

4600 Series Vibrating Wire Settlement System

APPLICATIONS

- Dams, roadways, and embankments
- Foundations
- Fills
- Surcharges

FEATURES & ADVANTAGES

- Closed loop vent line
- Low susceptibility to air bubbles, temperature and barometric pressure fluctuations



OPERATING PRINCIPLE

The standard Model 4600 is designed for applications where there is bed-rock or stable ground immediately beneath the point of settlement; this is used as a stable benchmark for subsequent settlement measurements. A vibrating wire pressure sensor, anchored on a pipe grouted into solid ground or bedrock at the bottom of the borehole, is connected by a liquid-filled tube to a reservoir attached to a surface level settlement plate. As the fill is placed, the reservoir settles and the liquid induced pressure on the sensor diminishes. An electrical cable runs from the sensor to a remote readout location.

Systems can also be specialized to locate settlement as it occurs in different subsurface settlement zones with the Model 4600M. This instrument array is comprised of several 4600 Series systems, installed one above the other in a single borehole. Intermediate combinations of reservoir and sensor are held in place inside the borehole by leaf springs or hydraulic anchors.

The Model 4600 is well suited for measuring sea-floor settlement beneath artificial land masses and settlement beneath surcharges in swampy areas.

ADVANTAGES AND LIMITATIONS

A closed loop vent line between the transducer and reservoir prevents temperature and barometric pressure fluctuations from affecting instrument readings. Also, because the Model 4600 does not require the use of horizontal liquid-filled tubes,

it is less susceptible to air bubble formation. A successful monitoring system requires that stable ground be located immediately beneath the point of settlement, so borehole drilling is necessary for proper installation. All 4600 Settlement Systems are supplied fully sealed, assembled, and ready for installation.

TECHNICAL SPECIFICATIONS

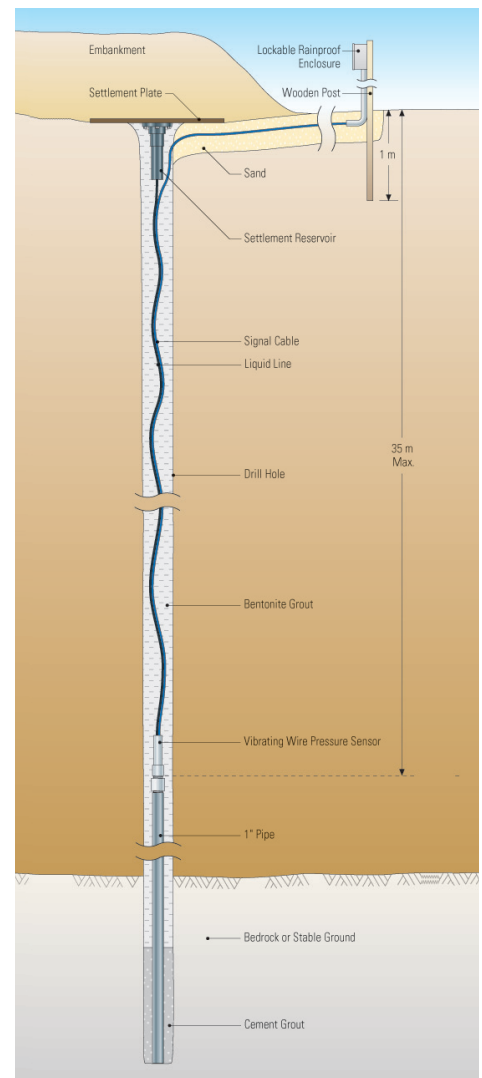
Standard Ranges¹	7, 17, 35 m
Resolution	0.025% F.S.
Sensor Accuracy²	0.1% F.S.
Temperature Range	-20°C to +80°C
Length x Diameter	(reservoir) 305 x 60 mm (sensor) 191 x 35 mm

¹Other ranges available on request.

²Laboratory accuracy. Total system accuracy is subject to site-specific variables.



Model 4600 Vibrating Wire Settlement System.



Typical Model 4600 installation.





Model 4650 Settlement System.

APPLICATIONS

The Model 4650 is designed for taking settlement measurements in or below fills, surcharges, and embankments from a remote readout location. Systems with tube lengths of up to 300 meters have been used successfully to measure settlements in earth dam embankments.

OPERATING PRINCIPLE

A vibrating wire pressure sensor is attached to a settlement plate located at the point of settlement. The sensor is connected via two liquid-filled tubes, extending laterally, to a reservoir

located on stable ground. The sensor measures the hydraulic head of liquid between the sensor and reservoir locations.

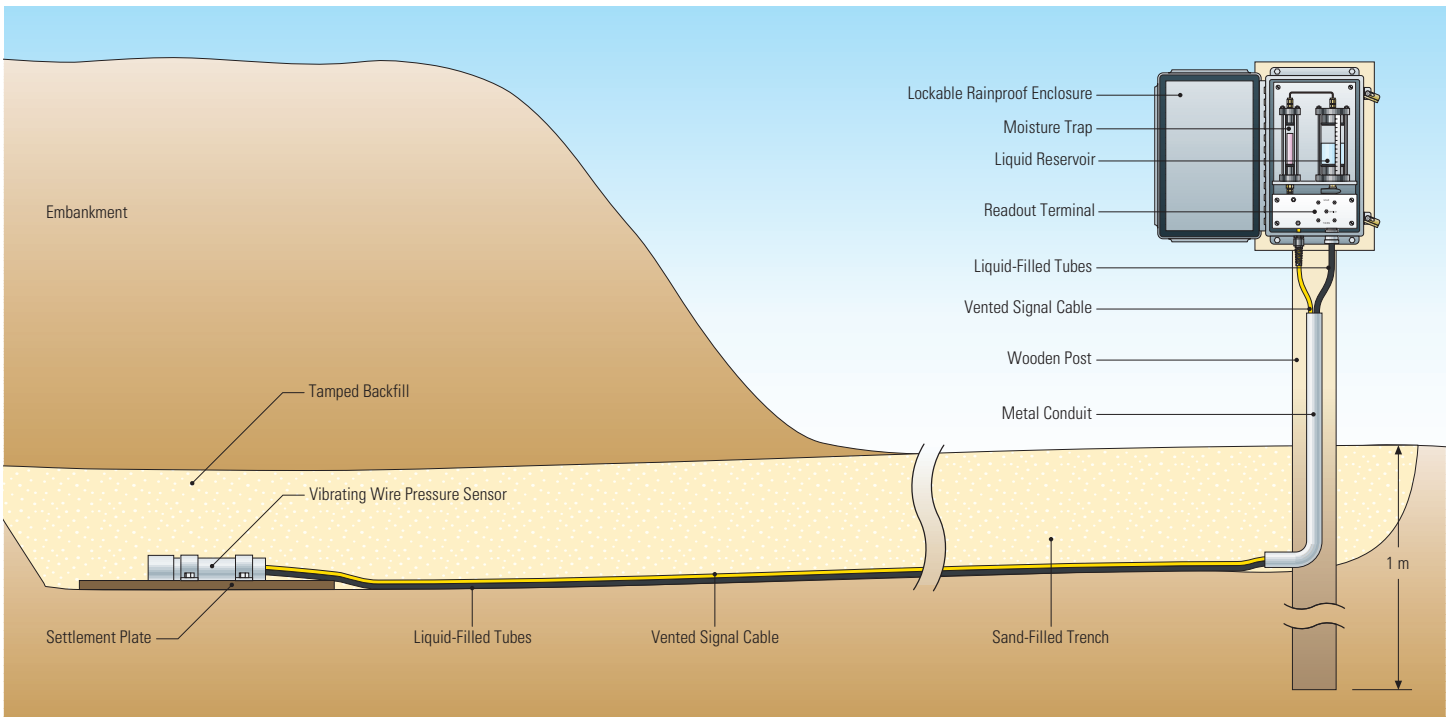
ADVANTAGES AND LIMITATIONS

A vented cable runs from the sensor to the remote readout location, and connects to the reservoir so that barometric pressure fluctuations do not affect the readings. The liquid-filled tubes can be flushed to remove any air bubbles that might form. The Model 4650's design also allows in-situ checks of calibration and zero stability to be performed at any time.

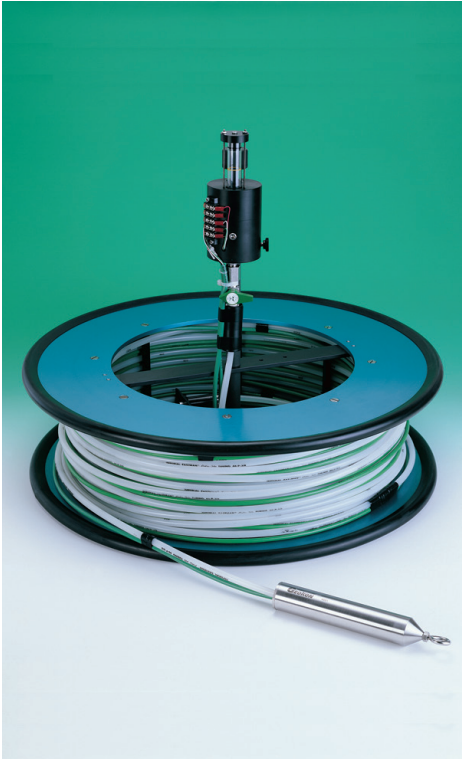
TECHNICAL SPECIFICATIONS	
Standard Ranges ¹	7, 17 m
Resolution	0.025% F.S.
Sensor Accuracy ²	0.1% F.S.
Temperature Range	-20°C to +80°C
Length x Diameter	(reservoir) 152 x 51 mm, (sensor) 191 x 35 mm

¹Other ranges available on request.

²Laboratory accuracy. Total system accuracy is subject to site-specific variables.



Model 4650 installation for the remote measurement of subsurface settlement beneath a large embankment.



Model 4651 Settlement Profiler.

APPLICATIONS

The Model 4651 Settlement Profiler is a portable device designed to measure profiles of heave and settlement beneath fills, embankments, roadways, storage tanks, and other structures. It can be used to measure differential settlements at discrete points on structures like building columns, or to monitor surface settlement above tunneling activities.

OPERATING PRINCIPLE

A sensitive vibrating wire pressure sensor is located inside a torpedo that can either be pulled through a buried pipe or carried from point to point. The sensor is connected via a liquid-filled tube to a reservoir located on

stable ground. Tubing is stored on a horizontally mounted reel at the reservoir location. The Model 4651's design allows tubing to turn freely as the torpedo travels through the hole or as it is repositioned at different locations. The sensor measures the hydraulic head between the reservoir and sensor location to achieve relevant pressure readings.

ADVANTAGES AND LIMITATIONS

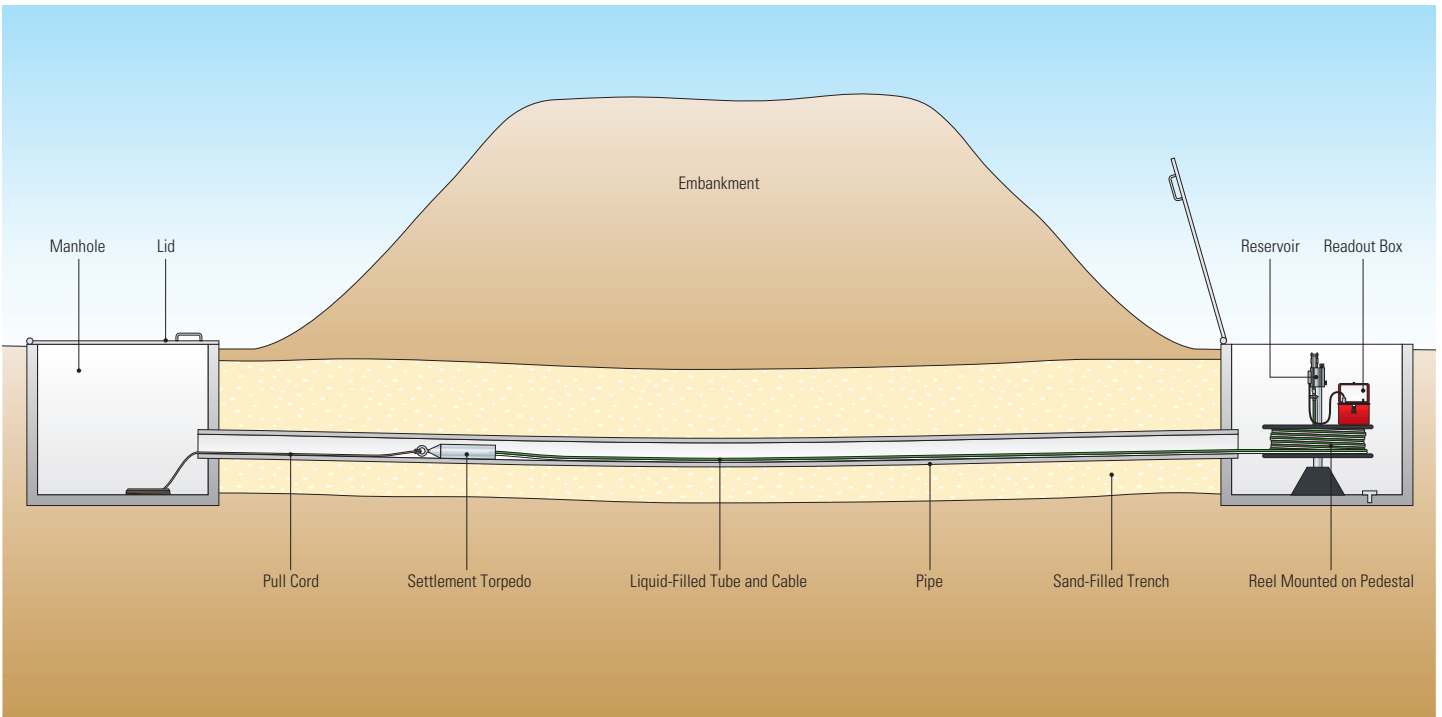
Independent settlement measurements can be made across closely spaced intervals to provide a detailed profile of differential settlements over wide areas. These sensors are also vented so that barometric pressure fluctuations have no effect on readings.

TECHNICAL SPECIFICATIONS

Standard Ranges¹	7 m
Resolution	0.025% F.S.
Sensor Accuracy²	0.1% F.S.
Temperature Range	-20°C to +80°C
Length x Diameter	(probe) 203 x 35 mm, (reel) 178 x 610 mm

¹ Other ranges available on request.

² Laboratory accuracy. Total system accuracy is subject to site-specific variables.



Model 4651 installation used to measure and monitor embankment settlement. As an alternative installation, the empty manhole (shown above at left) and open-ended pipe may be replaced by a capped pipe with a pulley and return cable to pull and position the torpedo from the reel end of the pipe (shown above at right).



Model 4675 High Sensitivity Settlement System.

APPLICATIONS

The Model 4675 is designed to detect and measure very small changes in elevation at discrete locations. It has been used to measure differential settlements along tunnels, bridges and piers, as well as settlement beneath building columns and floor slabs. This system will also measure settlement due to bridge deflection. Use the Model 4675 for projects where high sensitivity is essential.

OPERATING PRINCIPLE

A series of vessels are interconnected by a liquid-filled tube: one reference vessel is located on stable ground while the other vessels are located at the points of settlement. Each vessel contains a cylindrical weight suspended from a vibrating wire transducer.

The common liquid level inside each vessel partially submerges the hanging weights. Settlement around the vessel causes a rise in its contained water level. This leads to a greater buoyancy force on the weight and a reduction in the tension and frequency of the sensor's vibrating wire.

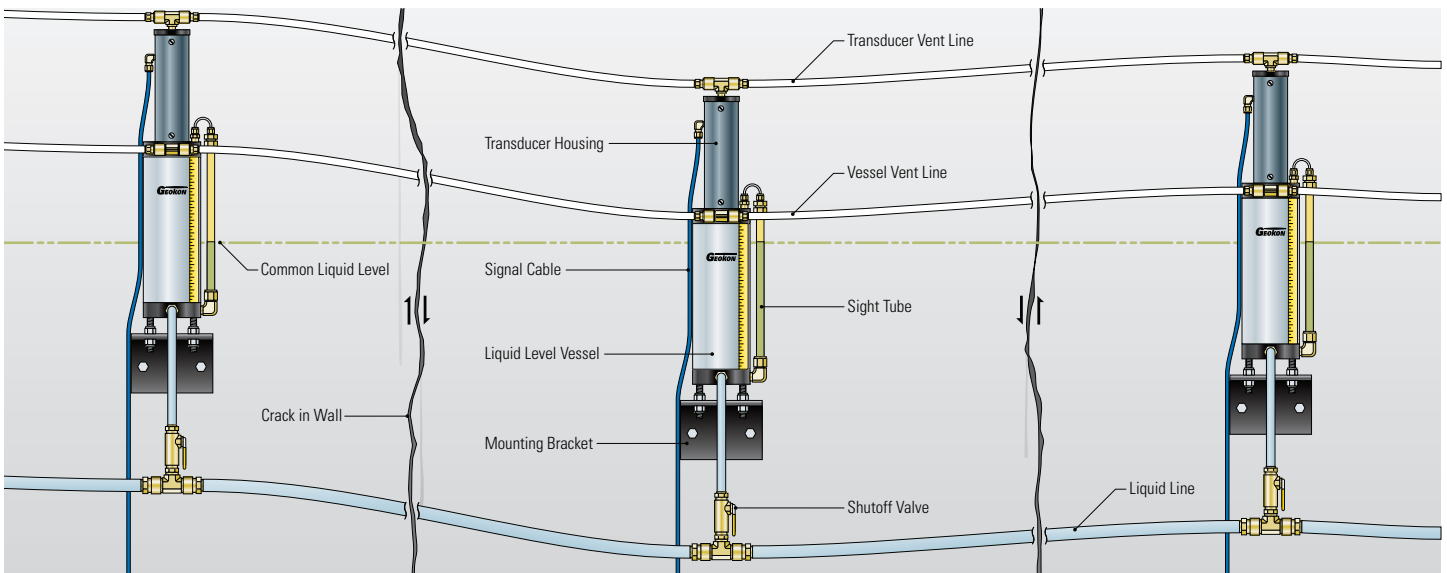
ADVANTAGES AND LIMITATIONS

The Model 4675 is capable of very high resolution: about 0.07 mm. A vent line connected to each of the vessels prevents the readings from being affected by ambient air currents and barometric fluctuations. Readings are not significantly affected by temperature changes. Settlement vessels must be installed at the same elevation and the connecting liquid-filled tubing must remain below the vessels at all points.

TECHNICAL SPECIFICATIONS	
Standard Ranges¹	100, 150, 300, 600 mm
Resolution	0.025% F.S.
Sensor Accuracy²	0.1% F.S.
Temperature Range	-20°C to +80°C (using antifreeze solutions)
Dimensions	depends on range

¹Other ranges available on request.

²Laboratory accuracy. Total system accuracy is subject to site-specific variables.



Installation of the Model 4675 on a concrete wall with exaggerated settlement to illustrate change in elevation.

APPLIED GEOMECHANICS

140 Chestnut St.
 San Francisco CA, 94111
 T: 1+415-364-3200
 F: 1+415-861-1448
 Geomechanics.com

A CARBO Company

