Designation: C1383 – 23

Standard Test Method for Measuring the P-Wave Speed and the Thickness of Concrete Plates Using the Impact-Echo Method[1]

This standard is issued under the fixed designation C1383; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This test method covers procedures for determining the thickness of concrete slabs, pavements, bridge decks, walls, or other plate-like structures using the impact-echo method.

1.2 The following two procedures are covered in this test method:

1.2.1 *Procedure A: P-Wave Speed Measurement*—This procedure measures the time it takes for the P-wave generated by a short-duration, point impact to travel between two transducers positioned a known distance apart along the surface of a structure. The P-wave speed is calculated by dividing the distance between the two transducers by the travel time.

1.2.2 *Procedure B: Impact-Echo Test*—This procedure measures the frequency at which the P-wave generated by a short-duration, point impact is reflected between the parallel (opposite) surfaces of a plate. The thickness is calculated from this measured frequency and the P-wave speed obtained from Procedure A.

1.2.3 Unless specified otherwise, both Procedure A and Procedure B must be performed at each point where a thickness determination is made.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 The text of this standard refers to notes and footnotes that provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C125 Terminology Relating to Concrete and Concrete Aggregates

C597 Test Method for Ultrasonic Pulse Velocity Through Concrete

E1316 Terminology for Nondestructive Examinations

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this test method, refer to Terminology C125 and Terminology E1316.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *acoustic impedance, n*—the product of P-wave speed and density that is used in computations of characteristics of stress wave reflection at boundaries.

3.2.2 *P-wave, n*—the dilatational (longitudinal or primary) stress wave that causes particle displacement parallel to the direction of wave propagation: this wave produces normal stresses (tensile or compressive) as it propagates.

3.2.3 *P-wave speed, n*—the speed with which the P-wave propagates through a semi-infinite solid.

3.2.3.1 *Discussion*—The P-wave speed is the same as the compressional pulse velocity measured according to Test Method C597.

3.2.4 *apparent P-wave speed in a plate*[3,4], *n*—a wave speed that is equal to 0.96 of the P-wave speed:

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[1] This test method is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.64 on Nondestructive and In-Place Testing.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Sansalone, M. and Streett, W.B., *Impact-Echo: Nondestructive Evaluation of Concrete and Masonry*, Bullbrier Press, Ithaca, NY and Jersey Shore, PA, 1997.

[4] Sansalone, M., Lin, J. M., and Streett, W. B., "A Procedure for Determining P-wave Speed in Concrete for Use in Impact-Echo Testing Using P-wave Speed Measurement Technique," *ACI Journal*, Vol. 94, No. 6, November–December 1997, pp. 531–539.

***A Summary of Changes section appears at the end of this standard**

$$C_{p,\,plate} = 0.96\, C_p \tag{1}$$

where:

$C_{p,\,plate}$ = the apparent P-wave speed in a plate, m/s, and
C_p = the P-wave speed in concrete that is obtained from Procedure A, m/s.

3.2.4.1 *Discussion*—The apparent P-wave speed is used in thickness calculations in impact-echo measurements on plates. The P-wave speed measured using Procedure A is converted to the apparent P-wave speed in a plate by multiplying by 0.96 as shown in Eq 1. The alternative procedure in 9.6 can also be used to determine the apparent P-wave speed in a plate.

3.2.5 *surface wave, n*—a stress wave in which the particle motion is elliptical and the amplitude of particle motion decreases rapidly with depth: also known as *Rayleigh wave* (or *R-wave*).

3.2.6 *thickness frequency, n*—the frequency of the high amplitude peak in the amplitude spectrum obtained from an impact-echo test of a plate that corresponds to the thickness resonance due to multiple reflections of the P-wave between the opposite surfaces of the plate.

3.2.6.1 *Discussion*—See Section 10 for additional information.

4. Significance and Use

4.1 This test method may be used as a substitute for, or in conjunction with, coring to determine the thickness of slabs, pavements, decks, walls, or other plate structures. There is a certain level of systematic error in the calculated thickness due to the discrete nature of the digital records that are used. The absolute systematic error depends on the plate thickness, the sampling interval, and the sampling period.

4.2 Because the wave speed can vary from point-to-point in the structure due to differences in concrete age or batch-to-batch variability, the wave speed is measured (Procedure A) at each point where a thickness determination (Procedure B) is required.

4.3 This test method is a pplicable to plate-like structures with lateral dimensions at least six times the thickness. These minimum lateral dimensions are necessary to prevent other modes[3] of vibration from interfering with the identification of the thickness mode frequency in the amplitude spectrum. As explained in Note 12, the minimum lateral dimensions and acceptable sampling period are related.

4.4 The maximum and minimum thickness that can be measured is limited by the details of the testing apparatus (transducer response characteristics and the specific impactor). The limits shall be specified by manufacturer of the apparatus, and the apparatus shall not be used beyond these limits. If test equipment is assembled by the user, thickness limitations shall be established and documented.

4.5 This test method is not applicable to plate structures with overlays, such as a concrete bridge deck with an asphalt or portland cement concrete overlay. The method is based on the assumption that the concrete plate has the same P-wave speed throughout its depth.

4.6 Procedure A is performed on concrete that is air dry as high surface moisture content may affect the results.

4.7 Procedure B is applicable to a concrete plate resting on a subgrade of soil, gravel, permeable asphalt concrete, or lean portland cement concrete provided there is sufficient difference in acoustic impedance[3] between the concrete and subgrade or there are enough air voids at the interface to produce measurable reflections. If these conditions are not satisfied, the waveform will be of low amplitude and the amplitude spectrum will not include a dominant peak at the thickness frequency. If the interface between the concrete and subgrade is rough, the amplitude spectrum will have a rounded peak instead of a sharp peak associated with a flat surface.

4.8 The procedures described are not influenced by traffic noise or low frequency structural vibrations set up by normal movement of traffic across a structure.

4.9 The procedures are not applicable in the presence of mechanical noise created by equipment impacting (jack hammers, sounding with a hammer, mechanical sweepers, and so forth) on the structure.

4.10 Procedure A is not applicable in the presence of high amplitude electrical noise, such as may produced by a generator or some other source, that is transmitted to the data-acquisition system.

PROCEDURE A—P-WAVE SPEED MEASUREMENT

5. Summary of Procedure

5.1 An impact on the concrete surface is used to generate transient stress waves. These waves propagate along the surface of the concrete past two transducers, placed on a line through the impact point and at a known distance apart.

5.2 The time difference between the arrival of the P-wave (stress wave with highest speed) at each transducer is used to determine the P-wave speed by dividing the time difference (travel time) by the known distance between the transducers.

6. Apparatus[5]

6.1 *Impactor*—The impactor shall be spherical or spherically tipped. It shall produce an impact duration of 30 µs ± 10 µs with sufficient energy to produce surface displacements due to the P-wave that can be recorded by the two transducers (see Note 1). The impactor shall be positioned to strike on the centerline passing through the two transducers at a distance of 150 mm ± 10 mm from the first transducer.

NOTE 1—Hardened steel balls ranging from 5 mm to 8 mm in diameter and attached to steel spring rods have been found to produce suitable impacts.

6.2 *Transducers*—Two broadband transducers that respond to displacements normal to the surface. These transducers must

[5] Suitable apparatus is available commercially.