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Standard Practice for Pre-Installation Acceptance Testing of Vibrating Wire Piezometers[1]

This standard is issued under the fixed designation D7764; 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

1.1 This practice describes two acceptance tests for a vibrating wire piezometer: a zero test and a down-hole test. The two tests can help a user verify that the piezometer is operating properly before it is installed.

1.2 *This practice offers an organized collection of information or a series of options and does not recommend a specific course of action. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

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

1.4 *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.*

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

3. Terminology

3.1 *Definitions:*

3.1.1 For general definitions, see Terminology D653.

3.1.2 *absolute pressure, n*—a pressure value that includes the effect of atmospheric pressure.

3.1.3 *gauge pressure, n*—a pressure value that excludes the effect of atmospheric pressure.

3.1.4 *vibrating wire piezometer, n*—a type of pressure sensor that is used to monitor pore-water pressure. Vibrating wire refers to the mechanism by which pressure on the sensor's diaphragm is converted to an electrical signal that is transmitted to a readout device. A typical vibrating wire piezometer reports absolute pressure, rather than gauge pressure. In this standard, the words "vibrating wire piezometer," "piezometer," and "sensor" will be used interchangably.

4. Significance and Use

4.1 Vibrating wire piezometers are typically not recoverable after installation. Replacement, which involves drilling a new borehole, is expensive and sometimes impossible. Thus it is important to be certain that the sensor is operational before it is installed.

4.2 Lacking sophisticated testing facilities, field testers must use equipment that is at hand. But in so doing, field testers should not expect to achieve the same accuracy and precision that manufacturers state on the sensor calibration record. Instead, field testers should look for obvious nonconformances, as explained in the procedures.

4.3 This standard practice is not meant to restrict the use of other appropriate acceptance tests and procedures.

NOTE 1—Notwithstanding the statements on precision and bias contained in this practice, the precision of this practice 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. Users of this practice are cautioned that compliance with Practice D3740 does not itself ensure reliable testing. Reliable testing depends on many factors; Practice D3740 provides a means of evaluating some of these factors.

[1] This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.23 on Field Instrumentation.

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[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.

5. Equipment

5.1 A readout in good working condition and compatible with the sensor to be tested. Consult manufacturer's user manual to verify compatibility of the readout.

5.2 The calibration record for the sensor to be tested. Vibrating wire sensors typically have unique calibrations, so it is important to match the calibration record to the sensor.

6. Zero-Reading Test Procedure

6.1 This procedure is used to verify that the sensor reads approximately zero when only atmospheric pressure is applied.

6.2 Ideally, this procedure is conducted in a temperature-stable location, since changes in temperature can affect the sensor. At minimum, ensure that the sensor is kept out of direct sunlight and away from other sources of heat.

6.3 Suspend the sensor in air by its signal cable and allow approximately one hour for the sensor to reach thermal equilibrium with the surrounding air. Do not handle the sensor during this time or during the test.

6.4 Connect the signal cable to the readout and obtain a reading according to the manufacturer's instructions. Typically, the reading will be in Hz or $Hz^2/1000$. Check that the reading is stable and repeatable. Readings that vary ± 2 Hz or ± 12 $Hz^2/1000$ should be regarded as unstable. If the reading is unstable, check that the excitation setting is correct. Also check if other sensors of the same type return similar readings. If only one sensor is unstable, it should probably be rejected. If other sensors are unstable as well, the environment may be electrically noisy. Try moving to a different location.

6.5 Convert the Hz or $Hz^2/1000$ reading to units of pressure by applying the calibration factors supplied by the manufacturer. The result will be called a "zero reading."

6.6 Correct the zero reading for elevation, as necessary. Calibration records are typically referenced to sea level or 1 atmosphere, but atmospheric pressure decreases at elevations above sea level. Thus a zero reading at sea level is likely to be negative value at higher elevations. To correct for this, add 1.15 kPa for every 100 m of elevation above sea level. This correction factor is suitable to elevations of 1500 m above sea level.

6.7 Compare the elevation-corrected zero reading with zero. If the value differs by more than 1 % of the rated range of the sensor, the sensor should be set aside. For example, a difference of 3.5 kPa is at the limit for a sensor rated to 350 kPa. The 1 % limit allows for variations barometric pressure, temperature, and the sensitivity of various ranges of sensors.

6.8 Sensors that exceed the 1 % limit may still be usable. The sensors may have experienced a one-time zero-shift during shipping, but are otherwise functioning correctly. Since piezometers are generally used to monitor changes in pressure, rather than absolute pressure, the zero-shift is of little concern in practice. Assuming that they produce stable readings, as defined above, such sensors are still candidates for the downhole test.

7. Downhole Test Procedure

7.1 The downhole test is used to verify that the sensor performs adequately over its range. Ideally, this procedure is performed in a water-filled borehole that is deep enough to test the full range of the piezometer. If the water table is well below the surface, then only a partial range can be tested.

7.2 Flush the borehole with clean water to remove heavy drilling mud.

7.3 Determine the depth to the water surface, as measured from a selected index, such as the top of the drill casing.

7.4 Calculate the range of the sensor in meters-head-of-water. 1 kPa is approximately 0.10197 meters of water.

7.5 Lay the sensor on the ground and uncoil the signal cable. Mark the signal cable in three places: a shallow mark, a mid-range mark, and a deep mark. Place the shallow mark so that the tip of the sensor will be at least 1.5 m below the surface of the water when it is lowered into the borehole. Place the deep mark as close as possible to the maximum range of the sensor. The mid-range mark should be somewhere between the other two marks.

7.6 Measure the distance between the shallow mark and the deep mark. Also measure the distance between the shallow mark and the mid-range mark. Keep these measurements for later use.

7.7 Pull the filter off the piezometer, fill the chamber in front of the diaphragm with clean water, and then replace the filter. Hold the piezometer filter-end down and check that water does not immediately drain out of the chamber. If necessary, tie the piezometer, filter-end up, to its signal cable, and note the changed distance between the sensor tip and the marked depths on the cable.

7.8 Lower the piezometer to the deepest depth. Wait about 20 min to allow the piezometer to reach thermal equilibrium with the surrounding water. Obtain a reading and check that it is repeatable.

7.9 Draw the piezometer upwards to the middle depth. Obtain a reading and check that it is repeatable.

7.10 Draw the piezometer upwards to the shallowest depth. Obtain a reading and check that it is repeatable.

7.11 Convert the three readings to units of pressure using the calibration factors provided by the manufacturer.

7.12 Subtract the shallow pressure from the deep pressure. Convert the result to meters of water head.

7.13 Subtract the shallow pressure from the mid-range pressure. Convert the result to meters of water head.

7.14 Correct the two values for displacement of water by the cable. As the piezometer and cable are lowered into the borehole, the water level in the borehole rises, resulting in higher pressure readings. To calculate the correction value, divide the volume of water displaced by cable by the cross-sectional area of the borehole. Subtract the correction value from the result from the calculated length.

7.15 The corrected calculated distances and the measured distances should differ by no more than 1 %. This allows for variations due to depth control and the specific gravity of the water. Piezometers that exceed this limit are candidates for return to the manufacturer.

8. Keywords

8.1 acceptance test; vibrating wire piezometers