It is suggested to use it as a reference method in the case of controversy. Le Chatelier volumenometer method is less accurate but easy and rapid to perform and can be used for production control.

8.2.2 Method A (pycnometer)

For each specimen, after having determined the apparent density and the open porosity, grind each specimen separately until the particles pass through a sieve with 0,063 mm mesh.

Dry the ground specimen to a constant mass and set apart a mass, me of approximately 10 g weighed to an accuracy of ± 0,01 g.

Introduce deionized water into the pycnometer and fill it approximately half full. Then add the weighed mass, me of the ground specimen into the pycnometer and agitate the liquid to disperse the solid matter.

NOTE Ethanol or other liquids may be used instead of deionised water if required. In this case the density of this liquid shall be used instead of density of water in the equation (5a).

Expose the pycnometer to a vacuum of (2 ± 0,7) kPa until no further air bubbles rise, then fill it with deionized water almost to the top and leave the solid matter to settle until the water above the residue is clear.

Next, carefully top up the pycnometer with deionized water, fit the ground stopper and gently wipe off any overflow. Finally weigh the pycnometer to an accuracy of ± 0,01 g (m1).

Empty and wash the pycnometer, fill it with deionized water only and weigh to an accuracy of ± 0,01 g (m2).

Before each weighing make sure that the ambient air temperature is (20 ± 5)°C.

8.2.3 Method B (Le Chatelier volumenometer)

For each specimen, after having determined the apparent density and the open porosity, grind each specimen separately until the particles will pass through a sieve with 0,063 mm mesh.

Dry the ground specimen to a constant mass and set apart a mass, me of approximately 50 g weighed to an accuracy of ± 0,1 g.

Introduce deionized water into Le Chatelier volumenometer until the level is up to the 0 graduation. Then add the weighed mass, me of the ground specimen into the volumenometer in five fractions in the region of 10 g each, ensuring that all of each fraction falls into the liquid. After the introduction of each fraction, agitate the liquid to disperse the ground specimen. Read the graduations to determine the Vs in millilitres to the nearest 0,1 ml of liquid displaced by the mass me of the ground specimen.

Before taking the initial at 0 level and final volume readings make sure that the ambient air temperature is (20± 5)°C.

9 Expression of results

9.1 General

The volume of the open pores (in millilitres) is expressed by the equation:

$$V_{\mathrm{o}} = \frac{m_s - m_d}{\rho_{\mathrm{rh}}} \mathrm{x}1000$$

The apparent volume (in millilitres) is expressed by the equation:

$$V_{\mathrm{b}} = \frac{m_s - m_h}{\rho_{\mathrm{rh}}} \mathrm{x}1000$$

which can alternatively be calculated on the basis of the dimensions of the specimen.

NOTE The value of the density of water ρ_{rh} at 20 °C is 998 kg/m^3 apparent density.

9.2 Apparent density

The apparent density (in kilograms per cubic metre) is expressed by the ratio of the mass of the dry specimenand its apparent volume, by the equation:

$$\rho_{\mathrm{b}} = \frac{m_d}{m_{\mathrm{s}} - m_{\mathrm{h}}} \mathrm{x}\rho_{\mathrm{rh}}$$

9.3 Open porosity

The open porosity is expressed by the ratio (as a percentage) of the volume of open pores and the apparent volume of the specimen, by the equation:

$$P_{\mathrm{o}} = \frac{m_s - m_d}{m_s - m_h} \mathrm{x}1000$$

9.4 Real density

The real density (in kilograms per cubic metre) is expressed by the ratio of the mass of the ground dry specimen m_e to the volume of liquid displaced by the mass m_e, by the equations:

Method A (pycnometer)

$$\rho_{\mathrm{r}} = \frac{m_e}{m_2 + m_{\mathrm{e}} - m_1} \mathrm{x}\rho_{\mathrm{rh}}$$

Method B (Le Chatelier volumenometer)

$$\rho_{\mathrm{r}} = \frac{m_e}{V_{\mathrm{s}}} x \rho_{\mathrm{rh}}$$

9.5 Total porosity

The total porosity is expressed by the ratio (as a percentage) of the volume of pores (open and closed) and the apparent volume of the specimen, by the equation:

$$P = \frac{\frac{1}{\rho_b} - \frac{1}{\rho_r}}{\frac{1}{\rho_b}} \mathrm{x}100 = \left(1 - \frac{\rho_b}{\rho_r}\right) \mathrm{x}100$$

10 Test report

The test report shall contain the following information:

a) unique identification number of the report;

b) number, title and date of issue of this Rwanda standard;

c) name and address of the test laboratory and the address where the test was carried out if different fromthe test laboratory;

d) name and address of the client;

e) it is the responsibility of the client to supply the following information:

- petrographic name of the stone;
- commercial name of the stone;
- country and region of extraction;
- name of the supplier;
- direction of any existing plane of anisotropy (if relevant to the test) to be clearly indicated on the sample or on each specimen by means of two parallel lines;
- name of the person or organization which carried out the sampling;
- surface finish of the specimens (if relevant to the test);

f) date of delivery of the sample or of the specimens;

g) date when the specimens were prepared (if relevant) and the date of testing;

h) number of specimens in the sample;

i) dimensions of the specimens;

j) for each specimen: the real density (if determined) and the apparent density to the nearest 10 kg/m3, the open porosity and the total porosity (if determined) to the nearest 0,1%;

k) arithmetic mean of the individual values for the real density (if determined) and for the apparent density (to the nearest 10 kg/m3), for the open porosity and for the total porosity (if determined) (to the nearest 0,1%);

l) method used for the determination of the real density (when relevant);

m) all deviations from the standard and their justification;

n) remarks.

The test report shall contain the signature(s) and role(s) of the responsible(s) party(s) for testing and the issuedate of the report. It shall also state that the report shall not be partially reproduced without written consentfrom the test laboratory.

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