Designation: D6874 – 22a

Standard Test Methods for Nondestructive Evaluation of the Stiffness of Wood and Wood-Based Materials Using Transverse Vibration or Stress Wave Propagation[1]

This standard is issued under the fixed designation D6874; 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.

INTRODUCTION

Nondestructive testing methods are used to determine the physical and mechanical properties of wood and wood-based materials. These test methods help ensure structural performance of products manufactured from a variety of wood species and quality levels of raw materials. These test methods also assist in evaluating the influence of environmental conditions on product performance.

Dynamic test methods based on the transverse vibration of a simply or freely supported beam, or the propagation of a longitudinal stress wave are methods used to nondestructively evaluate wood-based materials. These methods yield results comparable to traditional static test methods, permitting standardization of results, interchange and correlation of data, and establishment of a cumulative body of information on wood species and products of the world.

1. Scope

1.1 These test methods cover the non-destructive determination of the following dynamic properties of wood and wood-based materials from measuring the fundamental frequency of vibration:

1.1.1 Flexural (see Refs (**1-3**))[2] stiffness and apparent modulus of elasticity (E_{tv}) properties using simply or freely supported beam transverse vibration in the vertical direction, and

1.1.2 Axial stiffness and apparent longitudinal modulus of elasticity (E_{sw}) using stress wave propagation time in the longitudinal direction.

1.2 The test methods can be used for a broad range of wood-based materials and products ranging from logs, timbers, lumber, and engineered wood products.

1.2.1 The two flexural methods can be applied to flexural products such as glulam beams and I-joists.

1.2.2 The longitudinal stress wave methods are limited to solid wood and homogeneous grade glulam (for example, columns but not products with distinct subcomponents such as wood I-joists).

1.3 The standard recognizes three implementation classes for each of these test methods.

1.3.1 *Class I*—Defines the fundamental method to achieve the highest degree of repeatability and reproducibility that can be achieved under laboratory conditions.

NOTE 1—Testing should follow Class I methods to develop training and validation data sets for method conversion models (see Annex A2).

1.3.2 *Class II*—Method with permitted modifications to the Class I method that can be used to address practical issues found in the field, and where practical deviations from the Class I protocol are known and their effects can be accounted.

NOTE 2—Practical deviations include, for example, environmental and test boundary conditions. Class II methods allow for corrections to test results to account for quantifiable effect such as machine frame deflections.

1.3.3 *Class III*—Method permitting the broadest range of application, with permitted modifications to suit a wider range of practical needs with an emphasis on repeatability.

NOTE 3—Online testing machines implemented to grade/sort lumber may be treated as Class III.

1.4 The standard provides guidance for developing a model for estimating a non-destructive test method result (for example, static modulus of elasticity obtained in accordance with Test Methods D198) from another non-destructive test method result (for example, dynamic longitudinal modulus of elasticity from measurement of longitudinal stress wave propagation time).

[1] These test methods are under the jurisdiction of ASTM Committee D07 on Wood and is the direct responsibility of Subcommittee D07.01 on Fundamental Test Methods and Properties.

Current edition approved Oct. 1, 2022. Published November 2022. Originally approved in 2003. Last previous edition approved in 2022 as D6874 – 22. DOI: 10.1520/D6874-22A.

[2] The boldface numbers in parentheses refer to the list of references at the end of this standard.

1.4.1 The standard covers only models developed from test data obtained directly from non-destructively testing a representative sample using one test method, and retesting the same sample following a second test method.

1.4.2 Results used for model development shall not be estimated from a model.

1.5 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.6 *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.*

1.7 *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:*[3]

D9 Terminology Relating to Wood and Wood-Based Products

D198 Test Methods of Static Tests of Lumber in Structural Sizes

D1990 Practice for Establishing Allowable Properties for Visually-Graded Dimension Lumber from In-Grade Tests of Full-Size Specimens

D2395 Test Methods for Density and Specific Gravity (Relative Density) of Wood and Wood-Based Materials

D2915 Practice for Sampling and Data-Analysis for Structural Wood and Wood-Based Products

D3043 Test Methods for Structural Panels in Flexure

D4442 Test Methods for Direct Moisture Content Measurement of Wood and Wood-Based Materials

D4444 Test Method for Laboratory Standardization and Calibration of Hand-Held Moisture Meters

D4761 Test Methods for Mechanical Properties of Lumber and Wood-Based Structural Materials

D7438 Practice for Field Calibration and Application of Hand-Held Moisture Meters

E4 Practices for Force Calibration and Verification of Testing Machines

E2655 Guide for Reporting Uncertainty of Test Results and Use of the Term Measurement Uncertainty in ASTM Test Methods

2.2 *ISO Standards:*[4]

ISO 7626/1 Mechanical vibration and shock—Experimental determination of mechanical mobility—Part 1: Basic terms and definitions, and transducer specifications

ISO 7625/5 Vibration and shock—Experimental determination of mechanical mobility—Part 5: Measurements using impact excitation with an exciter which is not attached to the structure

3. Terminology

3.1 *Definitions*—See Terminology D9 and Test Methods D198.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *calibration, v*—the determination of the relationship between the response of a standardized instrumentation to properties determined by a standard method of a reference material in order to obtain comparable results between different instruments.

3.2.2 *fundamental mode of vibration, n*—the simplest mode of vibration for the given support condition.

3.2.2.1 *Discussion*—For a simply supported beam, the fundamental mode has the mode shape with a half-sine wave form (see Fig. 1).

3.2.2.2 *Discussion*—For a freely supported beam, the fundamental mode has the mode shape shown in Fig. 2.

3.2.3 *longitudinal stress wave, n*—the wave induced in a specimen by the transmission and attenuation of speed-of-audible sound generated by an excitation in the specimen's longitudinal direction.

3.2.3.1 *Discussion*—Resonant frequency (Fig. 3) is the frequency of the stress wave that reflects off the ends of the specimen following an end impact. The frequency may be determined from time-signal data collected by a single accelerometer, or by a microphone detecting sound waves emitted by the specimen following the impact. Higher frequencies will be present in the signal. Therefore, the signal will need to be analyzed to extract the fundamental frequency.

3.2.3.2 *Discussion*—Time of flight (Fig. 4) is the time required for stress wave to travel a known distance through the specimen. This method is excluded from this standard. Because

[3] 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.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

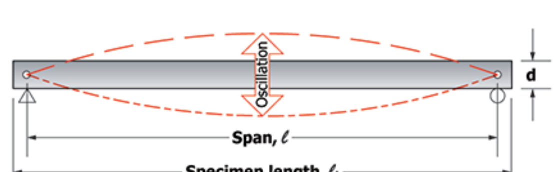

FIG. 1 Mode Shape of Simply Supported Beam Under Transverse Vibration in the Fundamental Mode

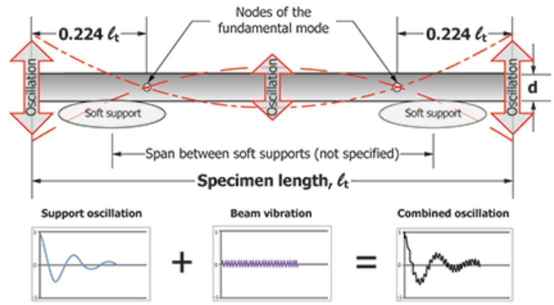

FIG. 2 Mode Shape of Freely Supported Beam Under Transverse Vibration in the Fundamental Mode

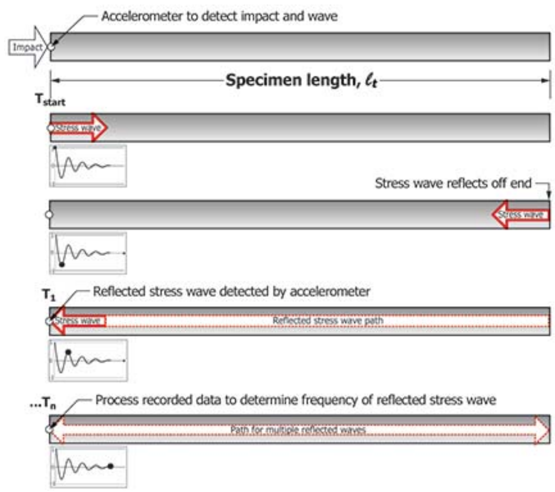

FIG. 3 Stress Wave Transmission in a Specimen (Resonant Frequency)

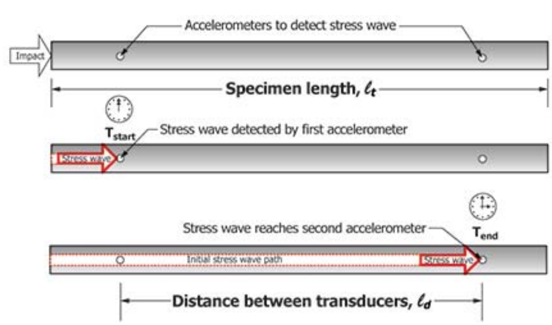

FIG. 4 Stress Wave Transmission in a Specimen (Time of Flight)

there are many frequencies excited in this manner, the signal needs to be analyzed to find the same wave that passes the first and second transducers. This is further complicated by the fact that higher frequencies attenuate faster than lower frequencies, and that these may vary depending on the specimen size and test configuration.

3.2.4 *modal analysis, v*—the process of determining the natural frequencies, modal damping ratios, and mode shapes of an object such as a beam for the vibration modes in the frequency range of interest from the Frequency Response Function (see Appendix X3).

3.2.5 *modal testing, v*—measurement of the Frequency Response Function (see Appendix X3).

3.2.6 *mode shape, n*—pattern of movement (that is, dynamic displacement, velocity, or acceleration) of an object for a vibration mode.

3.2.7 *oscillation, n*—the periodic movement of the specimen about a central position that includes both the rigid movement and the vibration of the specimen.