SIST

# SLOVENSKI STANDARD
# oSIST prEN 12390-13:2019

**01-november-2019**

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**Preskušanje strjenega betona - 13. del: Določanje sekantnega modula elastičnosti pri tlačni obremenitvi**

Testing hardened concrete - Part 13: Determination of secant modulus of elasticity in compression

Prüfung von Festbeton - Teil 13: Bestimmung des Elastizitätsmoduls unter Druckbelastung (Sekantenmodul)



Essais pour béton durci - Partie 13 : Détermination du module sécant d'élasticité en compression



**Ta slovenski standard je istoveten z: prEN 12390-13**

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**ICS:**

| | | |
|---|---|---|
| 91.100.30 | Beton in betonski izdelki | Concrete and concrete products |

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English Version

# Testing hardened concrete - Part 13: Determination of secant modulus of elasticity in compression

Essais pour béton durci - Partie 13: Détermination du module sécant d¿élasticité en compression

Prüfung von Festbeton - Teil 13: Bestimmung des Elastizitätsmoduls unter Druckbelastung (Sekantenmodul)

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 104.

If this draft becomes a European Standard, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

**CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels**



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# European foreword

This document (prEN 12390-13:2019) has been prepared by Technical Committee CEN/TC 104 “Concrete and related products”, the secretariat of which is held by SN.

This document is currently submitted to the CEN Enquiry.

It is based on an extensive investigation and comparison of existing National Standards: ASTM, BS, DIN, ISO, NORD TEST and UNI followed by the analysis of a test programme involving five laboratories carried out by UNI.

This document will supersede EN 12390-13:2013.

This document is one of a series on testing concrete.

EN 12390, *Testing hardened concrete*, consists of the following parts:

— Part 1: *Shape, dimensions and other requirements for specimens and moulds*

— Part 2: *Making and curing specimens for strength tests*

— Part 3: *Compressive strength of test specimens*

— Part 4: *Compressive strength – Specification for testing machines*



— Part 5: *Flexural strength of test specimens*

— Part 6: *Tensile splitting strength of test specimens*

— Part 7: *Density of hardened concrete*



— Part 8: *Depth of penetration of water under pressure*

— Part 10: *Determination of the carbonation resistance of concrete at atmospheric levels of carbon dioxide*

— Part 11: *Determination of the chloride resistance of concrete, unidirectional diffusion*

— Part 12: *Determination of the potential carbonation resistance of concrete: Accelerated carbonation method (in preparation)*

— Part 13: *Determination of secant modulus of elasticity in compression*

— Part 14: *Semi-adiabatic method for the determination of heat released by concrete during its hardening process*

— Part 15: *Adiabatic method for the determination of heat released by concrete during its hardening process*

— Part 16: *Determination of shrinkage of concrete (in preparation)*

— Part 17: *Determination of creep of concrete in compression (in preparation).*

The following amendments have been made to the former edition:

— upper limit of lower stress increased to prevent sample unloading when testing low strength concrete;

— change to the loading profile in Method B.

# 1 Scope

This document specifies the method for the determination of the secant modulus of elasticity in compression of hardened concrete on test specimens which can be cast or taken from a structure.

The test method allows the determination of two secant moduli of elasticity: the initial modulus, $E_{C,0}$ measured at first loading and the stabilized modulus, $E_{C,S}$ measured after three loading cycles.

Two different test methods are given. The first (Method A) is for determination of both initial and stabilized moduli, the second (Method B) is for determination of stabilized modulus only.

# 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.

EN 12390-1, *Testing hardened concrete — Part 1: Shape, dimensions and other requirements for specimens and moulds*

EN 12390-2, *Testing hardened concrete — Part 2: Making and curing specimens for strength tests*

EN 12390-3, *Testing hardened concrete — Part 3: Compressive strength of test specimens*

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



EN 12504-1, *Testing concrete in structures —Part 1: Cored specimens — Taking, examining and testing in compression*



EN ISO 9513, *Metallic materials — Calibration of extensometer systems used in uniaxial testing (ISO 9513)*

# 3 Terms, definitions, symbols and abbrivations

## 3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

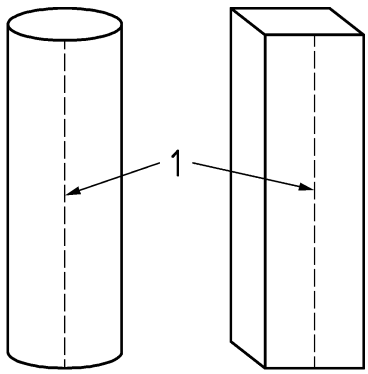
— ISO Online browsing platform: available at http://www.iso.org/obp

**3.1.1**
**initial secant modulus of elasticity**
$E_{C,0}$
secant slope of the stress strain curve at first loading

**3.1.2**
**stabilized secant modulus of elasticity**
$E_{C,S}$
secant slope of the stress strain curve after three loading cycles

**3.1.3**
**gauge length**
**base length**
length used as reference base for strain measurement

**3.1.4**
**measuring line**
straight line laying on the lateral surface of the specimen and parallel to the vertical axis (see Figure 1)




**Key**
1 measuring line



**Figure 1 — Measuring line on cylinder and prismatic specimens**

## 3.2 Symbols and abbreviations



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

| | |
|---|---|
| $d$ | Specimen diameter or width |
| $D$ | Upper sieve size (for definition of aggregates size, see EN 12620) |
| $D_{max}$ | Declared value of $D$ of the coarsest fraction of aggregates actually used in the concrete |
| $f_c$ | Compressive strength of concrete determined by testing companion specimens – cylinders, prisms, cubes or cores – or estimated from non-destructive tests |
| $E_{C,0}$ | Initial secant modulus of elasticity |
| $E_{C,S}$ | Stabilized secant modulus of elasticity |
| $\varepsilon$ | Measured strain |
| $\varepsilon_a$ | Strain along each measuring line at upper stress |
| $\varepsilon_{a,\,n}$ | Average strain at upper stress on loading cycle $n$ |
| $\varepsilon_b$ | Strain along each measuring line at lower stress |
| $\varepsilon_{b,\,n}$ | Average strain at lower stress on loading cycle $n$ |
| $\Delta\varepsilon_s$ | Strain difference during third loading cycle |
| $\Delta\varepsilon_0$ | Strain difference during first loading cycle |
| $L$ | Specimen length |

$L_0$ Initial gauge length of instrument

$\Delta L$ Change in measured length

$\sigma_a$ Nominal upper stress = $f_c$ / 3

$\sigma_b$ Nominal lower stress – arbitrary value between 10 % and 20 % of $f_c$

$\sigma_p$ Nominal preload stress – arbitrary value between 0,5 MPa and $\sigma_b$

$\sigma_a^m$ Measured stress corresponding to nominal upper stress, $\sigma_a$

$\sigma_b^m$ Measured stress corresponding to nominal lower stress, $\sigma_b$

$\Delta\sigma$ Difference between measured stresses $\sigma_a^m$ and $\sigma_b^m$

# 4 Principle

A test specimen is loaded under axial compression, the stresses and strains are recorded and the slope of the secant to the stress-strain curve is determined at first loading (Method A only) and after three loading cycles (Methods A and B).

The secant slope is known as the secant modulus of elasticity in compression.

The test specimens may be either cast or taken from an existing structure.



# 5 Apparatus

## 5.1 Test machine



Compression testing machine conforming to EN 12390-4 with following additional requirements:

a) suitable for execution of programmable loading cycles;

b) able to increase and decrease the load at a constant rate within a given tolerance (see 7.3.1 and 7.3.2);

c) able to maintain a constant load at selectable nominal values with a maximum variation within ± 5 %;

d) calibrated as Class 1 to EN 12390-4 over the working range from the lower stress to the upper stress as defined in 7.3.1 and 7.3.2.

NOTE The test lends itself to the use of automatic control test machines. However, if manual control test machines can be shown to comply with b), c) and d) above, they can be used.

## 5.2 Instrumentation

Instrumentation measuring the strain of the specimen under axial compression along a measuring line shall be Class 2 as determined in accordance with EN ISO 9513 in the range from 0 µm/m to 1 000 µm/m.

The instrumentation can measure strain directly (e.g. resistive strain gauges) or take the form of measuring length change from which the strain, $\varepsilon$, is calculated with Formula (1).

$$\varepsilon = \frac{\Delta L}{L_0} \quad (1)$$

### 5.3 Gauge length

The gauge length of the strain measuring instrument $L_0$ shall be between two-thirds of the specimen diameter (or section width) and one-half of the specimen length and not less than $3D_{max}$.

NOTE For specimens where $L/d$ is between 3,5 and 4,0, the gauge length can be increased to up to 2/3 of the specimen length.

## 6 Test specimens

### 6.1 Shape and dimensions of specimens

The test specimens shall be moulded (cylinder or prism) or drilled cores complying with the requirements of EN 12390-1 or EN 12504-1. The dimension $d$ (diameter or width) shall be at least 3,5 times $D_{max}$. The ratio between the specimen length $L$ and the dimension $d$ shall be in the range $2 \leq L/d \leq 4$.

The recommended test specimen shall be cylinders of diameter 150 mm and height 300 mm (reference specimen). Alternatively, other test specimens generally complying with the requirements of EN 12390-1 may be used, provided that the specimen complies with the dimensions and aggregate size to diameter or width stated above. In the case of specimens drilled or cut from a structure, this requirement sometimes cannot be fulfilled; in such cases, this shall be stated in the test report.

NOTE The size of the test specimen can have an influence on the result.

If relevant, the adjustment of test specimen shall comply with EN 12390-3.



Companion specimens should be available for the determination of compressive strength as described in 7.2 and shall be made from the same batch of concrete in the case of cast specimens, or shall be drilled from the same zone in the case of drilled specimens.



### 6.2 Curing, storage and conditioning

Moulded specimens shall be cured or stored in accordance with EN 12390-2, cored specimen in accordance with EN 12504-1. Before testing, they shall be maintained at (20 ± 2) °C for sufficient time for strain measuring instruments to be securely fixed but not longer than 24 h out of water. During the time out of water, precautions shall be taken to ensure the specimen remains moist.

## 7 Method

### 7.1 Specimen instrumentation and positioning

The strain measuring instruments shall be positioned in such a way that the measuring base is at equivalent distance from the end faces of the specimen.

At least two strain measuring instruments shall be symmetrically arranged with respect to the central axis of the specimen.

The specimen shall be centred on the lower platen.

## 7.2 Determination of compressive strength

The compressive strength of concrete $f_c$ shall be determined in accordance with EN 12390-3 on companion specimen(s) preferably having the same size and shape of those specimens used for secant modulus of elasticity determination.

If the companion specimens are not of the same size and shape as the specimen used for the determination of secant modulus of elasticity, the difference in compressive strength obtained from specimens of different shape and sizes shall be taken into account.

The compressive strength (measured or estimated), $f_c$ is used to define the stress levels of the test cycle for the determination of secant modulus of elasticity.

If companion test specimens for the determination of compressive strength are not available, the compressive strength may be estimated from non-destructive tests or by national provisions valid in the place of use of the concrete. Details of the test method and results from the non-destructive method adopted shall be indicated in the test report.

## 7.3 Determination of secant modulus of elasticity

### 7.3.1 Method A – Determination of initial and stabilized secant modulus of elasticity

#### 7.3.1.1 Preloading cycles

Three preloading cycles are carried out in order to check the wiring stability (first check) and specimen positioning (second check).



Place the test specimen, with the measuring instruments attached axially, centrally in the testing machine.

For the first loading cycle, apply stress to the specimen at a rate of (0,6 ± 0,2) MPa/s up to the lower stress $\sigma_b$. Hold the lower stress within ± 5 % of the nominal value for a period not exceeding 20 s. Record the lower stress. Reduce the stress at a rate of (0,6 ± 0,2) MPa/s down to the preload stress $\sigma_p$. Hold the preload stress for a period not exceeding 20 s. At the end of this period, zero the strain measuring instruments.



Repeat the loading cycles above for a further two times, i.e. cycles two and three. At the end of each of the second and third cycles at the lower stress level, record the strain $\varepsilon_b$ along each measuring line.

After the three cycles, maintain the preload stress within ± 5 % of the nominal value and perform the following consecutive checks within 60 s.

*First check*

On each measuring line, the variation of $\varepsilon_b$ from the second cycle to the third cycle shall not be greater than 10 %.

If the strain difference is greater than 10 %, stop the test; adjust the measuring instruments and restart. If it is not possible to reduce the difference below 10 % after re-starting, the test shall be stopped.

*Second check*

The strains $\varepsilon_b$ at the third cycle on all the measuring lines shall not differ from their average by more than 20 %.

If the limit is not achieved, re-centre the specimen and restart the test. If it is not possible to reduce the difference below 20 %, the test shall be stopped and the specimen rejected.