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Natural stone test methods — Determination of resistance to ageing by thermal shock

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Contents

Page

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.

DRS541was 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:

1. BS EN 14066:2013: Natural stone test methods — Determination of resistance to ageing by thermal shock
2. EN 14146, Natural stone test methods – Determination of the dynamic modulus of elasticity (by measuring the fundamental resonance frequency)

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

DRS541 consists of the following parts, under the general title *Natural stone test methods— Determination of resistance to ageing by thermal shock*

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

Mass Design Group

NP Construction Company (NPCC) Ltd

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Stonecraft Industries Ltd

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

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Natural stone test methods — Determination of resistance to ageing by thermal shock

1 Scope

This Draft Rwanda standard specifies a method to assess possible changes of natural stones under the effect of sudden changes in temperature (thermal shock).

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 edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

DRS 526 Natural stone test methods – Determination of real density and apparent density, and of total and open porosity

DRS 533 , Natural stone test methods – Determination of flexural strength under concentrated load

DRS 515, Natural stone – Terminology

3 Terms and definitions

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

4 Symbols (and abbreviated terms)

F_r Flexural strength tested on the reference specimens, in MPa

F_f Flexural strength tested on the specimens subjected to thermal cycles, in MPa

ΔF Change in flexural strength between reference and exposed specimens, in %

E_0 Dynamic elastic modulus of the specimens before the thermal cycles, in MPa

E_f Dynamic elastic modulus of the specimens after the thermal cycles, in MPa

ΔE Change in dynamic elastic modulus of the specimen, in %

ρ_0 Open porosity before the test, in %

ρ_f Open porosity after the test, in %

$\Delta\rho$ - Change in open porosity of the specimen, in %

v_0 Ultrasound pulse velocity (UPV) before the test, in km/s

v_f Ultrasound pulse velocity (UPV) after the test, in km/s

Δ_v Change in Ultrasound pulse velocity of the specimen, in %

5 Principal

After drying at (40 ± 5) °C for a week, the specimens are subjected to successive cycles, each formed by drying at (70 ± 5) °C followed by immediate immersion in water at (20 ± 5) °C.

The potential strength loss is measured according to DRS 533 . Exposed specimens and, when relevant, changes in other physical and mechanical properties are measured by one or more of the following non-destructive tests: UPV (v0) according to Annex A , and open porosity (ρ0) according to DRS 526 , performed on specimens before and after the thermal cycles.

6 Apparatus

6.1 A ventilated oven capable of maintaining a temperature of (70 ± 5) °C.

6.2 A covered tank with a flat base, comprising small non-oxidising and non-absorbent supports for the specimens.

6.3 A weighing instrument with an accuracy of at least 0,01 % of the mass to be weighed.

7 Preparation of specimens

7.1 Sampling

The sampling is not the responsibility of the test laboratory except where specially requested.

At least 20 specimens shall be selected from a homogeneous batch: a set of 10 specimens as references for flexural strength measurement of fresh material and the other set for the thermal cycles.

7.2 Dimensions of the test specimens

The dimensions of the specimens shall be in accordance with DRS 533, i.e. determined by their thickness.

— the thickness shall be between 25 mm and 100 mm and shall be greater than twice the size of the largest grain in the stone;

— the total length shall be equal to six times the thickness;

— the distance between the supporting rollers shall be equal to five times the thickness;

— the width shall be between 50 mm and three times the thickness and in no case shall it be less than the thickness.

7.3 Putting reference marks on the specimens

To ensure that the measurements of the dynamic elastic modulus or of the ultrasound pulse velocity performed before and after the thermal shock test are done at the same points, indelible marks in the form of points are made on the relevant faces of the specimens, to show the location of emitter and receiver.

Indelible lines are traced to show the location of the axis of the two supports on which the specimens will be placed during the determination of the dynamic elastic modulus and the UPV.

7.4 Drying the specimens

The specimens are dried in a ventilated oven at (40 ± 5) °C for one week and then cooled to ambient temperature (20 ± 5) °C before start of the cycles.

8 Test procedure

8.1 Control measurements before cycling

Before cycling, depending on the test chosen to evaluate the change in performance, the specimens subjected to cycles are measured according to one or more of the non-destructive tests:, UPV (v0) according to Annex A , and open porosity (ρ0) according to DRS 526.

8.2 Description of the cycles

The dried specimens are subjected to changes of temperature according to the following procedure: (18 ± 1) h in a ventilated oven at (70 ± 5) °C; immediately followed by (6 ± 0,5) h completely submerged in tap water, whose temperature before the immersion of the specimens is (20 ± 5) °C.

Both in the oven and in the water container, the specimens are placed on the supports at a distance of at least 50 mm from one another and from the wall. In the water container, the specimens are placed on supports located at the bottom of the container which has been filled with tap water to such a height that the water level above the specimens is (60 ± 10) mm. The procedure described above constitutes one cycle. If the test is to be interrupted at any time, other than for testing, then the specimens are to be immersed in water at (20 ± 5) °C.

8.3 Control measurements after cycling

After the 20th cycle, the specimens are dried to constant mass at (70 ± 5) °C. Constant mass is reached when the difference between two weighing at an interval of (24 ± 2) h is not greater than 0,1 % of the first of the two masses. Then they are visually inspected and compared with the reference specimens. All alterations are recorded.

One or more of the non-destructive tests are performed: the UPV (vf) according to Annex A , and/or the open porosity (ρf) according to DRS 526 .

Finally, the flexural strength test is performed according to DRS 533 , on the dried references specimens and on the specimens subjected to thermal cycles.

9 Expression of results

9.1 Visual appearance

Describe the modifications observed visually by comparison with the reference specimen, such as:

— cracking;

— scaling or exfoliation.

9.2 Modulus of elasticity

Calculate the change in dynamic elastic modulus to the nearest 0,1 % according to Formula (1):

$$\Delta E = \frac{E_f - E_o}{E_o} x100$$

9.3 Open porosity

Calculate the change in open porosity to the nearest 0,1 % according to Formula (2):

$$\Delta \rho = \frac{\rho_f - \rho_o}{\rho_o} x100$$

9.4 Ultrasound pulse velocity

Calculate the change in ultrasound pulse velocity to the nearest 0,1 % according to Formula (3):

$$\Delta V = \frac{V_f - V_o}{V_o} x100$$

9.5 Flexural strength

Measure the flexural strength on dried reference and exposed specimens. The percentage change in flexural strength (ΔF) is calculated as follows:

$$\Delta E = \frac{E_f - E_r}{E_r} x100$$

10 Test report

The test report shall contain the following information:

a) unique identification number of this report,

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

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

d) the name and address of the client;

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

1) the petrographic name of the stone;

2) the commercial name of the stone;

3) the country and region of extraction;

4) the name of the supplier;

5) the 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;

6) the name of the person or organisation which carried out the sampling;

7) the surface finish of the specimen (if relevant to the test).

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

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

h) the number of specimens in the sample;

i) the dimensions of the specimens;

j) any observed alteration for each specimen;

k) the percentage change in dynamic elastic modulus for each specimen and the mean percentage change in dynamic elastic modulus (if performed);

l) the percentage change in UPV for each specimen and the mean (if performed);

m) the percentage change in open porosity for each specimen and the mean (if performed);

n) the mean percentage change in flexural strength;

o) a statement on measurement uncertainty (where appropriate);

p) any deviations from the standard and their justification;

q) remarks.

The test report shall contain the signature(s) and role(s) of the responsible(s) for the testing and the date of issue of the report.

It shall also state that the report shall not be partially reproduced without the written consent of the test laboratory.

Annex A
(normative)

Determination of sound speed propagation

A.1 General

The apparatus shall be used within the operating conditions stated by the manufacturer.

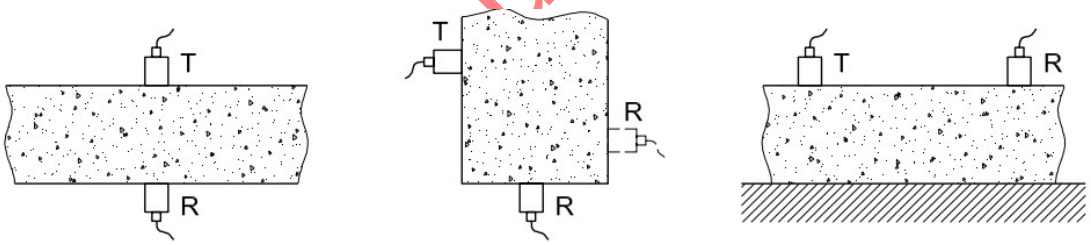
A.2 Determination of Pulse Velocity

A.2.1 Factors influencing pulse velocity measurements

In order to provide a measurement of pulse velocity which is reproducible, it is necessary to take into account various factors which can influence the measurements. These are set out in informative Annex B.

A.2.2 Transducer arrangement

Although the direction in which the maximum energy is propagated is at right angles to the face of the transmitting transducer, it is possible to detect pulses which have travelled through the natural stone in some other direction. It is therefore possible to make measurements of pulse velocity by placing the two transducers either on opposite face (direct transmission), or on adjacent faces (semi-direct transmission), or on the same face (indirect or surface transmission). (see Figure 1).



T = transmitter

R = receiver

a) direct transmission

b) semi-direct transmission

c) indirect or surface transmission

Figure 1 — Different transducer arrangements for the determination of pulse velocity

NOTE 1 It may be necessary to place the transducers on opposite faces but not directly opposite each other. Such arrangement shall be regarded as a semi-direct transmission. (see Figure 1.b).

NOTE 2 The indirect transmission arrangement is the least sensitive and should only be used, for in situ measurements when only a single face of the natural stone is accessible, or when it is more important to determine the strength of the layer near the surface than that of the body of the stone itself.

NOTE 3 The semi-direct transmission arrangement has a sensitivity intermediate between the other two arrangements and should only be used when the direct arrangement cannot be used.

A.2.3 Path length measurement

For direct transmission, the path length is the distance between the transducers measured with an accuracy of ± 1 %.

For semi-direct transmission, it is generally found to be sufficiently accurate to take the path length as the distance measured from centre to centre of the transducers faces. The accuracy of the measurement of the path length is dependent upon the size of the transducers compared with the centre to centre distance and it shall be estimated.

With indirect transmission, the path length is not measured, but a series of measurements is made with the transducers at different distances apart.

A.2.4 Coupling the transducer onto the stone

There shall be adequate acoustical coupling between the stone and the face of each transducer. For sufficiently smooth surface finishes a good acoustical contact is ensured by the use of a coupling medium such as petroleum jelly, grease, soft soap and kaolin/glycerol paste and by pressing the transducer against the stone surface.

Repeated readings of the transit time shall be made until a minimum value is obtained, so as to allow the layer of couplant to become thinly spread.

When the surface finish is very rough and uneven, the surface area shall be smoothed and levelled by grinding, or by the use of a quick-setting epoxy resin.

NOTE Special transducers are available for use on very rough surfaces

A.2.5 Measurement of the transit time

Using the electronic device the time interval indicated shall be recorded.

A.3 Expression of the results

For direct and semi-direct transmissions the pulse velocity shall be calculated from the formula:

$$V = \frac{L}{T}$$

where

V is the pulse velocity, in km/s

L is the path length, in mm

T is the time taken by the pulse to transverse the length, in μs

For indirect transmission, the velocity shall be calculated in accordance with normative Annex A.

The pulse velocity shall be expressed to the nearest 0,01 km/s.

NOTE Recommendations on the procedures for correlating test results to compressive strength are given in EN 12504-4.

Bibliography

[1] DRS 5287, Natural stone test methods – Petrographic examination

[2] EN 14146 Natural stone test methods Determination of the dynamic modulus of elasticity (by measuring the foundation resonance frequency)

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