SLOVENSKI STANDARD
oSIST prEN 12504-4:2019

01-november-2019

Preskušanje betona - 4. del: Določevanje hitrosti prehoda ultrazvoka

Testing concrete in structures - Part 4: Determination of ultrasonic pulse

Prüfung von Beton in Bauwerken - Teil 4: Bestimmung der Ultraschallgeschwindigkeit

Essais pour béton dans les structures - Partie 4 : Détermination de la vitesse de propagation des ultrasons

Ta slovenski standard je istoveten z: prEN 12504-4

ICS:

91.100.30	Beton in betonski izdelki	Concrete and concrete products

oSIST prEN 12504-4:2019 en,fr,de

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

DRAFT
prEN 12504-4

September 2019

ICS 91.100.30

Will supersede EN 12504-4:2004

English Version

Testing concrete in structures - Part 4: Determination of ultrasonic pulse

Essais pour béton dans les structures - Partie 4: Determination de la vitesse de propagation du son

Prüfung von Beton in Bauwerken - Teil 4: Bestimmung der Ultraschallgeschwindigkeit

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

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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

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Ref. No. prEN 12504-4:2019 E

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European foreword

This document (prEN 12504-4:2019) 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.

This document will supersede EN 12504-4:2004.

This standard is one of a series on testing concrete.

EN 12504, *Testing concrete in structures*, consists of the following parts:

— Part 1: *Cored specimens — Taking, examining and testing in compression;*

— Part 2: *Non-destructive testing — Determination of rebound number;*

— Part 3: *Determination of pull-out force;*

— Part 4: *Determination of ultrasonic pulse velocity.*

This document is based on the International Standard ISO 1920-7, *Testing of concrete — Part 7: Non-destructive tests on hardened concrete*. It is recognized that the ultrasonic pulse velocity determined using this document is a convention in as much that the path length over which the pulse travels is not always strictly known.

The measurement of pulse velocity can be used for the determination of the uniformity of concrete, the presence of cracks or voids, changes in properties with time and in the determination of dynamic physical properties. These subjects were considered to be outside the scope of this document, but some information is given in Annex B and more information can be found in the technical literature. The measurement can also be used to estimate the strength of *in situ* concrete elements or specimens given in EN 13791, *Assessment of in situ compressive strength in structures and precast concrete components*. However, it is not intended as an alternative to the direct measurement of the compressive strength of concrete.

The following amendments have been made to the former edition:

— option to use equipment utilizing transverse waves.

1 Scope

This document specifies a method for the determination of the velocity of propagation of pulses of ultrasonic longitudinal waves or ultrasonic transverse waves in hardened concrete, which is used for a number of applications.

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, *Concrete — Specification, performance, production and conformity*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 206 and the following 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
transit time
time taken for an ultrasonic pulse to travel from the transmitting transducer to the receiving transducer, passing through the interposed concrete

3.2
onset
leading edge of the pulse detected by the measuring apparatus

3.3
rise time
time for the leading edge of the first pulse to rise from 10% to 90% of its maximum amplitude

4 Principle

A pulse of longitudinal or transverse vibrations is produced by an electro-acoustical transducer held in contact with one surface of the concrete under test. After traversing a known path length in the concrete, the pulse of vibrations is converted into an electrical signal by a second transducer and electronic timing circuits enable the transit time of the pulse to be measured.

5 Apparatus

5.1 General

The apparatus consists of an electrical pulse generator, a pair of transducers, an amplifier and an electronic timing device for measuring the time interval elapsing between the onset of a pulse generated at the transmitting transducer and the onset of its arrival at the receiving transducer. A reference bar or prism is used to zero the instrument or to provide a datum for the velocity measurement.

NOTE 1 This is typically necessary when the user changes the length of the cables being used.

Three forms of the electronic timing apparatus are available:

a) an oscilloscope on which the first front of the pulse is displayed in relation to a suitable time scale;

b) an interval timer with a direct reading digital display;

c) an A-scan display built directly into the instrument.

NOTE 2 An oscilloscope or integrated A-scan display provides the facility for monitoring the wave form of the pulse, which can be advantageous in complex testing situations or in automatic system measurements.

5.2 Performance requirements

The apparatus shall conform to the following performance requirements:

— It shall be capable of measuring transit times in the reference bar or prism to a limit deviation of ± 0,1 μs and an accuracy of 2 %.

— The electronic excitation pulse applied to the transmitting transducer shall have a rise time of not greater than one-quarter of its natural period. This is to ensure a sharp pulse onset.

— The pulse repetition frequency shall be low enough to ensure that the onset of the received signal is free from interference by reverberations.

The apparatus shall be used within the operating conditions stated by the manufacturer.

5.3 Transducers

The natural frequency of the transducers should normally be within the range 20 kHz to 150 kHz.

NOTE For longitudinal waves, frequencies as low as 10 kHz and as high as 200 kHz can sometimes be used. High frequency pulses have a well defined onset, but, as they pass through the concrete, they become attenuated more rapidly than pulses of lower frequency. It is, therefore, preferable to use high frequency transducers (60 kHz to 200 kHz) for short path lengths (down to 50 mm) and low frequency transducers (10 kHz to 40 kHz) for long path lengths (up to a maximum of 15 m). Transducers with a frequency of 40 kHz to 60 kHz are found to be useful for most applications. For ultrasonic pulse echo measurements using transverse waves the transducer frequency of 40 kHz to 60 kHz is also typical, but the in this case the path length is limited to a maximum of approximately 2,5 m.

5.4 Apparatus for determination of arrival time of the pulse

The apparatus shall be capable of determining the time of arrival of the first front of the pulse with the lowest possible threshold, even though this may be of small amplitude compared with that of the first half wave of the pulse.

6 Procedures

6.1 Determination of Pulse Velocity

6.1.1 Factors influencing pulse velocity measurements

In order to provide a measurement of pulse velocity, which is reproducible, it is necessary to take into account various factors which can influence the measurements. These are set out in Annex B.

6.1.2 Transducer arrangement

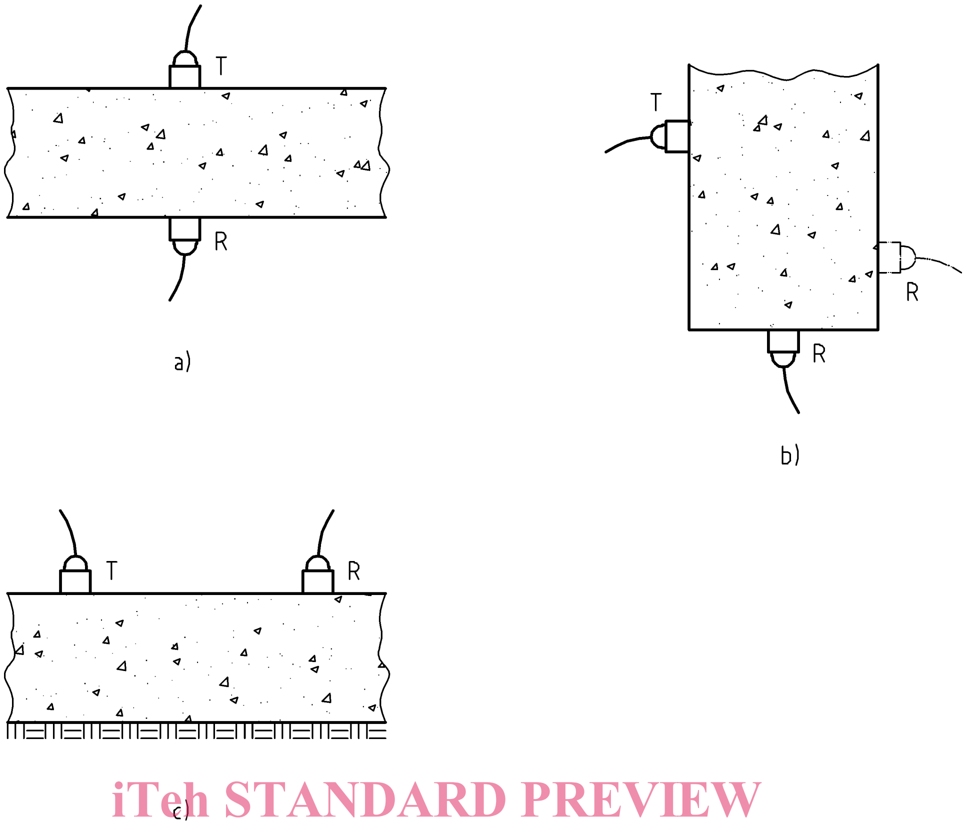
Although the direction in which the maximum energy is propagated is at right angles to the face of the transmitting transducer, it is possible to detect pulses which have travelled through the concrete in some other direction. It is therefore possible to make measurements of pulse velocity by placing the two transducers on opposite faces (direct transmission), or on adjacent faces (semi-direct transmission), or the same face (indirect or surface transmission; pulse echo transmission) (see Figure 1) of a concrete structure or specimen. In the case of pulse echo transmission, the receiver detects pulses which have travelled through the concrete to the opposite face and have been reflected back to the first face.

Where it is necessary to place the transducers on opposite faces but not directly opposite each other such arrangement shall be regarded as a semi-direct transmission (see Figure 1.b).

NOTE 1 The indirect transmission arrangement is the least sensitive and is used when only one face of the concrete is accessible or when the quality of the surface concrete relative to the overall quality is of interest.

NOTE 2 The semi-direct transmission arrangement is used when the direct arrangement cannot be used, for example at the corners of structures.

NOTE 3 Pulse echo transmission is an alternative to indirect transmission when only one face of the concrete is accessible. The sensitivity is comparable with direct transmission.



Key

R is the receiver transducer

T is the transmitter transducer

Figure 1 — Transducer positioning

6.1.3 Path length measurement

For direct transmission, the path length is the shortest distance between the transducers. The accuracy of measurement of the path length shall be recorded to an accuracy of ± 1 %.

For semi-direct transmission, it is generally found to be sufficiently accurate to take the path length as the distance measured from centre to centre of the transducer faces. The accuracy of path length is dependent upon the size of the transducer compared with the centre to centre distance.

With indirect transmission, the path length is not measured, but a series of measurements is made with the transducers at different distances apart (see Annex A).

For pulse echo transmission, the path length is two times the distance from the face where the transducer is placed and the opposite face. The path length shall be recorded as for direct transmission.

6.1.4 Coupling the transducer onto the concrete

There shall be adequate acoustical coupling between the concrete and the face of each transducer. For many concrete surfaces, the finish is sufficiently smooth to ensure good acoustical contact by the use of a coupling medium such as petroleum jelly, grease, soft soap and kaolin/glycerol paste and by pressing the transducer against the concrete surface.

Repeated readings of the transit time should be made until a minimum value is obtained, indicating that the thickness of the couplant has been reduced to a minimum.

When the concrete surface is very rough and uneven, the area of the surface should be smoothed and levelled by grinding, or by the use of a quick-setting epoxy resin.

NOTE 1 Special transducers are available for use on very rough surfaces.

NOTE 2 Pulse echo transducers can utilize dry point contact elements which do not require a couplant. In this case, it is typical for several transducer elements to be connected in parallel to provide sufficient signal strength.

6.1.5 Measurement of transit time

Using the electronic device the time interval indicated shall be determined in accordance with the manufacturer's instruction (see 5.2).

7 Expression of result

For direct, semi-direct and pulse echo transmissions the pulse velocity shall be calculated from the formula:

$$V = \frac{L}{T}$$

where

- V is the pulse velocity, in km/s;
- L is the path length, in mm;
- T is the time taken by the pulse to transverse the length, in µs.

For the velocity by indirect transmission, see Annex A.

The resultant determination of the pulse velocity shall be expressed to the nearest 0,01 m/s.

8 Test report

The test report shall include the following:

— identification of the concrete structure or specimens tested;

— location of performance of the test;

— date of the test;

— description of the concrete including mix proportions (if known);

— age of concrete, at time of test (if known);

— temperature of the concrete, at time of test (when appropriate, see B.3);