Designation: D5882 – 07 (Reapproved 2013) D5882 – 16

Standard Test Method for Low Strain Impact Integrity Testing of Deep Foundations[1]

This standard is issued under the fixed designation D5882; 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 Scope*

1.1 This test method covers the procedure for determining the integrity of individual vertical or inclined piles by measuring and analyzing the velocity (required) and force (optional) response of the pile induced by an (hand held hammer or other similar type) impact device usually applied axially and perpendicularly to the pile head surface. This test method is applicable to long structural elements that function in a manner similar to any deep foundation units (such as driven piles, augeured piles, or drilled shafts), regardless of their method of installation provided that they are receptive to low strain impact testing.

1.2 This standard provides minimum requirements for low strain impact testing of piles. Plans, specifications, and/or provisions prepared by a qualified engineer, and approved by the agency requiring the test(s), may provide additional requirements and procedures as needed to satisfy the objectives of a particular test program.

1.3 The text of this standard references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

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

1.5 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D6026.

1.6 The method used to specify how data are collected, calculated, or recorded in this standard is not directly related to the accuracy to which the data can be applied in design or other uses, or both. How one applies the results obtained using this standard is beyond its scope.

1.7 *This standard may involve hazardous materials, operations, and equipment. 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 and health practices and determine the applicability of regulatory limitations prior to use.*

NOTE 1—he quality of the result produced by this test method is dependent on the competence of the personnel performing it, and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D3740 are generally considered capable of competent and objective testing/sampling/ inspection/etc. Users of this test method are cautioned that compliance with Practice D3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D3740 provides a means of evaluating some of those factors.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D653 Terminology Relating to Soil, Rock, and Contained Fluids
D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
D6026 Practice for Using Significant Digits in Geotechnical Data
D6760 Test Method for Integrity Testing of Concrete Deep Foundations by Ultrasonic Crosshole Testing
D7949 Test Methods for Thermal Integrity Profiling of Concrete Deep Foundations

3. Terminology

3.1 *Definitions*—Except as defined in 3.2, the terminology used in this test method conforms with Terminology D653.

3.2 *Definitions of Terms Specific to This Standard:*

[1] This test method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.11 on Deep Foundations.

Current edition approved Nov. 1, 2013July 1, 2016. Published January 2014July 2016. Originally approved in 1995. Last previous edition approved in 20002013 as D5882 – 07.07(2013). DOI: 10.1520/D5882-07R13.10.1520/D5882-16.

[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.

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

3.2.1 *pile integrity, n*—the qualitative evaluation of the physical dimensions, continuity of a pile, and consistency of the pile material.

3.2.2 *pile impedance, n*—the dynamic Young's modulus of the pile material multiplied by the applicable cross sectional area of the pile and divided by the strain wave speed.

3.2.3 *pulse echo method, n*—test in which measurements of the pile head velocity and force (force measurement optional) are evaluated as a function of time.

3.2.4 *transient response method, n*—test in which the ratio of velocity transform to force transform (force measurement required) are evaluated as a function of frequency.

4. Significance and Use

4.1 Low strain impact integrity testing provides acceleration or velocity and force (optional) data on slender structural elements (that is, structural columns, driven concrete piles, cast in place concrete piles, concrete filled steel pipe piles, timber piles, etc.). The method works best on solid concrete sections, and has limited application to unfilled steel pipe piles, H piles, or steel sheet piles. These data assist evaluation of ~~pile integrity and pile physical dimensions (that is, cross-sectional area, length), continuity, and~~the pile cross-sectional area and length, the pile integrity and continuity, as well as consistency of the pile material, although evaluation is ~~approximate and not exact.~~ approximate. This test method will not ~~give~~provide information regarding the pile bearing capacity. It is generally helpful to consider the soil profile, construction method and site records when evaluating data obtained by this method. Other useful information to consider and compare with results of this test includes low strain integrity test results of similar piles at the same site, concrete cylinder or core strength test results, automated monitoring data on equipment placing the concrete when augered piles are used, or information obtained from crosshole sonic logging (Test Method D6760) or thermal integrity profiling (Test Methods D7949) if available.

4.1.1 *Methods of Testing:*

4.1.1.1 *Pulse Echo Method (PEM)*—The pile head motion is measured as a function of time. The time domain record is then evaluated for pile integrity.

4.1.1.2 *Transient Response Method (TRM)*—The pile head motion and force (measured with an instrumented hammer) are measured as a function of time. The data are evaluated usually in the frequency domain.

5. Apparatus

5.1 *Apparatus for Applying Impact:*

5.1.1 *Impact Force Application*—The impact may be delivered by any device (for example, a hand held hammer) that will produce an input force pulse of generally less than 1 ms duration and should not cause any local pile damage due to the impact. A hammer with a very hard plastic tip can induce a short input force pulse without causing local pile damage. The impact should be applied axially to the pile (normally on the pile head).

5.2 *Apparatus for Obtaining Measurements:*

5.2.1 *Velocity Measurement*—Obtain velocity data from integration of signals from (one or more) accelerometers, provided the acceleration signal(s) can be integrated to velocity in the apparatus for reducing data. The accelerometer(s) should be placed at (or near) the pile head and shall have their sensitive axis parallel with the pile axis. Accelerometers shall be linear to at least 50 *g*. Either A/C or D/C accelerometers can be used. If A/C devices are used, the time constant shall be greater than 0.5 s and the resonant frequency shall be at least 30 000 Hz. If D/C devices are used, they shall have frequency response up to 5 000 Hz with less than −3 dB reduction of content. Alternatively, velocity or displacement transducers may be used to obtain velocity data, provided they are equivalent in performance to the specified accelerometers. Calibrate the transducer to an accuracy of 5 % throughout the applicable measurement range. If damage is suspected during use, recalibrate or replace the accelerometer.

5.2.2 *Force Measurement (optional)*—The impact device shall be capable of measuring the impact force as a function of time. The hammer may have a force load cell between the tip and hammer body. Alternatively, the hammer may have an accelerometer attached and the measured acceleration may be converted to force using the hammer mass. The force calibration shall be within 5 %. The hammer must be tuned such that the fourrier transform of the measured force shall have a smooth spectrum, without any local peaks.

5.2.3 *Placement of Transducers*—The motion sensor should be placed at or near the pile head using a suitable, or temporary, thin layer of bonding material (that is, wax, vaseline, putty etc.) so that it is assured that it correctly measures the axial pile motion (transducer axis of sensitivity aligned with the pile axis). The motion sensor is placed generally near the center of the pile. Additional locations should be considered for piles with diameters greater than 500 mm. The low strain impact should be applied to the pile head within a distance of 300 mm from the motion sensor. If the pile head is not accessible, as when already integral with the structure, the sensor(s) may be attached to the side of the pile shaft.

5.3 *Signal Transmission*—The signals from the sensors shall be conveyed to the apparatus for recording, reducing, and displaying the data, see 5.4, by a low noise shielded cable or equivalent.

5.4 *Apparatus for Recording, Reducing and Displaying Data:*

5.4.1 *General*—The signals from the motion and force (optional) sensors, see 5.2, shall be conveyed to an apparatus for recording, reducing, and displaying data as a function of time. The apparatus shall include a graphic display of velocity (Fig. 1) and force (optional), and a data storage capability for retrieving records for further analysis. . The velocity display can be referenced either to the initial rise, as shown, or to the first peak. The apparatus should be capable of averaging data of several blows to reinforce the repetitive information from soil and pile effects while reducing random noise effects. The apparatus shall be able to apply increasing intensity amplification of the motion signal with time after the impact to enhance the interpretation of the measured motions that are reduced by soil and pile material damping. The apparatus must have filtering capability with variable frequency limits for eliminating high frequency, or low frequency signal components, or both. The apparatus shall be capable of transferring all data to a permanent storage medium. The apparatus shall allow for a permanent graphical output of the records. A typical schematic arrangement for this apparatus is illustrated in Fig. 2.

NOTE 2—It is recognized that the velocity signal may be drawn in either downward or upward positive amplitudes. The depth scale may be aligned either at the start of the rise (as shown) or at the initial peak. It is recommended that information be included in the plot showing the magnification function with time.

5.4.2 *Recording Apparatus*—Analog signals from the motion sensor must be directly digitized using an analog to digital converter with at least 12 bit resolution (16 bit or higher resolution is preferred)such that signal components having a low pass cut-off frequency of 5 000 Hz (−3dB) are retained. When digitizing, the sample frequency, therefore, shall be at least 25 000 Hz each for the motion sensor and the optional instrumented hammer, if used. The uniformity and accuracy of the digital sampling frequency is critical; the clock jitter (sampling frequency accuracy) must be within 0.01 %. Analog data acquisition systems are specifically prohibited. Attached to every digitized event should be identifying information names and descriptions, signal processing enhancement parameters, and date and time stamps. The digital record shall be permanently stored.

5.4.3 *Apparatus for Reducing Data*—The apparatus for reducing signals from the transducers shall be a digital computer or microprocessor capable of at least the following functions:

5.4.3.1 *Velocity Data*—If accelerometers are used (see 5.2.2), the apparatus shall provide signal conditioning and integrate acceleration to obtain velocity. The apparatus shall balance the velocity signal to zero between impact events.

5.4.3.2 *Force Measurements*—The apparatus shall provide signal conditioning and amplification, for the force measurements. The force output shall be balanced to zero between impact events.

5.4.3.3 *Signal Conditioning*—The force and velocity data shall have equal frequency response curves to avoid relative phase shifts and amplitude differences.

5.4.4 *Display Apparatus*—Ensure that the signals from the transducers specified in 5.2.1 and 5.2.2 are displayed by means of an apparatus, such as an LCD graphic display, such that the velocity and force (optional) can be observed as a function of time for each hammer blow. This apparatus may receive the signals after they have been processed by the apparatus for reducing the data. The apparatus shall display the digitized data of the impact event or upon recall by the user of the digitally stored event. Adjust the apparatus to reproduce a signal having a duration greater than 2L/c plus 5 milliseconds, where L is the pile length and c is the material wave speed.

6. Procedure

6.1 *General*—Record applicable project information into the apparatus when appropriate (Section 7). The appropriate motion sensor (see 5.2) shall be attached to or pressed against the pile head. Record the measurements from several impacts. Average the suitable records of at least three impacts and apply necessary amplification to the averaged record. The records from the individual impacts or the averaged record, or both, should then be stored (see 5.4.2). The averaged, amplified record then can be evaluated for integrity.

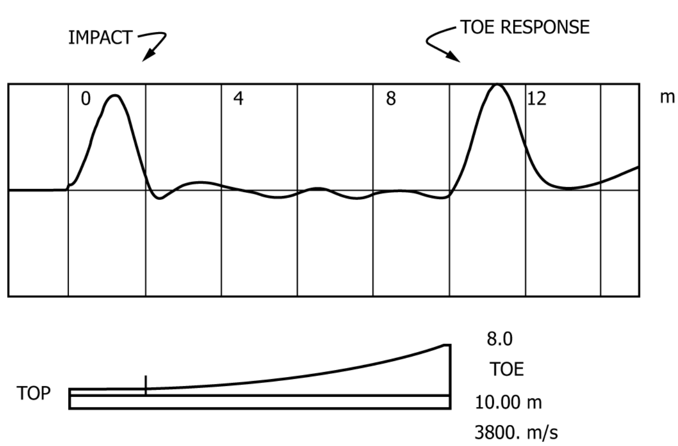

FIG. 1 Typical Velocity Traces for the Pulse Echo Method Generated by the Apparatus for Obtaining Dynamic Measurements (note the orientation of the input pulse is shown as positive in this standard; orientation could also be shown negative)