
Standard Method of Test for

**Real-Time Estimate of In-Place
Concrete Strength Using
Acoustical Resonance Method**

AASHTO Designation: T 412-24¹

First Published: 2024

Technical Subcommittee: 3c, Hardened Concrete



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1. SCOPE

- 1.1. This standard provides procedures for estimating in-place mechanical properties of concrete structures using the acoustical resonance of a specially designed sensor. The sensor directly measures the dynamic modulus of concrete during its hardening process and calculates the strength based on the dynamic modulus and pertinent formulas. This method is distinct from the maturity method specified in T 276, T 325, and ASTM C1074, which correlates the in-place strength of concrete with traditional cylinder testing results based on a temperature profile. The proposed method relies on direct, in-place measurements of concrete's mechanical properties rather than on a pre-established strength–maturity relationship that was developed in a laboratory for a particular mix design. This method does not require mix design-specific calibration and readily allows use for any mix design at any time of interest. Also, unlike current standards for resonant frequency testing specified in ASTM C215 and ASTM E1050, this method allows in-place testing of a localized region within a concrete structure, making it practical to apply resonance-based testing methods onsite.
- 1.2. This standard requires the determination of resonant frequencies of a localized region of a concrete structure using a piezoelectric sensing device and an impedance analyzer.
- 1.3. This test method covers the application of the test using either inch-pound or SI units. The values stated in either SI units or inch-pound units are to be regarded separately as standard. Within the text, the inch-pound units are shown in brackets. The values stated in each system may not be exact equivalents; therefore, each system must be used independently of the other. Combining values from the two systems may result in nonconformance with the standard.
- 1.4. Values in SI units shall be obtained by measurement in SI units or by appropriate conversion, using the rules for conversion and rounding given in IEEE/ASTM SI 10, of measurements made in other units.
- 1.5. *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all safety concerns associated with its use. It is the responsibility of the user of this procedure to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.*

2. REFERENCED DOCUMENTS

- 2.1. *AASHTO Standards:*
 - R 9, Acceptance Sampling Plans for Highway Construction

- T 276, Measuring Early-Age Compression Strength and Projecting Later-Age Strength
- T 325, Estimating the Strength of Concrete in Transportation Construction by Maturity Tests

2.2. *ACI Code:*

- 318, Building Code Requirements for Structural Concrete and Commentary

2.3. *ASTM Standards:*

- C125, Standard Terminology Relating to Concrete and Concrete Aggregates
- C138, Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
- C215, Standard Test Method for Fundamental Transverse, Longitudinal, and Torsional Resonant Frequencies of Concrete Specimens
- C1074, Standard Practice for Estimating Concrete Strength by the Maturity Method
- D3665, Standard Practice for Random Sampling of Construction Materials
- E1050, Standard Test Method for Impedance and Absorption of Acoustical Materials Using a Tube, Two Microphones and a Digital Frequency Analysis System
- IEEE/ASTM SI 10, American National Standard for Metric Practice

3. TERMINOLOGY

3.1. *Definitions of Terms Specific to This Standard:*

- 3.1.1. *electromechanical spectrum (EMS)*—a relationship between electrical properties of a piezoelectric sensor and its frequency, such as impedance spectrum, admittance spectrum, or conductance spectrum. The spectrum is influenced by both electrical and mechanical boundary conditions of the piezoelectric sensor.
- 3.1.2. *resonance*—the phenomenon of increased amplitude that occurs when the frequency of a periodically applied force is equal or close to a natural frequency of the system on which it acts.
- 3.1.3. *sensing region of concrete (SRC)*—the sampled region or volume of concrete that generates the EMS to calculate the testing results of the strength meter.
- 3.1.4. *strength meter*—an apparatus comprised of a piezoelectric disk that is integrated into a soft rubber housing and epoxy sealing. The piezoelectric disk actuates the sensing region of concrete and measures its EMS, which will be used to estimate the dynamic Young's modulus and strength of the concrete. The strength meter functions as an acoustical resonator specially designed for in-place concrete testing.

4. SUMMARY OF TEST METHOD

- 4.1. Place the strength meter within the testing site of interest before concrete is placed. Secure the cable of the strength meter and connect it to the impedance analyzer. The in-place Young's modulus and strength of concrete can be estimated using the EMS data following the equations set forth in Section 10.

5. SIGNIFICANCE AND USE

- 5.1. This standard is applicable for estimating the compressive strength and in-place Young's modulus of concrete used in various structures, including but not limited to pavements, beams, bridge