VW Settlement Cell

52612099

This equipment should be installed, maintained, and operated by technically qualified personnel. Any errors or omissions in data, or the interpretation of data, are not the responsibility of Slope Indicator Company. The information herein is subject to change without notification.

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Introduction

Introduction

The VW settlement cell is designed to measure settlements in construction areas which are inaccessible to standard optical survey techniques. It is especially useful in measuring large changes in settlement under earth dams, landfills, and soft soils.

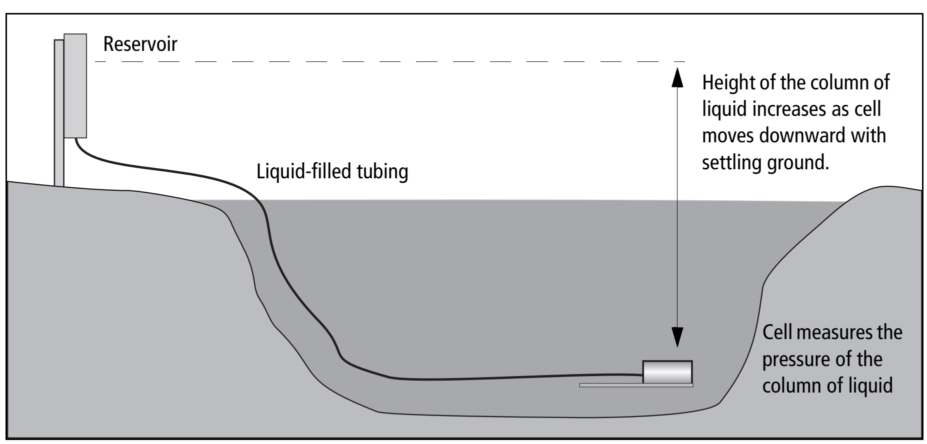
Theory of Operation

A settlement cell is a device used to monitor settlements in embankments, fills, and foundation soil. It provides a single point measurement of settlement or heave.

The settlement cell consists of three components: a liquid filled tube, a pressure transducer, and a reservoir of liquid. One end of the tubing is connected to the pressure transducer, which is embedded in the soil. The other end of the tubing is connected to the reservoir, which is located at a higher elevation on stable ground, away from construction activity.

The transducer measures the pressure created by the column of liquid in the tubing. The height of the column is equal to the difference in elevation between the transducer and the reservoir. As the transducer settles with the surrounding soil, the height of the column increases and the transducer measures a higher pressure.

Settlement is calculated by converting changes in pressure to millimeters or inches of liquid head.



Components

Components of the settlement cell system are:

VW Settlement Cell

The settlement cell is supplied with tubing and signal cable attached. An optional settlement plate may be included.

Tubing

Twin 3/16-inch diameter tubes bundled inside a polyethelene jacket. Tubing is pre-filled with de-aired liquid and is terminated with two quick-connect fittings that connect to the reservoir. Above-ground runs of tubing should be kept as short as possible.

Signal Cable

Signal cable is bundled with the liquid-filled tubing.

Reservoir

The simple vented reservoir accommodates one settlement cell and is suitable for manual or automated readings. Its liquid level must be maintained regularly.

Barometer

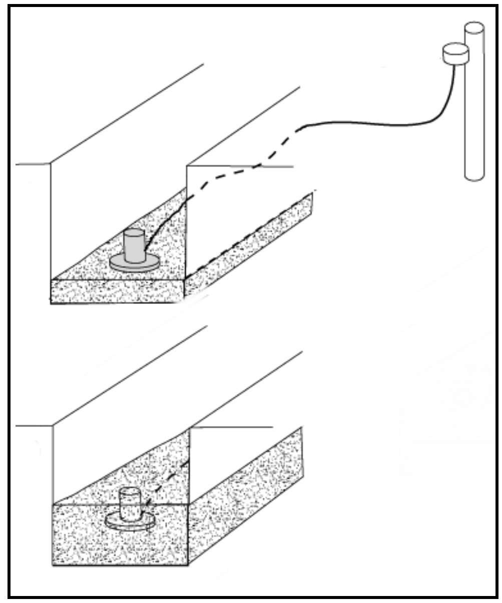
A on-site barometer is used to record atmospheric pressure at the same time that a settlement cell reading is taken. Variations in atmospheric pressure can change settlement cell readings ± six inches (150 mm) or more when no actual settlement or heave has occurred.

The barometer reading must be obtained on site at the same elevation as the reservoir. The barometer should provide station pressure, i.e. the actual pressure of the atmosphere, with no adjustment for elevation above sea level.

Reports from weather stations are not adequate for two reasons: they are no on site, and they usually report a normalized pressure, which is useful for tracking movements of weather fronts, but not suitable for correcting settlement readings.

Installation of the Settlement Cell

Installing the Settlement Cell



1. Stake out locations for the settlement cell, the reservoir, and the trench line between the two. Excavate the trench per specifications.
2. Remove sharp stones and rocks and place a 100 mm layer of wet, fine sand on the bottom of the trench.
3. Attach the optional settlement plate to the bottom of the cell. Place the settlement cell and note its serial number. Survey the exact elevation of the cell (optional).
4. Cover the cell with at least 100 mm of sand.

Install Tubing and Cable

1. Route cables and tubing along the trench, allowing some slack.
2. Cover tubing and cables with 100 mm layer of sand.
3. Backfill the trench with select fill.

Install the Reservoir

1. Mount the reservoir on a wall or post that is outside the area affected by settlement. The reservoir should be mounted such that it is at least three meters (ten feet) higher in elevation than the sensor.
2. Devise a means of minimizing temperature changes in the tubing and reservoir. Keep the reservoir out of the direct rays of the sun and minimize the lengths of above ground tubing.
3. Optional: Before mounting the reservoir permanently, you may want to test the system. The test is explained later in this chapter.

Connect Tubing to Reservoir

1. Fill reservoir with deaired liquid. Allow liquid to bleed from quick-connect plugs.
2. Fill quick-connect sockets (on tubing from cell) with deaired liquid, then press onto the quick-connect plugs. Note that liquid is under pressure in the tubing and excess liquid may splash out when you make the connection.

Terminate Signal Cable

Connect signal cable to data logger or terminal box.

Test the System

This test checks the response of the cell to changes in the elevation of the reservoir. Since the test occurs over a short period of time, you do not need to correct for barometric pressure.

1. Take a reading of the settlement cell.
2. Move the reservoir upwards 0.5 meters from its initial position. Take another reading.
3. Move the reservoir downwards 0.5 meters from its initial position. Take a third reading.
4. Convert the readings to head of water. The second and third readings should show a 0.5 m change in head. Note that the calculated head is approximate, not absolute.
5. After testing, mount the reservoir at its permanent elevation.

Obtain Initial Readings

Record pressure and temperature from the VW settlement cell. Also record barometric pressure.

Manual Readings

Introduction

These instructions tell how to read the VW settlement cell with DGSI's portable readout.

Basic Steps

1. Maintain the level of the liquid in the reservoir. To do this, you remove the cap from the reservoir. Add deaired liquid and allow it to run out the overflow hole. When you are done, replace the cap.

   Adding just water, and not the deaired liquid, may lead to a lower overall specific gravity of the fluid in the system, causing an apparent rise in the readings over time. In addition, the addition of water in freezing temperatures can lead to the fluid in the reservoir freezing and adding pressure to the system.

2. Obtain a settlement reading and a temperature reading. Note that the temperature reading is the temperature at the cell, which is buried.
3. Obtain barometer reading.

Reading with the VW Data Recorder

1. Connect signal cable to the data recorder:

Binding Posts	Wire Colors	
VW	Orange	Red
VW	White & Orange	Black
TEMP	Blue	White
TEMP	White & Blue	Green
SHIELD	Shield	Shield

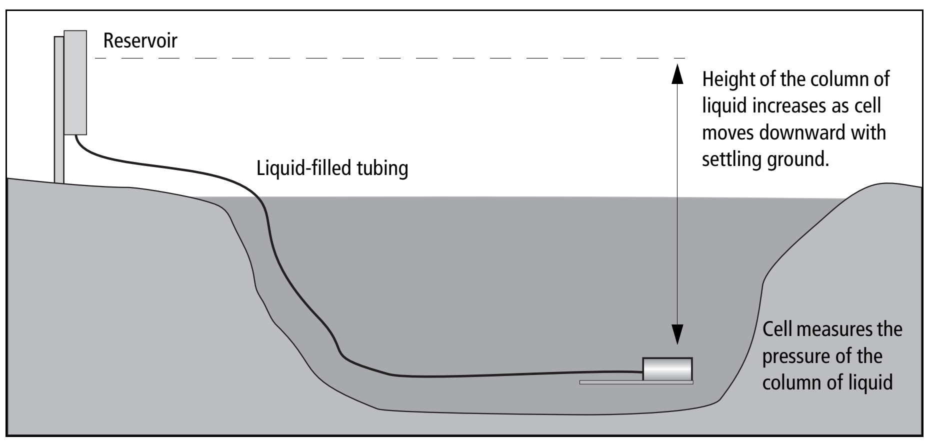
2. Choose Hz + RTD or Hz + Thermistor.
3. Select the 1400-3500 Hz range.
4. The recorder displays a pressure reading in Hz and a temperature reading in degrees C.
5. Record barometric pressure with barometer.

Data Reduction

Overview

For each settlement measurement, you will have collected two readings: a frequency reading and a temperature reading.

1. Calculate the cell pressure by converting the frequency reading to pressure in psi or bar, using the factors supplied on the sensor calibration record. Note that each cell has unique factors.
2. Subtract atmospheric pressure reading (from the barometer) from the corrected pressure reading to obtain the pressure of the column of liquid above the cell.
3. Convert the pressure of the column of liquid to meters or feet of liquid head.
4. Calculate settlement or heave by subtracting current head from the initial head.



Step 1 Calculate cell pressure

Convert the Hz reading to psi or bar using the “manual” ABC factors found on the sensor calibration record:

$$\text{Pressure Reading} = AF^2 + BF + C$$

where F is the sensor reading in Hz and A, B, and C are “manual abc factors” from the sensor calibration record.

Step 2 Subtract Atmospheric Pressure

The pressure reading from step 1 is the pressure of the column of liquid above the cell AND the pressure of the atmosphere at the time of reading (the reading obtained with your barometer). Subtract the atmospheric pressure to obtain the pressure of the column of liquid.

Pressure of Column of Liquid = Pressure Reading (from step 1) - Atmospheric Pressure

Step 3 Convert Column Pressure to Head of Water

Convert the corrected column pressure to head of water using one of the conversion factors below.

Head of Water = Column Pressure x Conversion Factor

To convert this pressure unit:	To this unit in head of water:	Multiply by this conversion factor:
psi	inch	27.73
	feet	2.31
	mm	704.3
	m	0.7043
bar	mm	10215
	m	10.215

Step 4 Calculate Settlement

The change in head of water represents settlement or heave. If the change is positive, settlement has occurred. If the change is negative, heave has occurred:

$$\text{Change in Water Head} = \text{Water Head}_{current} - \text{Water Head}_{initial}$$

Optional Adjustment for Density of Liquid

The deaired liquid supplied with the settlement cell is a 50/50 mixture of water and ethylene glycol, which is about 7% heavier than water.

The table at right shows how the density of the water/ethylene glycol mix varies with temperature. To calculate the actual head of liquid, divide the head of water value by the appropriate value in the table. This is normally 1.07.

Reference RTD temperature	Divide settlement by this density factor
-10	1.0800
-5	1.0775
0	1.0750
5	1.0725
10	1.0700
15	1.0672
20	1.0645
25	1.0617
30	1.0590
35	1.0560

$$\text{Settlement} = \frac{\text{Change in Water Head}}{\text{Density Factor}}$$

The table lists density for selected temperatures. You can calculate density factors for other temperatures using the equation below. T should be the temperature of the reference cell.

$$\text{Density Factor} = C_2 \times T^2 + C_1 \times T + C_0$$

$$C_2 = -1.19814 \times 10^{-6}$$

$$C_1 = -5.02420 \times 10^{-4}$$

$$C_0 = 1.07505$$

Before you decide to make this correction, consider that the temperature of the colum of liquid is unlikely to be uniform. In moderate climates, buried tubing that is 1.5 to 3 meters below the surface tends to stay between 10 and 15° C, but the temperature of the liquid in tubing that is not buried, including the liquid in the reservoir, can vary significantly during the day.

Acceptance Test

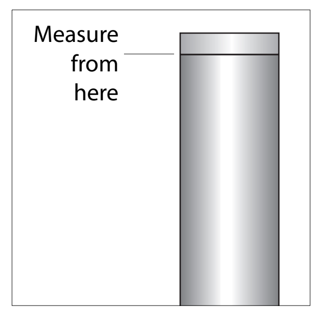
Introduction

The main purpose of an acceptance test is to provide reasonable assurance that a sensor is functioning properly. Unless you have access to sophisticated test facilities and calibration equipment, acceptance tests should not be expected to achieve the accuracy and precision of the calibration data provided on the sensor calibration record.

Thus when you evaluate the results of an acceptance test, look for obvious non-conformance rather than an exact match between your data and the data on the calibration record.

Test Procedure

1. Ideally, this test would be conducted in a draft-free room the cell and tubing are allowed to reach temperature equilibrium.
2. The cell should be stood vertically and tubing should be raised above the level of the cell.
3. Measure the distance between the top of the tubing and the top of the cell, as shown in drawing.



4. Connect signal cable to readout and obtain a frequency reading. Be sure that the vent tube is open to atmosphere. Also obtain a temperature reading.
5. Use the data reduction procedures given in the previous section to calculate cell pressure, head of water, and to correct for temperature and density.
6. The difference between the measured distance and the calculated head of liquid should compare within two inches or 50 mm.

Diagnostics

Introduction

Perform the tests below to check the sensor and cable.

No Reading

Set your handheld multimeter to a low-ohm range (5k ohm).

- Measure the resistance between the two VW wires (orange and white-and-orange). A normal reading should be about 300 ohms. If the reading is very high or infinite, the coil is damaged (or the cable is severed). If the reading is very low, the cable may have been crushed and a short has developed.
- Measure the resistance between the temperature sensor wires (blue and white). Thermistors should read about 3000 ohms. RTDs should read about 2000 ohms. If the reading is very high or infinite, the temperature device is damaged (or the cable is severed). If the reading is very low, the cable may have been crushed and a short has developed.

Unstable Reading

Set your handheld multimeter to a high range (10 or 20 M ohm).

- Measure the resistance between a VW wire and a Temp wire. The reading should be infinite or out of range.
- Measure the resistance between any of the colored wires and the drain (shield) wire. The reading should be infinite or out of range.
- Measure the resistance between the shield wires of two installed VW sensors. Wires must be disconnected from data logger or terminal box to make this test. The reading should be very high or infinite. A lower reading indicates the presence of a ground loop.
- Other sources of unstable readings are electrical noise from nearby power lines, radio transmitters, or motors. Also, over ranged or shocked instruments can exhibit this problem.