SLOVENSKI STANDARD
oSIST prEN 13791:2017

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Ocenjevanje tlačne trdnosti konstrukcije na mestu vgradnje in betonski elementi

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: **prEN 13791**

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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

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

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European foreword

This document (prEN 13791:2017) has been prepared by Technical Committee CEN/TC 104 “Concrete and related products”, the secretariat of which is held by DIN.

This document is currently submitted to the CEN Enquiry.

This document will supersede EN 13791:2007.

Introduction

(1) This revised European Standard covers two applications of in-situ strength assessments. These are:

— to estimate in-situ characteristic strength and/or in-situ strength at specific locations;

— to assess whether the supplied concrete conformed to the specified compressive strength class.

(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 is taken into account when estimating the value. Where the objective of the investigation is to assess if the recently supplied concrete in cast structures or precast concrete elements conformed to the specified compressive strength class (Clause 9), the assessment is an estimate of whether it conformed or it did not conform. A positive outcome confirms that the in-situ strength is within the EN 1992-1-1 design allowance. Whether this is due to:

— the concrete coming from a conforming population;

— any adjustments to the concrete on site, e.g. adding water or admixtures, were not significant;

— the care in placing, compacting and curing the concrete conformed to EN 13670 or EN 13369 as appropriate;

— a higher than assumed level of execution compensated for a lower concrete compressive strength or vice versa;

cannot be determined from the procedures given in this Standard. If the procedures given in Clause 9 are satisfied, the concrete in the structure fulfils the design assumptions. In this situation, established practice is to accept the concrete as conforming to its specification for compressive strength, any adjustments to the concrete on site are not significant and the level of execution conformed to EN 13670 or EN 13369 as appropriate.

(3) As the two applications have different approaches this may lead to different outcomes.

(4) This Standard 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 Standard uses the recommended value of 0,85 for conversion factor η given in A.2.3 of EN 1992-1-1:2004 and this will need modification if the national provisions use a different value.

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

— use of cores of diameter less than 50 mm, micro-cores;

— use of pull-out testing;

— 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 Standard. For example, these include:

— lightweight concretes;

— 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;

— 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 reference value of 0,85;

— in Clause 9.2 and Clause 9.3, core test criteria for concrete not under production control certification.

(6) Guidance on undertaking an investigation is given in Annex B.

(7) Further guidance and background information on this revision of EN 13791 and worked examples of the calculations are given in FprCEN/TR 17086, *Further guidance on the application of* EN 13791 *and background to the provisions* [1].

Table 1 — Guidance on relevant clauses

Action	Clause
Objective of the investigation	Clause 4, B.1, B.6
Selection of test methods	B.2, B.3, B.4
Selection of assessment method:	B.2
for determination of in-situ strength:	
— based on core test data;	8.1
— based on core and indirect testing; — based on indirect testing calibrated against test specimens.	8.2, 8.3 8.2, Annex A
or, for assessment of compressive strength of recently supplied concrete:	
— based on core test data; — based on indirect testing and selected core testing;	9.2 9.3
— screening test using rebound hammer;	9.4
— based on indirect testing calibrated against test specimens.	9.5, Annex A
Selection of test regions and test locations	5.1, 5.2, B.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	B.1, B.4, B.5, B.6

1 Scope

(1) This European Standard:

— 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;

— 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 on in-situ assessment of the compressive strength class of concrete where there is doubt over the strength of concrete recently supplied to a structure or precast concrete component.

This European Standard does not include the following cases:

— assessment based on cores less than 50 mm in diameter, micro-cores;

— assessment of the quality of concrete for properties other than compressive strength, e.g. durability-related properties;

— specific provisions for lightweight concretes;

— use of pull-out testing;

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

— use of comparative testing (see FprCEN/TR 17086, *Further guidance on the application of EN 13791 and background to the provisions* [1] for explanation).

(2) This European Standard 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.

(3) This European Standard 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, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 design*[1)]

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

1) This document is impacted by the amendment EN 1990:2002/A1:2005.

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, *Common rules for precast concrete products*

EN 13670, *Execution of concrete structures*

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

3 Terms and definitions, symbols and abbreviations

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply. Terms related to expressions of compressive strength are given in 3.2.2.

3.1.1
maturity
function of age and temperature such that for a given concrete, any batch with the same maturity will have 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 should be based on an appropriate maturity function, proven for the type of cement or combination of cement and addition in use.

3.1.2
rebound number
result of test in accordance with EN 12504-2

Note 1 to entry: This European Standard has been framed around the use of a Type N, spring driven steel hammer.

3.1.3
test location
limited area selected for measurements used to estimate one test result that is to be used in the assessment of in-situ compressive strength

3.1.4
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.

3.1.5
test result
average 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 80 mm to 160 mm diameter core or a single UPV measurement.

3.1.6
ultrasonic pulse velocity
UPV
result of a test in accordance with EN 12504-4.

3.2 Symbols and abbreviations

3.2.1 Symbols and abbreviations

R^2 coefficient of determination

k_n factor applied to the sample standard deviation, see Table 5

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 sample standard deviation

s_c standard error of the correlation

s_e standard deviation of all the estimated values of in-situ strength

$x_{i,cor}$ 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)

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

See also 3.2.2.

3.2.2 Abbreviations used in the relationships between different expressions of 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 term used to cover all length to diameter ratios.
$f_{c,1:1core}$ or $f_{c,2:1\ core}$	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.
$f_{c,is}$	Average compressive strength for all the cores 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 in the range 80 mm to 160 mm NOTE This value is based on the in-situ moisture condition and it is not adjusted to a standard moisture condition.
$f_{c,is,ck}$	Value of in-situ compressive strength (expressed as the strength of a 2:1 core of diameter in the range 80 mm to 160 mm)) 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 in the range 80 mm to 160 mm) NOTE If more than one core is taken at a test location, the core results for each test location are averaged and the 'highest value' is the highest of these averaged results.
$f_{c,is,lowest}$	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 in the range 80 mm to 160 mm) NOTE If more than one core is taken at a test location, the core results for each test location are averaged and the 'lowest value' is the lowest of these averaged results.
$f_{c,is,reg}$	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 N/mm² for compressive strength class C30/37. See EN 206 for all strength classes.
$f_{c,m(n)is}$	Mean in-situ compressive strength of a set of '*n*' test locations (expressed as the strength of a 2:1 core of diameter in the range 80 mm to 160 mm)

4 Investigation objective and test parameters

(1) Prior to commencing testing on site, the following shall be determined and documented:

a) objective of the investigation;

b) standards, test methods and assessment techniques to be applied;

c) test region(s) and test locations;

d) number of tests per test location;

e) if cores are being taken, the diameter and length of the cores to be taken from the surface;

NOTE The specified diameter of the core refers to the finished core diameter and not the hole size.

f) where the cores are to be cut to obtain the trimmed length(s) for testing;

g) technique to be used to prepare the ends of the cores;

h) whether sampling and testing shall be undertaken by a laboratory that has accredited procedures according to ISO/IEC 17025.

(2) Figure 1 and Figure 2 are flowcharts to help select the appropriate techniques and clauses.

(3) Guidance on undertaking an investigation is provided in Annex B.