

**PILE INTEGRITY TEST**

**1. General Remarks**

Pile Integrity Testing (PIT) is a Non-Destructive integrity test method for foundation piles. It is a “Low Strain” Method (since it requires the impact of only a small hand-held hammer). The evaluation of PIT records is conducted either according to the Pulse-Echo (or Sonic Echo – a time domain analysis) or the Transient Response (frequency domain analysis) Procedure. This test is standardized by **ASTM D5882** Standard Test Method for Low Strain Impact Integrity Testing of Deep Foundations. Pile Integrity Test is performed to check that a pile is free of major cracks and voids, prior to construction of the super-structure.

**2. Scope**

2.1 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, augured piles, or drilled shafts), regardless of their method of installation provided that they are receptive to low strain impact testing.

2.2 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.

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

2.4 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Code of Practice ASTM D 6026.

2.5 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.

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:**

The 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 D 3740 are generally considered capable of competent and objective testing/ sampling/ inspection/etc. Users of this test method are cautioned that compliance with Practice D 3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D 3740 provides a means of evaluating some of those factors.

**3. Description of Method**

Low Strain Integrity Testing may be applied to any concreted pile (e.g. concrete piles, drilled shafts, augured cast-in-place piles, concrete filled pipe piles). The test requires the impact of a

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small hand held hammer on the shaft top and the measurement of the shaft top motion (acceleration or velocity). The input compression wave from the hammer is reflected from pile toe (or a change in cross sectional area or pile material quality) and returns to the pile top at a time related to the speed of travel of the wave in the pile material.

The pile top velocity is displayed as a function of time with an exponentially increasing magnitude such that the pile toe reflection is enhanced. The averaged, amplified velocity, averaged for several impacts, is the standard result of the Pulse Echo Method. The force as a function of time, if available, provides additional information as to the pile quality near the pile top.

The Transient Response Method result shows the ratio of velocity to force transforms for all relevant frequencies in a plot called Mobility. It should be shown together with the related low frequency pile stiffness. Transient Response requires that hammer force is measured.

### **4. Test Equipment**

Provide a Pile Integrity Tester (PIT) or an equivalent equipment. The equipment shall have the following minimum requirements:

- The analog to digital resolution shall be at least 24 bits.
- The sampling frequency shall be at least 25,000 Hz.
- Data shall be stored such that additional processing or further wave analysis is possible.
- Data shall be displayed in the field for evaluations of preliminary data quality and interpretation.
- The equipment shall allow attachment of a motion sensing device capable of measuring acceleration, velocity or displacement due to the impact of the pile top with a hand held hammer.



The PIT (Pile Integrity Tester) performs the wave equation-based non-destructive test known as Pulse or Sonic Echo Test, or Low Strain Dynamic Test.

The PIT test consists of attaching one or two accelerometers to the foundation, and using a hand held hammer to impact it. The PIT collects the acceleration data and displays curves that reveal any significant changes in cross section that may exist along the pile. The software post processes the data and generates reports, while the software simulates a PIT test and performs simplified signal matching to assess the shape of the pile.

### **5. Test Personnel**

The field testing shall be performed by an experienced technician with at least one year experience in integrity testing. The interpretation of the records requires extensive experience by a graduated engineer with at least Three years experience in integrity testing.

### **6. Test Preparation**

For the cast in place piles, integrity testing shall not be performed until the concrete has cured for a minimum of seven (7) days unless otherwise approved by the engineer. The pile head shall be free from water, dirt or other debris. The concrete at the pile top surface must be relatively smooth and provide sufficient space for attaching the motion sensing device and for the hammer impact area.

50% of total piles shall be integrity tested. The location of piles for designated for integrity testing shall be specified by the engineer after pile installation. Additional piles may be selected for

testing at the discretion of the engineer if circumstances either during or after pile installation should make a piles' integrity suspect, or if the initial tests reveal major defects.

### **7. Result Presentation**

The testing engineer shall present a report 5 working days after performing the field test to provide the final test results and integrity evaluation. For each pile tested, the averaged, amplified velocity versus time record shall be included in the report, with a table summarizing results and conclusions. Additional plots and analyses can be included as required or suggested by the testing engineer.

### **8. Acceptance and Rejection**

Shafts with no significant reflections from locations above the pile toe and with a clear pile toe reflection may be accepted. Where no clear toe reflection is apparent, the experienced test engineer shall state to which shaft depth the test appears to be conclusive. Where reflections from locations with significant reductions in pile area or pile material strength or stiffness above the pile toe are observed, the pile has a serious defect. If the record is complex, the results may be deemed inconclusive. Construction records (concrete usage, grout pressure records, soil borings) may be valuable in result interpretations or additional numerical analysis modeling may be used to quantify the record. The decision to reject and replace, or repair, any defective shaft is at the sole responsibility of the engineer-of-record for the foundation.

### **9. Remedial Action**

Rejected or questionable piles may be replaced. Questionable piles may also be subjected to further testing, e.g., static load testing, dynamic load testing, core drilling, ultra-sonic logging, etc. Remedial action may include pressure grouting through core holes. If the pile top appears questionable, further pile top cut-off and retesting may be advisable. If a majority of piles diagnose as "inconclusive", partial or even complete pile excavation or another test method may be necessary for pile acceptance.

### **Related ASTM Standards**

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