Natural stone test methods — Determination of static elastic modulus

The European Standard EN 14580:2005 has the status of a British Standard

ICS 73.020; 91.100.15

British Standards

National foreword

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Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 14, an inside back cover and a back cover.

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English version

Natural stone test methods - Determination of static elastic modulus

Méthodes d'essai pour pierres naturelles - Détermination du module d'élasticité statique

Prüfverfahren für Naturstein - Bestimmung des statischen Elastizitätsmoduls

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Contents

Foreword

This document (EN 14580:2005) 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of an identical text or by endorsement, at the latest by October 2005, and conflicting national standards shall be withdrawn at the latest by October 2005.

This document is one of the series of draft standards for tests on natural stone.

Test methods for natural stone consist of the following parts:

EN 1925, *Natural stone test methods – Determination of water absorption coefficient by capillarity*

EN 1926, *Natural stone test methods – Determination of compressive strength*

EN 1936, *Natural stone test methods – Determination of real density and apparent density, and of total and open porosity*

EN 12370, *Natural stone test methods – Determination of resistance to salt crystallisation*

EN 12372, *Natural stone test methods – Determination of flexural strength under concentrated load*

EN 12407, *Natural stone test methods – Petrographic examination*

EN 13161, *Natural stone test methods – Determination of flexural strength under constant moment*

EN 13364, *Natural stone test methods – Determination of the breaking load at dowel hole*

EN 13373, *Natural stone test methods - Determination of geometric characteristics on units*

EN 13755, *Natural stone test methods – Determination of water absorption at atmospheric pressure*

EN 13919, *Natural stone test methods – Determination of resistance to ageing by SO_2 action in the presence of humidity*

EN 14066, *Natural stone test methods – Determination of resistance to ageing by thermal shock*

EN 14147, *Natural stone test methods – Determination of resistance to ageing by salt mist*

EN 14157, *Natural stone test methods – Determination of the abrasion resistance*

EN 14158, *Natural stone test methods – Determination of rupture energy*

EN 14205, *Natural stone test methods – Determination of Knoop hardness*

EN 14231, *Natural stone test methods – Determination of the slip resistance by means of the pendulum tester*

EN 14579, *Natural stone test methods – Determination of sound speed propagation*

prEN 14580, *Natural stone test methods – Determination of static elastic modulus*

EN 14581, *Natural stone test methods – Determination of linear thermal expansion coefficient*

No existing document is superseded.

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, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

1 Scope

The document specifies a method to determine the static elastic modulus of natural stone in uniaxial compression.

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 1926, *Natural stone test methods – Determination of compressive strength*

EN 12390-4, *Testing hardened concrete – Part 4: Compressive strength – Specification for testing machines*

3 Principle

The longitudinal deformations of a specimen under basic and upper uniaxial compressive stresses are measured. From these values the static elastic modulus is calculated.

4 Symbols and definitions

E_b static elastic modulus in Megapascals (MPa);

σ_u basic stress, of approximately 2 % of the mean value of the tested compressive strength, prior to the third loading cycle, in MPa;

σ_o upper stress, of approximately 33 % of the mean value of the tested compressive strength, during the third loading cycle in MPa;

ε_u mean unitary deformation under the basic stress at point A (see Figure 2);

ε_o mean unitary deformation under the upper stress at point B (see Figure 2).

5 Apparatus

5.1 A compression testing machine of appropriate force in accordance with EN 12390-4 and calibrated according to that standard.

5.2 Length measuring devices (for example inductance gauges) or strain measuring devices (for example strain gauges) with a gauge length of at least ten grain diameters with a minimum of 50 mm. The apparatus shall be capable of measuring changes in strain of 5 m/m $\times$ 10^{-6} m/m or less.

5.3 A ventilated oven which can maintain a temperature of (70 $\pm$ 5) °C.

6 Preparation of the specimens

6.1 Sampling

The sampling is not the responsibility of the test laboratory except where especially requested. At least six specimens shall be selected from an homogeneous batch.

6.2 General

The test may be carried out as an identification test or as a technological test.

In identification tests the conditioning of the specimens before testing is performed according to 6.3.5.1. For the conditioning before testing in technological tests see 6.3.5.2.

6.3 Test specimens

6.3.1 Dimensions of test specimens

The specimens shall be cylinders with a diameter (d) or prisms with a plan dimension (a) of 50 mm min. The diameter or the plan dimension of the specimen shall be related to the size of the largest cristal grain in the stone with a ratio of 10:1. The ratio height to diameter or height to smaller plan dimension shall be between 2 and 4.

6.3.2 Dimensions of the gauges

The minimum gauge length shall be the diameter or the larger plan dimension (b) of the specimen (Figure 1).

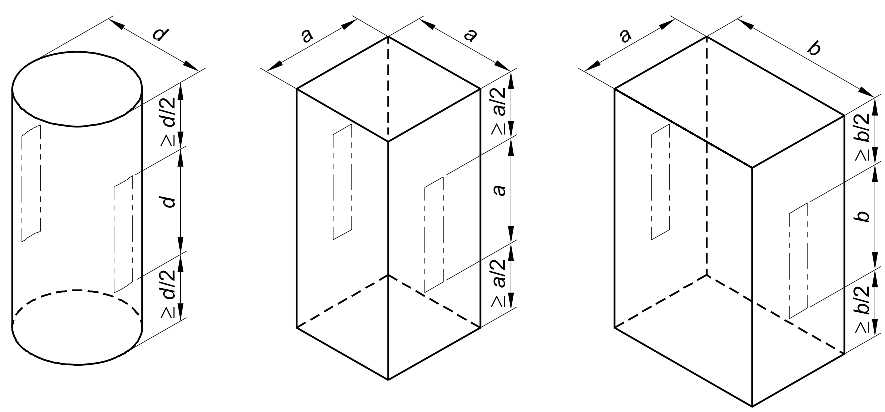


Figure 1 — Arrangement of the length (or strain) measuring devices

6.3.3 Surface finish

6.3.3.1 General

The faces through which the load is to be applied shall be plane to a tolerance of 0,1 mm and shall not depart from perpendicularity to the axis of the specimen by more than 0,01 radian or 1 mm in 100 mm. The sides of the specimen shall be smooth and free of abrupt irregularities and straight to within 0,3 mm over the full length of the specimen.

To meet the above mentioned requirements, the specimen shall be finished on either lathe or surface grinder, with a final touching on a lapping machine if needed.

Capping with mortar according to the procedure indicated in 6.3.3.2 is admitted only if the indicated tolerances are not obtainable with the prescribed mechanical preparation. This condition shall be clearly indicated in the test report.

6.3.3.2 Capping with mortar

It is possible to cap the specimen by using a mortar made up with cement CEM I 52,5 R according to EN 197-1 and waiting as much as needed for hardening.

6.3.4 Planes of anisotropy

If the stone shows planes of anisotropy (e.g. bedding, foliation), the axis of the specimens shall be perpendicular to the principal planes of anisotropy.

If a test with loading perpendicular to any other orientation is required, another set of specimens with the same dimensional characteristics shall be prepared.

6.3.5 Conditioning of specimens before testing

6.3.5.1 Identification test

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 at an interval of (24 ± 2) h is not greater than 0,1 % of the first of the two masses.

6.3.5.2 Technological test

The conditioning of the specimens may be different from the identification test, according to the use in practice. The conditioning shall be described in the test report.

6.3.6 Attaching the gauges on the specimens

At least two length (or strain) measuring devices shall be attached to the specimen parallel to its axis in such a way that they are symmetrical about the middle of the specimen and equally spaced. They shall not be nearer to either end of the specimen than a distance equal to half its diameter for cylindrical and equal to half of the larger plan dimension of the end face for prismatic specimens (see Figure 1).

7 Test procedure

7.1 General

Before the static elastic modulus test is carried out, the compressive strength determined in accordance with EN 1926 shall be known.

7.2 Measuring the specimen

The cross-sectional dimension(s) of the test specimens (diameter for cylindrical and plan dimension(s) for prismatic test specimens) shall be measured to the nearest 0,1 mm by averaging two measurements taken at right angles to each other at about the upper height and the lower height of the specimen. The average plan dimension(s) or the average diameter shall be used for calculating the cross-sectional area. The height of the specimen shall be determined to the nearest 0,1 mm.

7.3 Placing the specimen in the testing machine

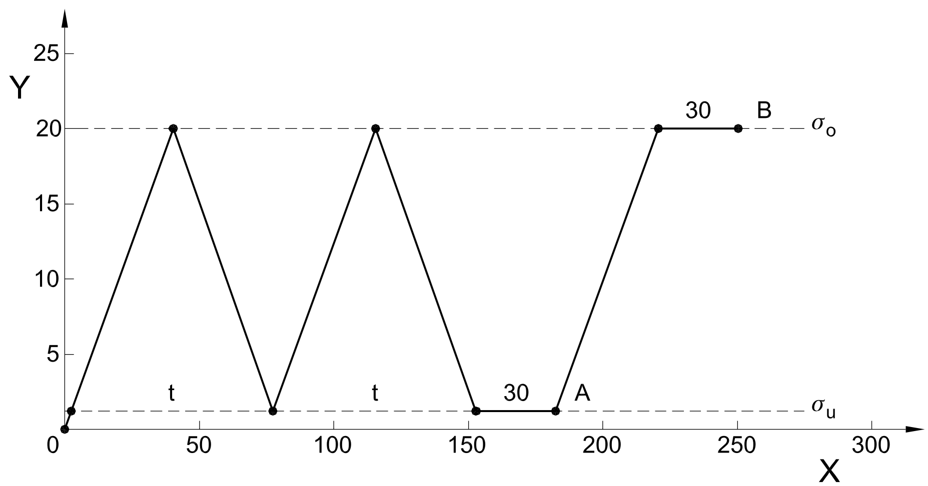
The specimen shall be placed centrally in the testing machine and the upper plate aligned so that it is in full contact with the specimen.

7.4 Loading

The specimen shall be subjected to cycles of loading and unloading from the basic stress.

The specimen shall be subjected to cycles of loading and unloading from the basic stress (σ_u to the upper stress σ_o in accordance with the diagram of Figure 2 at a constant stress rate of (0,5 ± 0,2) MPa/s. The measurements of the stress and of the corresponding deformation shall be taken prior to the third loading cycle (point A, in Figure 2) and during the third loading cycle (point B, in Figure 2).

After completing the measurements at point B the specimen shall be loaded at the specified rate until failure. If the compressive strength of the specimen differs from the mean value (7.1) by more than 20 %, this shall be stated in the test report.



Key

X-axis : time (s)

Y-axis : stress (expressed as a percentage of the mean value of the tested compressive strength)

A is the point of reading of the basic stress, (σ_u) and corresponding deformation, (ε_u), prior to the third loading cycle;

B is the point of reading the upper stress, (σ_o) and corresponding deformation, (ε_o), during the third loading cycle;

t is the time (in seconds) for a cycle of loading and unloading resulting from the specified stress rate.

Figure 2 - Stress-time diagram for determining the static elastic modulus – example for a stone with a compressive strength of 60 MPa

8 Expression of results

The static elastic modulus in compression is calculated by the following equation:

$$Eb = \frac{\Delta\sigma}{\Delta\varepsilon} = \frac{\sigma_o - \sigma_u}{\varepsilon_o - \varepsilon_u}$$

The result shall be expressed in MPa with at least three significant figures.

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 document;

c) the name and the address of the test laboratory and the address of 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, 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;

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 type of test (identification or technological test);

k) the orientation of the axis of loading with respect to the planes of anisotropy;

l) the compressive strength of each specimen, in MPa;

m) the basic stress σ_u and the upper stress, σ_o of each specimen, in MPa;

n) the basic deformation, ε_u, and the upper deformation ε_o of each specimen;

o) the static elastic modulus in compression (E_b) of each specimen, in MPa with at least three significant figures;

p) the mean value of the static elastic modulus in compression, in MPa with at least three significant figures;

q) all deviations from the standard and their justification;

r) 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)

Statistical evaluation of test results

A.1 Scope

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

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	$s = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}}$
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	$s_{\ln} = \sqrt{\frac{\sum (\ln x_i - \bar{x}_{\ln})^2}{n-1}}$
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 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
∞	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 1 for: n = 10 k_s = 2,1

lower expected value 1 819

Bibliography

EN 197-1, *Cement – Part 1: Composition, specifications and conformity criteria for common cements*

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