
Standard Method of Test for High-Strain Dynamic Testing of Piles

AASHTO Designation: T 298-15 (2023)¹

Technically Revised: 2015

Reviewed but Not Updated: 2023

**Technical Subcommittee: 1b, Geotechnical Exploration,
Instrumentation, Stabilization, and Field Testing**



**American Association of State Highway and Transportation Officials
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1. SCOPE

- 1.1. This test method covers the procedure for testing vertical or batter piles individually to determine the force and velocity response of the pile to an impact force applied axially by a pile-driving hammer to the top of the pile. This test method is applicable to deep foundation units that function in a manner similar to foundation piles, regardless of their method of installation, provided that they are receptive to high-strain impact testing. These elements can include drilled shafts, micropiles, and continuous flight auger cast piles.
- 1.2. This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. For a specific precautionary statement, see Note 7.
- Note 1**—High-strain dynamic testing requires a strain at impact that is representative of a force in the pile having the same order of magnitude, or greater, than the ultimate pile-soil resistance.
- Note 2**—This standard method may be applied to the high-strain dynamic testing of piles with the use of either force or strain transducers and either acceleration, velocity, or displacement transducers as long as the test results clearly state how the testing deviates from the standard, i.e., what combination of instruments was used.
- Note 3**—A suitable follower may be required for testing existing cast-in-place concrete piles. This follower should have an impedance within 50 percent of the impedance of the pile. However, additional caution and analysis may be required if the impedance is not within 10 percent.
- Note 4**—For mandrel-driven piles, the mandrel may be instrumented in a similar way to a driven pile. However, results from a mandrel that is more than two pieces, one that has joints, will require additional analysis.
- 1.3. *The quality of the results produced by this standard are dependent on the competence of the personnel performing the procedure and the capability, calibration, and maintenance of the equipment used. Agencies that meet the criteria of R 18 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with R 18 alone does not completely assure reliable results. Reliable results depend on many factors; following the suggestions of R 18 or some similar acceptable guideline provides a means of evaluating and controlling some of those factors.*

2. REFERENCED DOCUMENTS

- 2.1. AASHTO Standard:

- R 18, Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories

2.2. *ASTM Standards:*

- C469/C469M, Standard Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression²
- D198, Standard Test Methods of Static Tests of Lumber in Structural Sizes³
- D653, Standard Terminology Relating to Soil, Rock, and Contained Fluids⁴
- D1143/D1143M, Standard Test Methods for Deep Foundations Under Static Axial Compressive Load⁴
- D4945, Standard Test Method for High-Strain Dynamic Testing of Deep Foundations¹

3. TERMINOLOGY

- 3.1. For common definitions of terms used in this standard see ASTM D653, Standard Terminology Relating to Soil, Rock, and Contained Fluids.

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

- 3.2.1. *hammer cushion*—cast steel insert between the hammer striker plate and the drive cap or helmet to protect the hammer during driving.
- 3.2.2. *pile cushion*—the material inserted between the drive cap or helmet and top of the pile to protect the pile during driving.
- 3.2.3. *impact event*—the period of time during which the pile is moving in a positive and/or negative direction of penetration due to a single impact force application (see Figure 1).

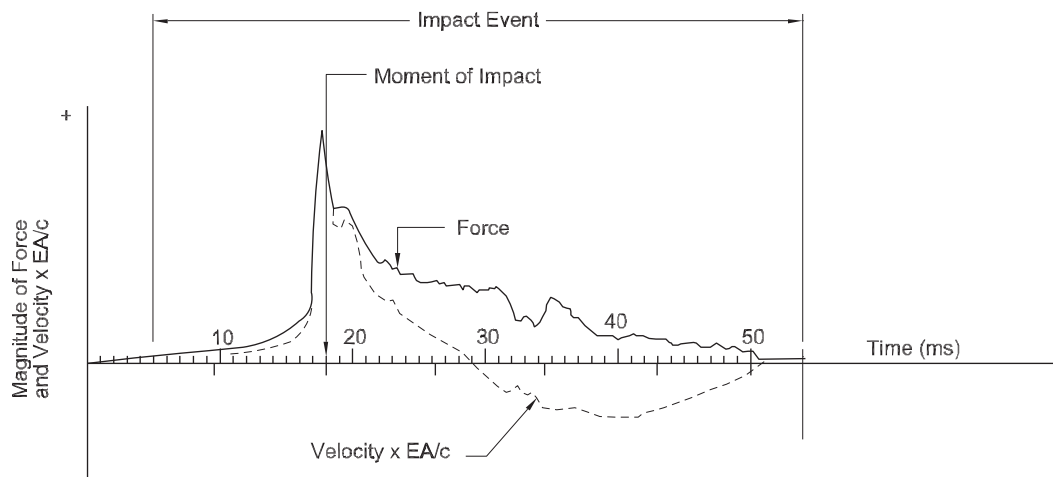


Figure 1—Typical Force and Velocity Traces Generated by the Apparatus for Obtaining Dynamic Measurements

- 3.2.4. *moment of impact*—the first moment of time after the start of the impact event when the acceleration is zero, i.e., first major velocity peak (see Figure 1).
- 3.2.5. *strain wave speed (or wave speed)*—the speed with which a strain wave propagates through a pile. It is a property of the pile material.

- 3.2.6. *particle velocity*—the velocity of a particle in the pile as a strain wave passes by.
- 3.2.7. *pile impedance*—indicates the resistance a pile has to a sudden change in velocity. It can be calculated by multiplying Young’s Modulus of Elasticity by the cross-sectional area and dividing the product by the strain wave speed (proportionality constant):
- $$Z = AE/c = \rho cA \quad (1)$$
- where:
- Z = impedance,
 A = cross-sectional area,
 E = Young’s Modulus of Elasticity,
 c = wave speed of the pile, and
 ρ = unit mass density of the pile material.
- 3.2.8. *restriking*—the redriving of a previously driven pile after a waiting period of from 15 min to 30 days or more, to assess changes in ultimate axial compressive static capacity during the elapsed time from the initial installation. Waiting period shall be determined based on type of pile, soil, and time constraints.
- 3.2.9. *transducer attachment area (TAA)*—the minimum distance from the top of the pile to the transducers. The minimum length of the TAA is two element diameters. This length can be achieved by using a buildup to extend the column height and/or by excavation of the soil from around the existing pile.

4. SIGNIFICANCE AND USE

- 4.1. This test method is used to provide data on strain or force and acceleration, velocity, or displacement of a pile under impact force. The data may be used to estimate the bearing capacity (nominal resistance) and the integrity of the pile, as well as hammer performance, pile stresses, and soil dynamics characteristics such as soil damping coefficients and quake values.

5. APPARATUS

- 5.1. *Apparatus for Applying Impact Force:*
- 5.1.1. *Impact Force Application*—Any conventional pile-driving hammer or similar device is acceptable for applying the impact force. The hammer or device should be capable of generating:
- A net measurable pile penetration; or
 - An estimated mobilized static resistance in the bearing strata that exceeds the nominal resistance assigned to the pile, as judged by the engineer.
- The device shall be positioned so that the impact is applied axially to the head of the pile and concentric with the pile. For nondriven piles, the concrete should be level with or above any casing. The top should be fitted with a cushioning material with a thickness of 50 to 150 mm. The final thickness shall be determined from a wave equation study. A steel striker plate, if used, should be greater than the lesser of the 70 to 90 percent of the shaft area or the area of drop weight impact surface. The striker plate should have a minimum thickness of 50 mm.
- Note 5**—If protruding reinforcing bars are present, the contractor has the option to incorporate the reinforcing bars inside the TAA, or use a pedestal follower (see Note 3).
- 5.2. *Apparatus for Obtaining Dynamic Measurements:*

- 5.2.1. *Measurement Transducer Requirements*—The apparatus shall include transducers that are capable of independently measuring strain and acceleration versus time at a specific location along the pile axis during the impact event. The transducers should have a natural frequency in excess of 2000 Hz once they are attached to the pile. A minimum of two each of these devices shall be attached securely to the pile so that they do not slip. Bolt-on, glue-on, or weld-on transducers are acceptable. The transducers shall be calibrated to a traceable standard such as the National Institute of Standards and Technology with an accuracy of ± 3.0 percent and recalibrated as required according to ASTM D4945 to maintain accuracy throughout the applicable measurement range. If damage is suspected during use, the transducers shall be replaced or recalibrated.
- 5.2.2. *Location of Transducers*—The measurement transducers shall be located at equal radial distances on diametrically opposite sides of the pile. They shall be located the same axial distance from the bottom of the pile, so that measurements are not affected by bending of the pile. When near the upper end of the pile, they shall be attached at least one and one-half pile diameters from the head; where practicable, this distance should be three diameters. When testing large diameter piles or nondriven elements, it is recommended to use four transducers, if practicable. Attach transducers to a TAA created with a casing. This is illustrated in Figures 4 through 7.

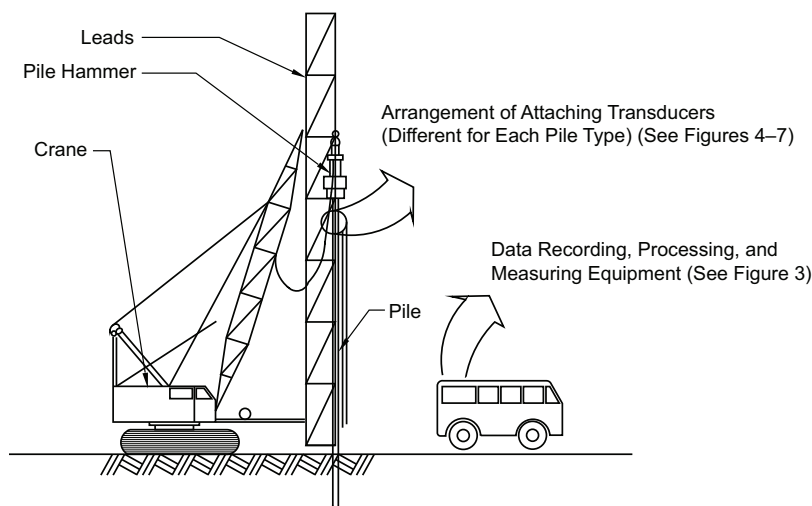


Figure 2—Typical Arrangement for High-Strain Testing