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Preskuġanje betona ï 4. del: Doloļevanje hitrosti prehoda ultrazvoka

Testing concrete - Part 4: Determination of ultrasonic pulse velocity

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

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

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This European Standard was approved by CEN on 26 February 2004.

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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Foreword

This document (EN 12504-4:2004) has been prepared by Technical Committee CEN/TC 104 “Concrete and related products”, the secretariat of which is held by DIN.

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of an identical text or by endorsement, at the latest by February 2005, and conflicting national standards shall be withdrawn at the latest by February 2005.

A draft standard was submitted in 1998 to CEN enquiry as prEN 13296. It was one of a series of individually numbered test methods for fresh or hardened concrete. For convenience it has now been decided to combine these separate draft standards into three new standards with separate Parts for each method, as follows:

— Testing fresh concrete (EN 12350)

— Testing hardened concrete (EN 12390)

— Testing concrete in structures (EN 12504)

This series, EN 12504, includes the following Parts where the brackets give the numbers under which particular test methods were submitted to CEN enquiry:

EN 12504, *Testing concrete in structures*

Part 1: Cored specimens — Testing, examining and testing in compression (former prEN 12504:1996)

Part 2: Non-destructive testing — Determination of rebound number (former prEN 12398:1996)

Part 3: Determination of pull-out force (former prEN 12399:1996)

Part 4: Determination of ultrasonic pulse velocity (former prEN 12396:1998)

This European Standard is based on ISO/DIS 8047 "*Concrete hardened — Determination of ultrasonic pulse velocity*". It is recognised that the ultrasonic pulse velocity determined using this standard is a convention in as much that the path length over which the pulse travels may not strictly be 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 standard, but some information is given in Annex B and more information can be found in the technical literature. The measurement may also be used to estimate the strength of in-situ concrete elements or specimens. However, it is not intended as an alternative to the direct measurement of the compressive strength of concrete.

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

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

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 206-1:2000, *Concrete — Part 1: Specification, performance, production and conformity.*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 206-1:2000 and the following apply.

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 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 calibration bar is provided to provide a datum for the velocity measurement.

Two 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.

NOTE An oscilloscope 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 calibration bar 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 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.

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.

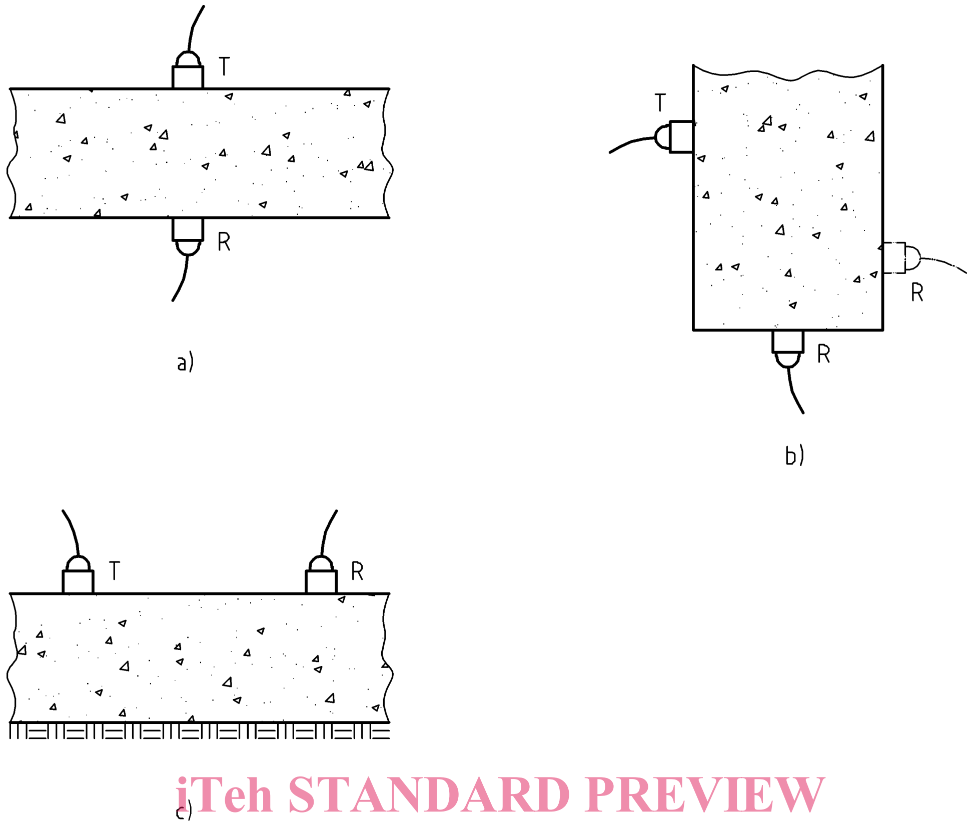
6.1.2 Transducer arrangement

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) (see Figure 1) of a concrete structure or specimen.

NOTE 1 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 2 The indirect transmission arrangement is the least sensitive and should be 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 3 The semi-direct transmission arrangement is used when the direct arrangement cannot be used, for example at the corners of structures.



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).

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 Special transducers are available for use on very rough surfaces.

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

$$V = \frac{L}{T} \quad 1$$

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 km/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);
- type and make of apparatus used, including:
  - a) dimensions of contact area transducers;
  - b) natural pulse frequency of transducers;
  - c) any special characteristics;
- transducer arrangements and transmission method (sketch, when appropriate);
- details of reinforcing steel or ducts in the vicinity of the test areas (if known);
- surface conditions and preparation at test points;