SLOVENSKI STANDARD
SIST EN 13791:2019

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Nadomešča:
SIST EN 13791:2007

Ocenjevanje in-situ tlačne trdnosti betona v konstrukcijah in v montažnih betonskih elementih

Assessment of in-situ compressive strength in structures and precast concrete components

Bewertung der Druckfestigkeit von Beton in Bauwerken oder in Bauwerksteilen

Évaluation de la résistance à la compression sur site des structures et des éléments préfabriqués en béton

Ta slovenski standard je istoveten z: **EN 13791:2019**

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91.080.40	Betonske konstrukcije	Concrete structures
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EUROPEAN STANDARD

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Assessment of in-situ compressive strength in structures and precast concrete components

Évaluation de la résistance à la compression sur site des structures et des éléments préfabriqués en béton

Bewertung der Druckfestigkeit von Beton in Bauwerken oder in Bauwerksteilen

This European Standard was approved by CEN on 7 July 2019.

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European foreword

This document (EN 13791:2019) has been prepared by Technical Committee CEN/TC 104 “Concrete and related products”, the secretariat of which is held by SN.

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of an identical text or by endorsement, at the latest by February 2020, and conflicting national standards shall be withdrawn at the latest by February 2020.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 13791:2007.

The main changes compared to EN 13791:2007 are:

a) the standard is fully revised but for continuity the methodological approaches and scope is retained as well as much of the previous layout;

b) the primary focus is on the determination of the characteristic *in situ* compressive strength for application with EN 1990 and EN 1992-1-1;

c) more comprehensive guidance is provided on applying the procedures, particularly with respect to defining a test result, a measurement, volume of concrete, test location, small test region and test region;

d) requirements to set out the purpose of the investigation, procedures to be adopted, test methods, test locations and test regions to be defined prior to commencing the testing, are included;

e) Clause 8, "Estimation of compressive strength for structural assessment of an existing structure", covers the previous requirements for assessment of characteristic *in situ* compressive strength by either testing cores or indirect methods;

f) Clause 9, "Assessment of compressive strength class of concrete in case of doubt", covers previous requirements for the assessment where conformity of concrete based on standard tests is in doubt;

g) approaches A and B in EN 13791:2007 are no longer valid;

h) EN 13791 is aligned with the requirements of EN 206.

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

Introduction

(1) This document covers two applications of *in situ* strength assessments. These are:

— to estimate *in situ* characteristic compressive strength of a test region and/or *in situ* strength at specific locations;

— assessment of compressive strength class of concrete supplied to a structure under construction where there is doubt about the compressive strength based on results of standard tests or doubt about the quality of execution.

(2) Both applications have a number of common steps as shown in Table 1, but the assessment methods differ. The reason for this difference is that with the estimation of the *in situ* strength (Clause 8) there is no presumption as to what this should be and the uncertainty associated with the number of data are taken into account when estimating the value. The *in situ* strength determined in accordance with Clause 8 is a value based on testing a finished structure or element, as referred to by EN 1992-1-1:2004, A.2.3.

NOTE Information may be available on the original quality of the supplied concrete, but the *in situ* strength may have changed over time.

(3) Most of the procedures in Clause 9 apply where there is verification that the concrete supplied is in accordance with the producer's declaration of performance for compressive strength but test results from samples taken on site indicate non-conformity, and where this difference cannot be resolved by other means. As the procedures given in CEN standards for the verification of the declaration of performance are regarded as being reliable, the assumption is that the concrete conforms to the specified characteristic strength and the applied statistical tests check the validity of this hypothesis.

Where a Clause 9 assessment indicates non-conformity of compressive strength then the 9.5 procedure should be adopted by the producer and other involved parties.

(4) The Clause 8 and Clause 9 procedures have different approaches that may lead to significantly different outcomes.

(5) Unless indicated otherwise, the provisions given in this document apply to concrete structures made from normal-weight, lightweight or heavyweight concrete.

(6) This document only covers the use of a single relationship between an indirect test method (UPV or rebound hammer) and compressive strength. The combined use of both UPV and rebound hammer techniques with core strength is a useful technique, but the procedures are not detailed in this document.

(7) This document was developed with the expectation that it will be used with EN 1992-1-1. If it is used in conjunction with other design standards, some of the factors may need modification. In addition, this document uses the EN 1992-1-1:2004, 3.1.6, recommended value of 1,0 for the factor α_{cc} and EN 1992-1-1:2004, A.2.3, recommended value of 0,85 for the factor η. Where national provisions adopt different values for these coefficients then adjustments to the appropriate formula within this Standard may be required.

(8) Techniques outside the range of those specified in this document may be given in provisions valid in the place of use. For example, these include:

— combining two indirect test methods with core testing;

— use of cores of diameter less than 50 mm;

— use of pull-out testing;

— a screening test conforming to the principles specified in 9.4;

— in the Clause 8 procedures, provisions for less than 8 cores without indirect testing;

— assessing the strength gradient across a section after a fire;

— in the Clause 9 procedures, comparing an element where the concrete quality is in doubt with a similar element containing conforming concrete.

In addition, provisions valid in the place of use may give requirements for other aspects not specified in this document. For example, these include:

— relationship between 2:1 and 1:1 core compressive strengths if a value other than 0,82 is justified on the basis of test data for the local materials;

— relationship between *in situ* compressive strength and core length to diameter ratio for values other than 2:1 or 1:1;

— relationship between *in situ* compressive strength for lightweight concretes and core length to diameter ratio;

— adjustment to core strength for cores containing transverse reinforcement;

— relationship between core strength and the strength of a cast cylinder of equal diameter and length;

— factors when the assessment is other than with EN 1992-1-1 or EN 1990;

— factor η given in A.2.3 of EN 1992-1-1:2004 where the national provisions use a value different to the recommended value of 0,85;

— in 8.3 different criteria for structural assessment;

— in 9.2 and 9.3 different criteria where the criteria for compressive strength in EN 206:2013+A1:2016, B.3.1, were not used for the assessment of a number of loads delivered to a construction site;

— guidance on appropriate actions where the producer of the concrete has declared non-conformity or where the concrete has been proven to be non-conforming.

(9) Guidance on undertaking an investigation is given in Annex A.

(10) Further guidance and background information on this revision of EN 13791 and worked examples of the calculations are given in CEN/TR 17086 [1].

Table 1 — Guidance on relevant clauses

Action	Clause
Objective of the investigation	Clause 4, A.1
Selection of test methods	A.3, A.4
Selection of assessment method:	A.2
for determination of *in situ* strength based on:	
— core test data;	8.1
— indirect testing calibrated against test specimens;	8.2
— core and indirect testing.	8.3
or, for assessment of compressive strength where production control data show conformity and identity testing data indicate non-conformity based on:	
— core test data;	9.2
— indirect testing and selected core testing;	9.3
— screening test.	9.4
Procedure where the producer has declared non-conformity of compressive strength	9.5
Selection of test regions and test locations	5.1, 5.2, A.4
Determination of *in situ* strength from core test data	Clause 6
Evaluation of data set to see if it comprises a single concrete	7.1
Evaluation of data set to see if it includes outliers	7.2
Assessment and use of the data	A.4, A.5, A.6

1 Scope

(1) This document:

— gives methods and procedures for the estimation of the *in situ* compressive strength and characteristic *in situ* compressive strength of concrete in structures and precast concrete components using direct methods (core testing) and indirect methods, e.g. ultra-sonic pulse velocity, rebound number;

NOTE To align with the design standard EN 1992-1-1, where the compressive strength is based on 2:1 cylinders, the *in situ* compressive strength is based in 2:1 cores of diameter ≥ 75 mm.

— provides principles and guidance for establishing the relationships between test results from indirect test methods and the *in situ* compressive strength;

— provides procedures and guidance for assessing the conformity with the compressive strength class of concrete supplied to structures under construction where standard tests indicate doubt or where the quality of execution is in doubt.

(2) This document provides requirements for determining the *in situ* strength at test locations and the characteristic strength of test regions, but how this information is to be applied needs to be considered in the light of the specific situation and engineering judgement applied to the specific case.

(3) This document does not include the assessment of the quality of concrete for properties other than compressive strength, e.g. durability-related properties.

(4) This document is not for the assessment of conformity of concrete compressive strength in accordance with EN 206 or EN 13369, except as indicated in EN 206:2013+A1:2016, 5.5.1.2 or 8.4.

(5) This document does not cover the procedures or criteria for the routine conformity control of precast concrete components using either direct or indirect measurements of the *in situ* strength.

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 206:2013+A1:2016, *Concrete — Specification, performance, production and conformity*

EN 1990:2002, *Eurocode — Basis of structural design*

EN 1992-1-1:2004, *Eurocode 2: Design of concrete structures — Part 1-1: General rules and rules for buildings*

EN 12350-1, *Testing fresh concrete — Part 1: Sampling*

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

EN 12504-2, *Testing concrete in structures — Part 2: Non-destructive testing — Determination of rebound number*

EN 12504-4, *Testing concrete — Part 4: Determination of ultrasonic pulse velocity*

EN 13369:2018, *Common rules for precast concrete products*

EN 13670, *Execution of concrete structures*

3 Terms, definitions, symbols and abbreviations

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

NOTE Abbreviations related to expressions of compressive strength and their meaning are given in 3.2.

3.1.1
core length factor
factor for converting the core test measurement or a core test result to the equivalent value of the same diameter core with a length that is twice its diameter

3.1.2
indirect test
non-destructive test in accordance with either EN 12504-2 for rebound number or EN 12504-4 for ultrasonic pulse velocity (UPV)

3.1.3
load
quantity of concrete transported in a vehicle comprising one or more batches

3.1.4
maturity
function of age and temperature such that for a given concrete, any batch with the same maturity has the same compressive strength

Note 1 to entry: Maturity is often expressed as equivalent age in days at 20 °C. In accordance with EN 13670, maturity calculations shall be based on an appropriate maturity function, proven for the type of cement or combination of cement and addition in use.

3.1.5
rebound number
median of at least nine valid rebound hammer readings taken at one test location after adjusting where necessary for the orientation of the rebound hammer

Note 1 to entry: The rebound number is expressed as a whole number.

Note 2 to entry: The procedure for determining the rebound number is specified in EN 12504-2.

3.1.6
screening test
indirect test procedure with a generic or specific relationship to compressive strength

Note 1 to entry: The established relationship may be used to indicate conformity to a specified compressive strength class.

3.1.7
small test region
for structural assessment a small test region is one that is sufficiently small for the variations in the in-situ compressive strength to be primarily due to the selected test locations and testing variability and not due to variations in the quality of the concrete supplied

3.1.8
test location
limited area selected for measurements usually used to estimate one test result that is to be used in the assessment of in-situ compressive strength

Note 1 to entry: See Clause 6 (9) and 8.1 (2) for the exception.

3.1.9
test region
one or several similar structural elements or precast concrete components known or assumed to be made from concrete with the same constituents and the same compressive strength class or equivalent to the defined volume associated with identity testing for compressive strength

Note 1 to entry: A test region contains test locations.

3.1.10
test result
arithmetic mean of the measurements or in the case of a rebound number the median of the measurements taken at a test location

Note 1 to entry: A test result may comprise a single ≥ 75 mm diameter core or a single UPV measurement.

3.1.11
ultrasonic pulse velocity
UPV
speed at which an ultrasonic pulse passes through concrete

Note 1 to entry: The procedure for determining the UPV is specified in EN 12504-4.

3.2 Symbols and abbreviations

CLF core length factor

G_p critical value according to Grubbs' test

k_n characteristic fractile factor [SOURCE: EN 1990:2002]

m number of valid indirect test results in test region under investigation

n number of core test results

p number of parameters of the correlation curve

s estimate of the overall standard deviation of *in situ* compressive strength

NOTE 1 See Formula (6) for the calculation of s.

s_c residual standard deviation, which is a measure of the spread of the core strength test data around the fitted regression curve

NOTE 2 See Formula (8) for the calculation of s_c.

s_e standard deviation of all the estimated strength values, which is a measure of the spread of the estimated core strengths around its mean value

NOTE 3 See Formula (7) for the calculation of s_e.

$x_{i,cor}$ indirect test value at test location "i" that is used for the correlation

x_0 indirect test value at test location "0" (where the *in situ* strength is required for structural assessment purposes)

$\overline{x}$ mean of the m indirect test values used for the correlation

NOTE 4 The abbreviations used for compressive strength are given in Table 2.

Table 2 — Abbreviations used for compressive strength

Abbreviation	Description and explanation
f_c or $f_{c,cube}$	Compressive strength determined from samples of concrete taken in accordance with EN 12350-1, made into cylinder or cube specimens and cured in accordance with EN 12390-2 and tested in accordance with EN 12390-3.
$f_{c,core}$	Compressive strength of a core determined in accordance with EN 12504-1. NOTE This is a generic abbreviation used to cover all length to diameter ratios.
$f_{c,1:1core}$ or $f_{c,2:1core}$	Compressive strength of a core determined in accordance with EN 12504-1. NOTE Where the length to diameter ratio of the core is 1:1 the abbreviation $f_{c,1:1core}$ is used and where the length to diameter ratio is 2:1, the abbreviation $f_{c:2:1core}$ is used.
$f_{c,is}$	Compressive strength of a core taken at a test location within a structural element or precast concrete component expressed in terms of the strength of a 2:1 core of diameter ≥ 75 mm. NOTE 1 If more than one core is taken at a test location, the test result is the mean of the individual test measurements. NOTE 2 This value is based on the *in situ* moisture condition and it is not adjusted to a standard moisture condition.
$f_{ck,is}$	Characteristic *in situ* compressive strength (expressed as the strength of a 2:1 core of diameter ≥ 75 mm), i.e. the *in situ* compressive strength below which 5 % of test results are expected to fall if all the volume of concrete under consideration had been cored and tested. NOTE 1 These values are not normalized to a standard moisture condition. NOTE 2 The *in situ* volume of concrete under consideration is unlikely to be the same volume used to determine the conformity of the fresh concrete in accordance with EN 206. It is generally a smaller volume.
$f_{c,is,est}$	Estimated *in situ* compressive strength at a specific test location.
$f_{c,is,highest}$	Highest value of *in situ* compressive strength in a set of "*n*" test locations (expressed as the strength of a 2:1 core of diameter ≥ 75 mm). NOTE If more than one core is taken at a test location, the core test values for each test location are averaged and the "highest value" is the highest of these averaged measurements.
$f_{c,is,lowest}$	Lowest value of *in situ* compressive strength in the set of "*n*" test locations (expressed as the strength of a 2:1 core of diameter ≥ 75 mm). NOTE If more than one core is taken at a test location, the core test values for each test location are averaged and the "lowest value" is the lowest of these averaged measurements.
$f_{c,is,reg}$	Indirect test value converted to its equivalent *in situ* compressive strength using a regression equation.
$f_{ck,spec}$	Minimum characteristic strength of 2:1 cylindrical test specimens associated with the specified compressive strength class. NOTE For example $f_{ck,spec}$ is 30 MPa for compressive strength class C30/37. See EN 206 for all strength classes.
$f_{c,m(i)is}$	Mean *in situ* compressive strength of a set of "i" test locations (expressed as the strength of a 2:1 core of diameter ≥ 75 mm).