
Geotehnično preiskovanje in preskušanje - Geotehnične meritve - 6. del: Meritve posedanja: Hidravlični sistemi za merjenje posedanja (ISO/DIS 18674-6:2026)

Geotechnical investigation and testing - Geotechnical monitoring by field instrumentation - Part 6: Measurement of settlement: Hydraulic settlement systems (ISO/DIS 18674-6:2026)

Geotechnische Erkundung und Untersuchung - Geotechnische Messungen - Teil 6: Messung von Setzungen: Hydraulische Setzungsmesssysteme (ISO/DIS 18674-6:2026)

Reconnaissance et essais géotechniques - Surveillance géotechnique par instrumentation in situ - Partie 6: Mesure de tassement: systèmes hydrauliques de mesure de tassement (ISO/DIS 18674-6:2026)

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DRAFT International Standard

ISO/DIS 18674-6

Geotechnical investigation and testing — Geotechnical monitoring by field instrumentation —

Part 6: Measurement of settlement: Hydraulic settlement systems

*Reconnaissance et essais géotechniques — Surveillance
géotechnique par instrumentation in situ —*

*Partie 6: Mesure de tassement: systèmes hydrauliques de mesure
de tassement*

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ISO/DIS 18674-6:2026(en)**Foreword**

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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This document was prepared by Technical Committee ISO/TC 182, Geotechnics.

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Geotechnical investigation and testing — Geotechnical monitoring by field instrumentation —

Part 6:

Measurement of settlement: Hydraulic settlement systems

IMPORTANT — The electronic file of this document contains colours which are considered to be useful for the correct understanding of the document. Users should therefore consider printing this document using a colour printer.

1 Scope

This document specifies the measurement of settlement of geotechnical structures/works or structures influenced by geotechnical works by means of hydraulic settlement systems. General rules of performance monitoring of the ground, or structures interacting with the ground, of geotechnical fills and of geotechnical works are presented in ISO 18674-1:2015.

This document is applicable to:

- monitoring of settlement acting onto, or within, geotechnical structures such as embankments, excavations, compensation grouting, tunnel lining, railways, roads and other civil structures;
- checking geotechnical designs and adjustment of construction in connection with the Observational Design procedure;
- evaluating (subsoil) stability during or after construction.

Not subject of this document are horizontal inclinometers, which are dealt with in reference [1] nor monitoring devices based on a geodetical principle such as total stations or other optical level instruments, which are dealt with in reference [2].

NOTE 1 This document fulfils the requirements for the performance monitoring of the ground, of structures interacting with the ground and of geotechnical works by the means of hydraulic settlement systems as part of the geotechnical investigation and testing in accordance with References [3] and [4].

NOTE 2 Throughout the text, settlement is used as a general term, referring to both heave and settlement.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 18674-1:2015, *Geotechnical investigation and testing — Geotechnical monitoring by field instrumentation — Part 1: General rules*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 18674-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>

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— IEC Electropedia: available at <https://www.electropedia.org/>

3.1

Hydraulic settlement system

system consisting of one or more sensors measuring levels or pressures of a hydraulic circuit, resulting in a settlement measurement

Note 1 to entry: The vertical movement of the measuring point, located on a structure or within the subsoil can be determined by measuring the relative vertical level of a liquid column with respect to the liquid level in a reference reservoir.

Note 2 to entry: There are 3 main types of hydraulic settlement systems, namely hydrostatic profiler (see 3.2 and 3.3), hydraulic settlement cell (see 3.4) and liquid level system (see 3.5).

3.2

Hydrostatic profiler with reservoir

system where a probe is moved along a line in a pre-installed sub horizontal tube and where the elevation of the probe is related to the elevation of the liquid in a reservoir

Note 1 to entry: The sensor is typically manually pulled through the tubing.

Note 2 to entry: The pressure sensor can be vented or non-vented (connected to atmospheric pressure or not).

Note 3 to entry: See 5.2.

3.3

Hydrostatic profiler without reservoir

system where a sensor or series of sensors measures the pressure within a pre-installed sub horizontal tube, filled with a liquid, and where the elevation of the tube is related to the pressure of the liquid in the tube

Note 1 to entry: For a manual system, a probe is manually pulled through the tubing.

Note 2 to entry: For an automatic system, a series of sensors is placed fixed within a filled tube.

Note 3 to entry: See 5.3.

3.4

Hydraulic settlement cell

Hydraulic settlement gauge

cell with a pressure sensor, permanently installed into the ground and connected to a reservoir, measuring the pressure at the sensor's location in order to calculate vertical displacement

Note 1 to entry: The pressure sensor can be vented or non-vented (connected to atmospheric pressure or not).

Note 2 to entry: See 5.4.

3.5

Liquid level system

a series of cells with a pressure sensor, installed on a structure and connected to a reservoir, measuring the pressure at the sensor's location in order to calculate vertical displacement

Note 1 to entry: See 5.5.

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4 Symbols and abbreviated terms

Symbol	Name	Unit
d	Distance	m
g	Gravitational acceleration	m/s ²
h_i	Absolute vertical position	m
h_{ref}	Absolute vertical position of reference point	m
p_i	Measured pressure	[N/m ²]
RL	Reference level (e.g. sea level)	m
$w_{i,t}$	Displacement at a certain date	m
z_i	Reading of a hydrostatic profiler with reservoir	m
Δz_i	Relative vertical position	m
ρ	Density of the liquid	kg/m ³

5 Instruments

5.1 General

5.1.1 Different hydraulic settlement systems should be distinguished from each other (see [Table 1](#)).

NOTE Within the measuring range of the sensors, settlement is monitored as function of a liquid column.

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Table 1 — Hydraulic settlement systems

No.	Type	Sub-type	Principle measuring procedure
1	Hydraulic profiler with reservoir (see 5.2)	— Manual system	A sub horizontal tube is installed at the level where the settlements need to be identified. A pressure sensor, hydraulically connected to a reservoir with constant liquid level, is manually pulled through the tube and measurements are made at fixed intervals within the tube.
2	Hydraulic profiler without reservoir (see 5.3)	— Manual system — In place system	A sub horizontal tube is installed at the level where the settlements need to be identified. The tube is filled with a liquid In a manual system, a pressure sensor is manually pulled through the tube and measurements are made at fixed intervals within the tube. In an in place system, several pressure sensors are installed on a fixed interval and continuous measurements are made during the monitoring period.
3	Hydraulic settlement cell (see 5.4)	— Single point — Multiple point/array	A plate with a pressure sensor is installed in the ground at the level where the settlements need to be identified. A liquid filled tube connects the pressure sensor to the reference reservoir, which is installed outside the settlement sensitive area. Multiple pressure sensors can be connected to the same reference reservoir.
4	Liquid level system (see 5.5)	— Open system — Closed system	System of pressure sensors or level measuring systems, hydraulically interconnected and typically installed on a structure. In an open system the pressure sensor or level measuring system measure the absolute liquid level. In a closed system the sensor measures the relative pressure of the liquid compared to a reservoir.

5.1.2 Settlements shall be deduced by comparison of the measured values with those of the reference measurement.

5.1.3 The point to which the measurements are related shall be denoted the “reference point”.

5.1.4 The reference point shall be located in a stable area outside the influence of settlement and/or shall be monitored regularly in order to obtain absolute displacements.

NOTE 1 The accuracy by which the reference measurement is made, has a strong influence on the accuracy of the absolute derived displacement.

NOTE 2 When making manual reading, it is good practice to independently determine the absolute coordinates of the reference point for each measurement survey.

5.1.5 The connection between the reservoir and the measuring device shall be continuous and the liquid column shall be completely clear of air bubbles or air pockets.

NOTE Air pockets within the tubing will influence the measurements, as they are compressible.

5.1.6 The influence of the temperature should be considered, if possible, based on the correlation between temperature and vertical position measurements.

NOTE 1 Temperature has an influence on the measuring results, as the density of the liquid changes with temperature. This effect is particularly noticeable when the temperature changes along vertically laid pipes.

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NOTE 2 Temperature might affect the behaviour of the structure. It is not easy to separate the effect on the structure from the effect on the measurement.

5.1.7 The density of the liquid shall be considered.

NOTE If additives are used, this might affect the density.

5.1.8 Initial liquid column and expected settlement shall be considered when selecting the measuring range of the pressure sensors.

5.2 Hydrostatic profiler with reservoir

5.2.1 A hydrostatic profiler with reservoir shall include the following components (see [Figure 1](#)): a sub horizontal profile tube, a probe containing a pressure sensor, a permanently marked pull cord, a reel with an internal reservoir, a hydraulic tube connecting the transducer to the liquid reservoir, a read-out device and a stable base for the reel

NOTE 1 This is a manually operated system where the sensor records settlement at a fixed interval inside the tubing.

NOTE 2 The horizontal tubing is installed at the level where one is interested in the settlement behaviour. This implies that, although it is typically installed near the ground level, it can also be installed at different heights within the ground, e.g. during the construction of an embankment.

NOTE 3 Typically 1 base is used, but it is possible to have a base at each end of the horizontal tubing.

NOTE 4 If the tube is only accessible from one end, a dead end pulley system or a pushing rod can be used to move the sensor along the tube.

5.2.2 The level of the reservoir (inside the reel) shall remain constant during the survey.

NOTE 1 To obtain this, it is best to keep the reel in the same position during the survey.

NOTE 2 A level or pressure change in the reservoir can be caused by leakage.

5.2.3 The system design shall ensure that the height difference between the reservoir and the tube is within the instrument range.

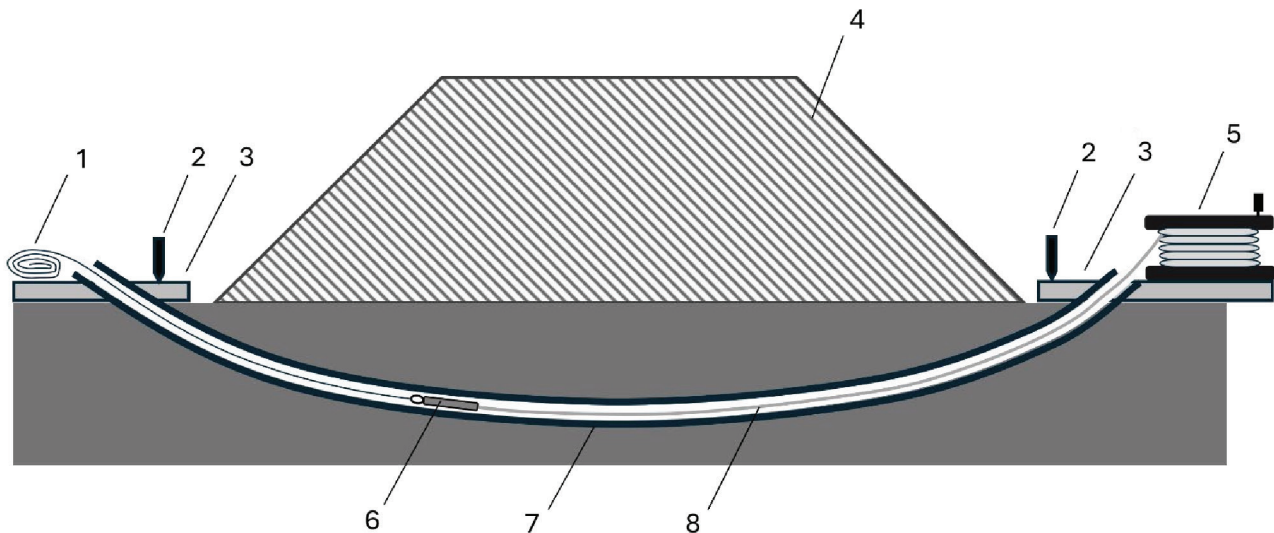
5.2.4 The tubing shall be installed avoiding unnecessary or local bending.

5.2.5 In between readings, the head of the tube shall be protected by a cap to prevent material getting into the tube.

5.2.6 The pressure sensor can be vented or non-vented. In case a non-vented pressure sensor is used, the atmospheric variation during the measurement should be considered.

NOTE In general, the atmospheric variations within the timeframe of a measurement are negligible.

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**Key**

- 1 pull cord
- 2 reference datum pin
- 3 base plate
- 4 embankment
- 5 cable reel
- 6 pressure sensor
- 7 profile tubing
- 8 hydraulic tube

Figure 1 — Example of a hydrostatic profiler set-up

5.3 Hydrostatic profiler without reservoir

5.3.1 Manually operated

5.3.1.1 A manually operated hydrostatic profiler without reservoir shall include the following components: a sub horizontal profile tube filled with a liquid, a pressure sensor, a permanently marked pull cord, a read-out device, and a base at the end of the horizontal tube.

NOTE 1 The sensor records the pressure head continuously while the sensor is pulled through the tubing and paused at a fixed distance inside the tubing. A time log is made of the handling.

NOTE 2 The liquid level in the tubing is refilled to the maximum level possible before each survey and maintained at the same level during the survey.

NOTE 3 It is good practice to measure the atmospheric pressure before and after each survey in case of a non-vented pressure sensor.

5.3.2 In place hydrostatic system

5.3.2.1 An in place hydrostatic system without reservoir shall include the following components: a sub horizontal profile tube filled with a liquid, an array of pressure sensors and a reading device.

NOTE 1 When the tube is open, the liquid level in the tube is checked and refilled periodically.

NOTE 2 The pressure sensors are installed at fixed positions.

NOTE 3 The pressure sensors can be installed on a river or seabed, taking into account waves, tidal and other water level variations.

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NOTE 4 An in place hydrostatic system may be used when there is no access to the sensors

5.3.2.2 In case of a non-vented pressure sensor, the measurement shall be compensated for atmospheric pressure.

5.3.2.3 When an in place hydrostatic system is located under water, the water pressure variation above the sensors shall be measured and used as a reference.

NOTE 1 Typically, a pressure sensor is installed outside the tube on a location where no settlement is expected, to measure the pressure variation above the tube.

NOTE 2 When measuring in the sea, the presence of waves and tides can affect the measurements. The influence depends on the water depth, the wave height and the wave period.

5.4 Hydraulic settlement cell

5.4.1 A hydraulic settlement cell should include the following components: a settlement plate, a pressure sensor attached to the plate, a data cable, a read-out unit or a logging device, a liquid filled tube and a reference reservoir (see [Figure 2](#)).

NOTE 1 A reference survey is typically made and measured to ensure the stability and position of the reservoir.

NOTE 2 Multiple pressure sensors can be connected to the same reservoir.

NOTE 3 A hydraulic settlement cell is typically installed within the ground, e.g. underneath an embankment. A hydraulic settlement cell is especially used at locations with difficult access.

NOTE 4 An alternative system exists where the hydraulic settlement cell is installed in a borehole or pushed into the ground. In this case, there is no settlement plate.

NOTE 5 It is recommended to install a temperature sensor both at the location of the settlement cell and in areas of vertically laid hydraulic lines if temperature fluctuations are to be taken into account.

5.4.2 The reference reservoir shall be open to allow atmospheric pressure within the reservoir.

5.4.3 The reservoir shall be protected against direct sun exposure, damage, leakage and displacements.

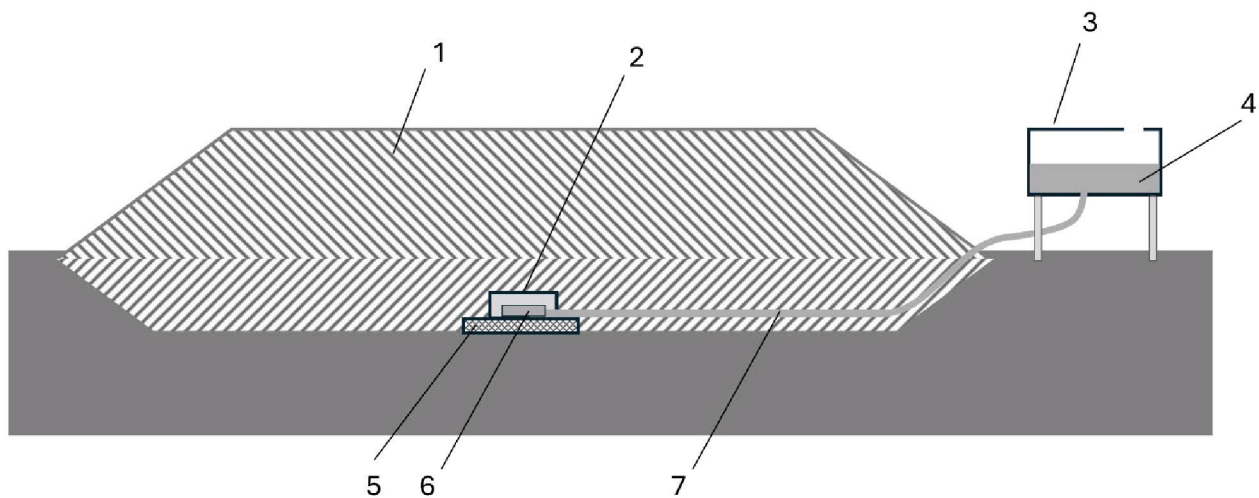
5.4.4 The liquid level in the reservoir should be checked and refilled periodically when necessary.

NOTE 1 A reference sensor within the reservoir is typically used to compensate for changes in the liquid level within the reservoir.

NOTE 2 It can be necessary to fill the reservoir, e.g. to keep the liquid level above the reference sensor.

5.4.5 In case of a non-vented pressure sensor, the measurement shall be compensated for atmospheric pressure.

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**Key**

- 1 embankment
- 2 mechanical protection
- 3 reference reservoir
- 4 liquid
- 5 settlement plate
- 6 pressure sensor
- 7 hydraulic tube

Figure 2 — Example of a hydraulic settlement cell set-up**5.5 Liquid level system****5.5.1 General**

Two types of liquid level systems should be distinguished from each other:

- Closed liquid level system
- Open liquid level system

NOTE 1 Liquid level systems are typically installed on a structure, rather than in the ground.

NOTE 2 The readings of liquid levels system are significantly affected by temperature, and open systems are also affected by liquid flow and evaporation of the liquid.

5.5.2 Open liquid level system

5.5.2.1 An open liquid level system shall include the following components: one or more liquid level vessels, a liquid line, a vent line, a data cable, a level measuring system and a reference vessel (see [Figure 3](#)).

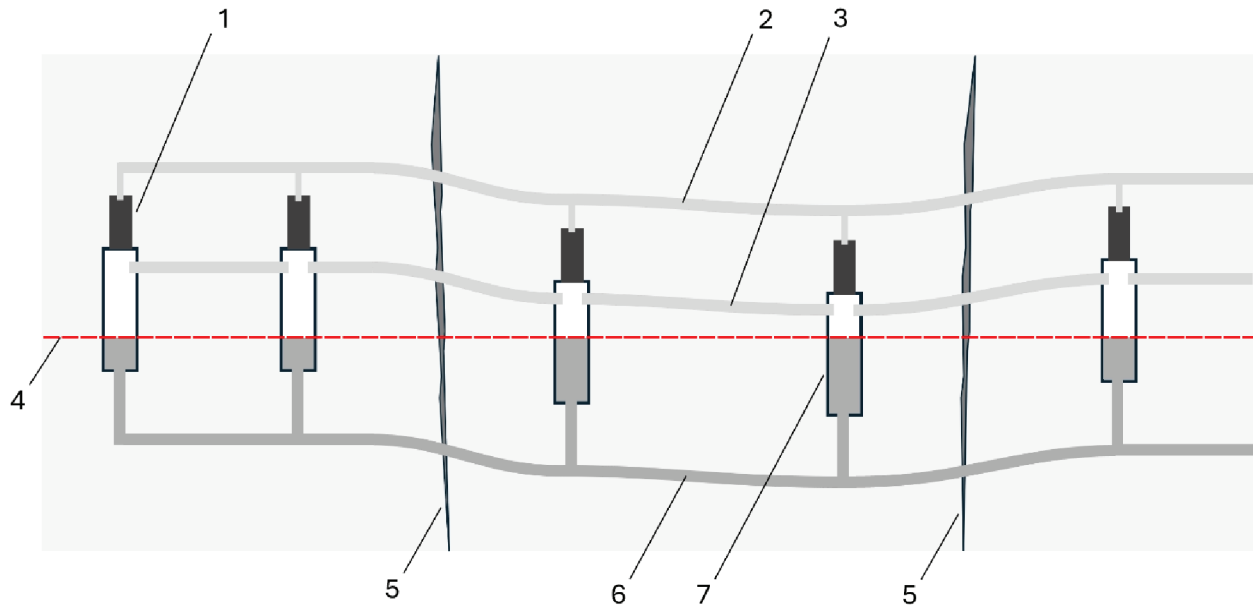
NOTE 1 Multiple liquid level vessels can be connected to each other.

NOTE 2 An open liquid level system is based on the principle of communicating vessels. When vertical displacements occur on a location, there will be an active flow of liquid between the vessels. Due to the flow of the liquid there will be a small delay between the movements and the stabilization of the liquid level. This delay prevents the system to be used for dynamic measurements.

NOTE 3 Generally these systems have a limited measuring range with a high accuracy.

NOTE 4 The vent line is open to the atmosphere to allow liquid flow. The vent line interconnects the different vessels, to guarantee an equal atmospheric pressure at all locations.

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**Key**

- 1 transducer housing
- 2 transducer vent line
- 3 vessel vent line
- 4 liquid level
- 5 simulated crack in wall
- 6 liquid line
- 7 liquid level vessel

Figure 3 — Example of an open liquid level systemget full document from standards.iteh.ai

5.5.2.2 The reference vessel shall be used to obtain relative settlements.

5.5.3 “Closed” liquid level system

5.5.3.1 A “closed” liquid level system shall include the following components: one or an array of pressure sensors installed on a structure, a reservoir, a liquid line, a vent line and a data cable (see [Figure 4](#)).

NOTE 1 Temperature sensors help in the validation and analysis of the results and are typically included in the sensor.

NOTE 2 A “closed” liquid level system has only one open end, located at the top of the reservoir. When vertical displacements occur on a location, there will be no flow of liquid between the vessels. The displacement will result in a pressure change at the location of the vessel.

NOTE 3 The vent line interconnects the pressure sensors to the open atmosphere at the location of the reservoir, to guarantee an air pressure equal to the air pressure at the location of the reservoir.