BRITISH STANDARD

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12372:2006

Natural stone test methods — Determination of flexural strength under concentrated load

The European Standard EN 12372:2006 has the status of a British Standard

ICS 73.020; 91.100.15

BSI
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National foreword

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The UK participation in its preparation was entrusted to Technical Committee B/545, Natural stone.

A list of organizations represented on B/545 can be obtained on request to its secretary.

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English Version

Natural stone test methods - Determination of flexural strength under concentrated load

Méthodes d'essai pour pierres naturelles - Détermination de la résistance à la flexion sous charge centrée

Prüfverfahren für Naturstein - Bestimmung der Biegefestigkeit unter Mittellinienlast

This European Standard was approved by CEN on 25 October 2006.

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Foreword

This document (EN 12372:2006) has been prepared by Technical Committee CEN/TC 246 “Natural stones”, the secretariat of which is held by UNI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2007, and conflicting national standards shall be withdrawn at the latest by June 2007.

This document supersedes EN 12372:1999.

The change of the specimens’ dimensions requested a revision of this European Standard.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

1 Scope

This European Standard specifies a test method for determination of flexural strength under a concentrated load for natural stone. Both an identification and a technological product testing procedure are included.

2 Normative references

The following referenced documents are indispensable for the application 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.

EN 12390 (all parts), *Testing hardened concrete*

3 Principle

The principle of this method is to place a specimen on two rollers and to progressively load the specimen in the middle. The breaking load is measured and the flexural strength calculated.

4 Symbols

For the purposes of this document, the following symbols apply.

R_{tf} flexural strength, in Megapascals

F breaking load, in newtons

a load rate, in Megapascals/second

V loading rate, in newtons/second

l distance between the supporting rollers, in millimetres

b width of the specimen adjacent to the plane of fracture, in millimetres

h thickness of the specimen adjacent to the plane of fracture, in millimetres

L total length of the specimen, in millimetres

5 Apparatus

5.1 A balance capable of weighing the specimen with an accuracy of 0,01 % of the mass of the specimen.

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

5.3 A linear measuring device with an accuracy of 0,05 mm.

5.4 A testing machine of appropriate force, in accordance with the EN 12390 and calibrated according to this European Standard.

5.5 A device for applying loads on the specimen by a centre-point load. It consists of two lower rollers (supporting rollers) and one upper roller (load-applying roller) which shall be centred exactly in the middle between the two supporting rollers (see Figure 1). The distance between the two supporting rollers shall be reported as requested in 6.2.2.

5.6 A room which can be maintained at a temperature of (20 ± 10) °C.

6 Preparation of the specimens

6.1 Sampling

The sampling is not the responsibility of the test laboratory except where specially requested. At least 10 specimens shall be selected from a homogeneous batch (see also 6.2.4).

6.2 Test specimens

6.2.1 Surface finish

As a standard reference, the surface finish of the faces of the specimens shall be sawn, honed or polished (identification test). In case of necessity to test specimens with other surface finishes (e.g. flamed, sandblasted) as required for application, this may be done (technological test). For the technological test the specimens may be final products or sawn from final products. The surface intended for use shall be in contact with the two supporting rollers (facing downwards). In any case the kind of surface finish shall be stated in the report.

6.2.2 Dimensions

For stones with a size of the largest grain lower than 25 mm, preferred dimensions are 50 mm × 50 mm × 300 mm.

Other dimensions are possible, but shall fulfil the following requirements:

— the thickness h 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 L shall be equal to six times the thickness;

— the width b shall be between 50 mm and three times the thickness (50 mm ≤ b ≤ 3h), and in no case it shall be less than the thickness.

The distance between the supporting rollers l shall be equal to five times the thickness.

6.2.3 Tolerance

The tolerance on the distance between the supporting rollers l shall be ± 1 mm.

6.2.4 Planes of anisotropy

If the stone shows planes of anisotropy (e.g. bedding, foliation) the specimens shall be prepared in accordance with at least one of the arrangements shown in Figures 2 to 4 and the direction of the planes of anisotropy shall be marked on each specimen by at least two parallel lines.

If the use of the stone in respect of the position of the planes of anisotropy is known, the test shall be carried out with the force applied on the face that will be loaded during use.

If the way of use of the stone is not known but the position of the planes of anisotropy is indicated on the specimens (by means of at least two parallel lines), the test shall be carried out on each of the three arrangements shown in Figures 2 to 4; the total number of specimens will then be 3 times 10.

6.2.5 Conditioning before testing

The specimens shall be dried at (70 ± 5) °C to a constant mass.

Constant mass is reached when the difference between two weighings carried out (24 ± 2) h apart is no greater than 0,1 % of the first of the two masses.

After drying and prior to testing the specimens shall be stored at (20 ± 5) °C until the thermal equilibrium is reached. After that the test shall be performed within 24 h.

7 Test procedure

Wipe the surface of the rollers clean and remove any loose grits from the faces of the specimen that will be in contact with the rollers.

The specimen is placed centrally on the supporting rollers (see Figures 1 to 4). The loading roller is placed in the middle of the specimen.

The load is increased uniformly at a rate of (0,25 ± 0,05) MPa/s until the specimen breaks.

NOTE 1 The breaking load is rounded to the nearest 10 N and also the place where the fracture occurs. The width and the thickness of the specimen are measured adjacent to the fracture plane and the dimensions are expressed in millimetres to the nearest 0,1 mm.

NOTE 2 Where the loading rate (V) is needed in N/s the following equation can be used to determine the required rate in N/s:

$$V = \frac{2abh^2}{3l} \quad \text{(N/s)} \tag{1}$$

8 Expression of the results

The flexural strength R_{tf} of each specimen is calculated using the following equation:

$$R_{tf} = \frac{3Fl}{2bh^2} \tag{2}$$

The result shall be expressed in Megapascals to the nearest 0,1 MPa.

If the fracture is situated more than 15 % of the distance between the supporting rollers from the middle of the specimen and/or flaws are present (veins, fissures etc.) it shall be mentioned in the test report.

9 Test report

The test report shall contain the following information:

a) unique identification number of the report;

b) the number, title and date of issue of this European Standard, i.e. EN 12372;

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

d) the name and address of the client;

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

— the petrographic name of the stone;

— the commercial name of the stone;

— the country and region of extraction;

— the name of the supplier;

— 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;

— the name of the person or organization which carried out the sampling;

— the surface finish of the specimens (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) the surface finish of the specimens;

k) the rate of loading in Megapascals per second to the nearest 0,05 MPa/s;

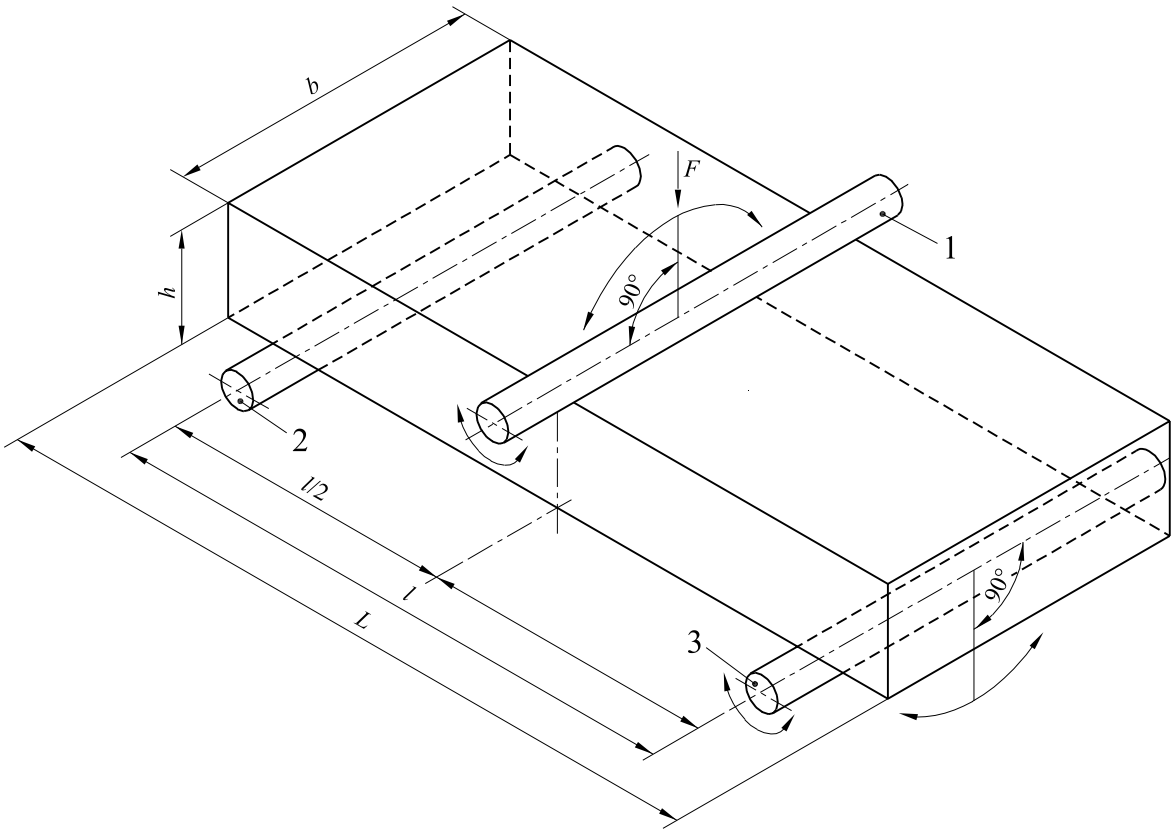
l) for each specimen: the width and thickness adjacent to the fracture plane and the distance between the supporting rollers in millimetres to the nearest 0,1 mm, the orientation of the force relatively to any plane of anisotropy following Figures 2 to 4, the breaking force in newton to the nearest 10 N, the flexural strength in Megapascals to the nearest 0,1 MPa, the location of the fracture and any anomalies observed;

m) for each relevant direction of loading the mean value $\overline{R}_{tf}$ of the flexural strength and the standard deviations, in Megapascals to the nearest 0,1 MPa;

n) all deviations from the standard and their justification;

o) remarks.

The test report shall contain the signature(s) and the 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 written consent of the test laboratory.

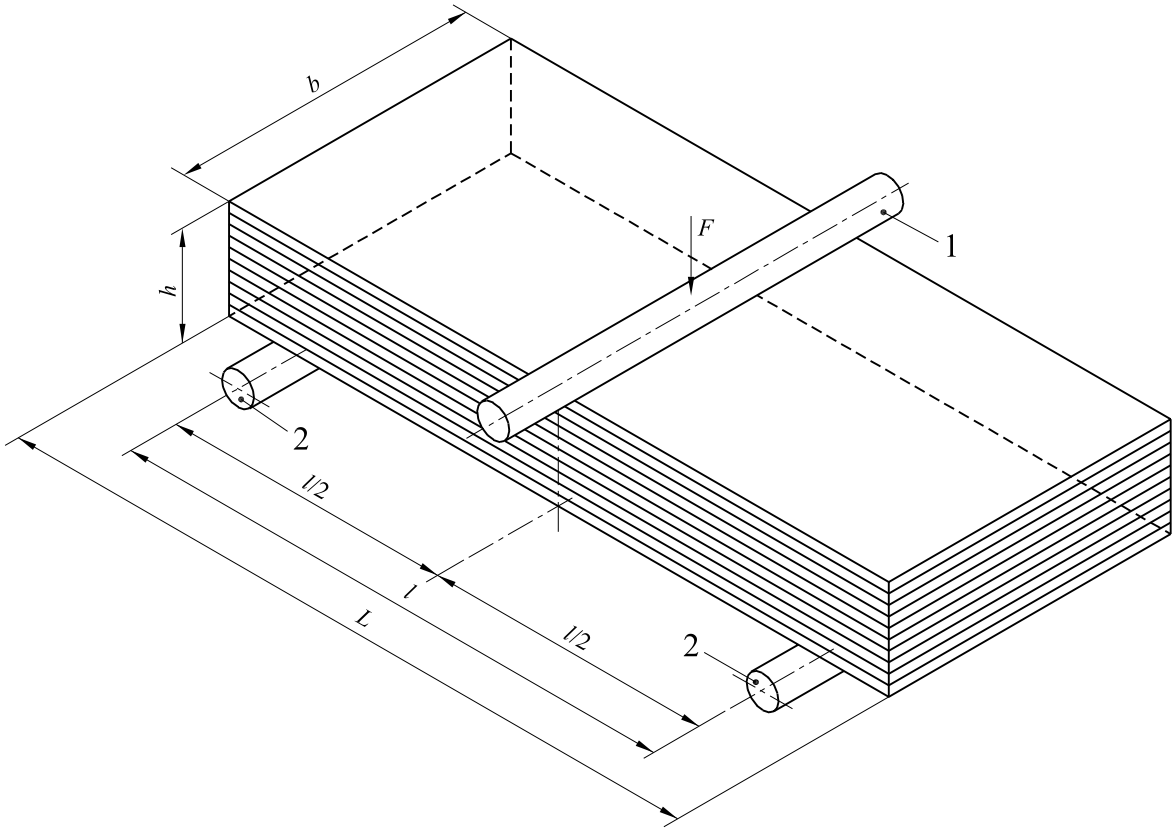


Key

1 loading roller

2 supporting roller

Figure 1 — Arrangement of loading of test specimen (centre point loading)

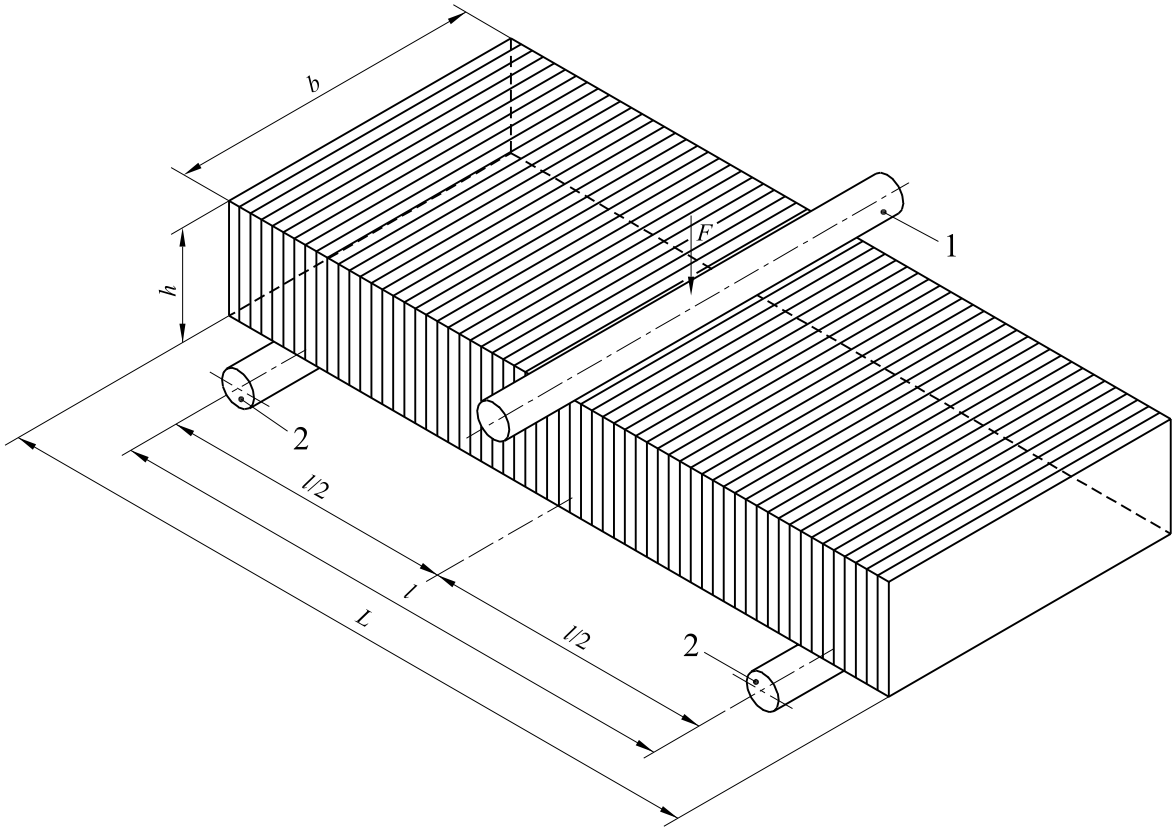


Key

1 loading roller

2 supporting roller

Figure 2 — Test arrangement for a specimen with the load applied perpendicular to the planes of anisotropy

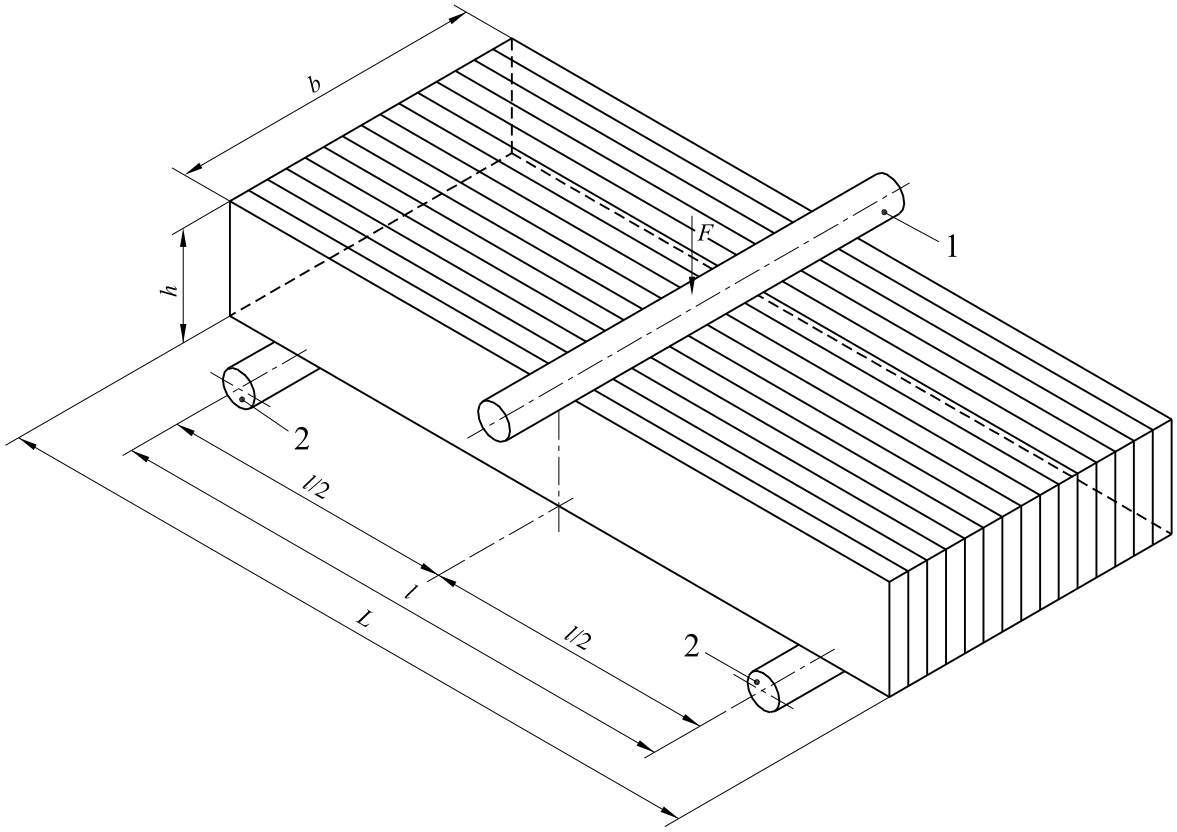


Key

1 loading roller

2 supporting roller

Figure 3 — Test arrangement for a specimen with the load applied parallel to the planes of anisotropy



Key

1 loading roller

2 supporting roller

Figure 4 — Test arrangement for a specimen with the load applied perpendicular to the edges of the planes of anisotropy

Annex A
(normative)

Statistical evaluation of the test results

A.1 Scope

This annex establishes a method for the statistical treatment of test results obtained following the natural stone test methods described in this European Standard.

A.2 Symbols and definitions

Measured values	$x_1, x_2, .. x_i .., x_n$
Number of measured values	n
Mean value	$\bar{x} = \frac{1}{n}\sum_i x_i$
Standard deviation	$s = \pm\sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}}$
Coefficient of variation	$v = \frac{s}{\bar{x}}$ (for individual values)
Logarithmic mean	$\bar{x}_{\ln} = \frac{1}{n}\sum_i \ln x_i$
Logarithmic standard deviation	$s_{\ln} = \pm\sqrt{\frac{\sum (\ln x_i - \bar{x}_{\ln})^2}{n-1}}$
Maximum value	Max
Minimum value	Min
Lower expected value	$E = e^{(\bar{x}_{\ln} - (k_s \cdot s_{\ln}))}$ where k_s (quantile factor) is given in Table A.1
Quantile factor	k_s see Table A.1

A.3 Statistical evaluation of test results

For the calculation of the mean value $(\bar{x})$, the standard deviation (s) and the coefficient of variation (v) a normal distribution is assumed.

For the calculation of the lower expected value (E) a logarithmic normal distribution is assumed. The lower expected value (E) corresponds to the 5 % quantile of a logarithmic normal distribution for a confidence level of 75 %.

Table A.1 — Quantile factor (k_S) in dependence on the number of measured values (n) in correspondence to the 5 % quantile for a confidence level of 75 %

n	k_S
3	3,15
4	2,68
5	2,46
6	2,34
7	2,25
8	2,19
9	2,14
10	2,10
15	1,99
20	1,93
30	1,87
40	1,83
50	1,81
8	1,64

The following examples should help to clarify the method:

EXAMPLE 1 Calculation of mean value, standard deviation, maximum value and minimum value of 6 measured values:

Measurement no	**Measured value *x***
1	2 000
2	2 150
3	2 200
4	2 300
5	2 350
6	2 400

Mean value	2 333
Standard deviation	147
Maximum value	2 400
Minimum value	2 000

EXAMPLE 2 Calculation of mean value, standard deviation, coefficient of variation and lower expected value of 10 measured values:

Measurement no	**Measured value *x***	**(ln *x*)**
1	2 000	(7,60)
2	2 150	(7,67)
3	2 200	(7,70)
4	2 300	(7,74)
5	2 350	(7,76)
6	2 400	(7,78)
7	2 600	(7,86)
8	2 750	(7,92)
9	2 900	(7,97)
10	3 150	(8,06)
	---------	---------
Mean value	2 480	(7,807)
Standard deviation	363	(0,143)
Variation coefficient	0,15	

From Table A.1 for: n=10 k_S=2,1

lower expected value 1 819

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[6] EN 12407, *Natural stone test methods — Petrographic examination*

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[15] EN 14146, *Natural stone test methods — Determination of dynamic modulus of elasticity (by measuring the fundamental resonance frequency)*

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[17] EN 14157, *Natural stone test methods — Determination of abrasion resistance*

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[19] EN 14205, *Natural stone test methods — Determination of Knoop hardness*

[20] EN 14231, *Natural stone test methods — Determination of slip resistance by means of the pendulum tester*

[21] EN 14579, *Natural stone test methods — Determination of sound speed propagation*

[22] EN 14580, *Natural stone test methods — Determination of static elastic modulus*

[23] EN 14581, *Natural stone test methods — Determination of linear thermal expansion coefficient*

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