INTERNATIONAL STANDARD

**ISO 18674-1**

First edition
2015-05-15

# Geotechnical investigation and testing — Geotechnical monitoring by field instrumentation —

## Part 1: General rules

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

*Partie 1: Règles générales*



Reference number
ISO 18674-1:2015(E)



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# Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information



ISO 18674-1 was prepared by European Committee for Standardization (CEN) in collaboration with ISO/TC 182, *Geotechnics*, Subcommittee SC 01, *Geotechnical investigation and testing*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).



ISO 18674 consists of the following parts, under the general title *Geotechnical investigation and testing — Geotechnical monitoring by field instrumentation:*

— *Part 1: General rules*

The following parts are under preparation:

— *Part 2: Displacement measurements along a line: Extensometers*

The following parts are planned:

— *Part 3: Displacement measurements across a line: Inclinometers*

— *Part 4: Piezometers*

— *Part 5: Total pressure cells*

— *Part 6: Hydraulic settlement gauges*

— *Part 7: Strain gauges*

— *Part 8: Load cells*

— *Part 9: Geodetic monitoring instruments*

— *Part 10: Vibration monitoring instruments*

NOTE For further information on geotechnical monitoring by field instrumentation, see References [1] to [7].

# Geotechnical investigation and testing — Geotechnical monitoring by field instrumentation —

# Part 1: General rules

## 1 Scope

This part of ISO 18674 lays out the general rules for the performance monitoring of the ground, of structures interacting with the ground, of geotechnical fills, and of geotechnical works.

NOTE ISO 18674 fulfils the requirements for general rules for the performance monitoring of the ground, of structures interacting with the ground, of geotechnical fills, and of geotechnical works as part of the geotechnical investigation and testing according to EN 1997-1[8] and EN 1997-2[9].

Specifically, this part of ISO 18674 applies to field instrumentation and measurements carried out

— in connection with site investigations of soils and rocks,

— in connection with Observational Design procedures,

— in connection with the performance of geotechnical structures before, during, and after construction,

— for ground behaviour evaluation, e.g. unstable slopes, consolidation etc.,

— for the proof or follow-up of a new equilibrium within the ground, after disturbance of its natural state by construction measures (e.g. foundation loads, excavation of soil, tunnelling),

— for the proof or follow-up of the stability, serviceability, and safety of structures and operations which might be influenced by geotechnical construction,

— for perpetuation of evidence, and

— for the evaluation and control of geotechnical works.



## 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 14688-1, *Geotechnical investigation and testing — Identification and classification of soil — Part 1: Identification and description*

ISO 14689-1, *Geotechnical investigation and testing — Identification and classification of rock — Part 1: Identification and description*

ISO 22475-1, *Geotechnical investigation and testing — Sampling methods and groundwater measurements — Part 1: Technical principles for execution*

ISO/IEC Guide 99:2007, *International vocabulary of metrology — Basic and general concepts and associated terms (VIM)*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

# 3 Terms and symbols

## 3.1 Terms

For the purposes of this document, the terms and definitions given in ISO/IEC Guide 99:2007 and the following apply.

**3.1.1**
**geotechnical monitoring**
observation of the ground behaviour and/or performance of geotechnical structures before, during, and/or after construction

Note 1 to entry: Geotechnical monitoring is an integral part of the Observational Design procedure (see EN 1997–1: 2004).

Note 2 to entry: Geotechnical monitoring is based on field observation, including construction site inspection.

**3.1.2**
**field instrument**
measuring tool to assist geotechnical monitoring

Note 1 to entry: Monitoring by field instruments comprises the measurement of physical parameters, in particular, the change of the parameter values.

**3.1.3**
**geotechnical key parameter**
physical parameter indicative of the geotechnical issue under consideration and subject to geotechnical monitoring

EXAMPLE Displacement (absolute or relative), strain, inclination, stress, pore pressure, earth pressure, force, velocity, acceleration, temperature.



**3.1.4**
**geotechnical monitoring project**
entirety of aspects and processes which, in a specific project, are relevant for geotechnical monitoring

Note 1 to entry: Includes planning, risk assessment, specifying, procurement, delivery, and installation of a project-specific monitoring system and collecting, processing, evaluating, and reporting of the monitoring data.

**3.1.5**
**geotechnical monitoring concept**
preliminary plan for the measurement of geotechnical key parameters developed within the conceptual design phase, identifying specific objectives such as risk mitigation to be addressed by monitoring, thereby considering type of measurement, measuring locations, and schedule(s) for carrying out the measurement

**3.1.6**
**geotechnical monitoring plan**
advancement of the monitoring concept within the specification design phase

**3.1.7**
**geotechnical monitoring system**
hardware and software to provide field data

Note 1 to entry: Includes instruments signal, transmission (e.g. electric cables), data acquisition, and auxiliary units.

Note 2 to entry: The performance (e.g. the accuracy, stability, precision) of the geotechnical monitoring system will not necessarily be identical to the performances of the system components.

**3.1.8**
**geotechnical monitoring programme**
entirety of those components of a monitoring project which can be systematically planned, consisting of a monitoring plan and monitoring system

**3.1.9**
**commissioning**
demonstration and acceptance of the correct functioning of an installed monitoring system

Note 1 to entry: The commissioning criteria are commonly defined in the monitoring plan.

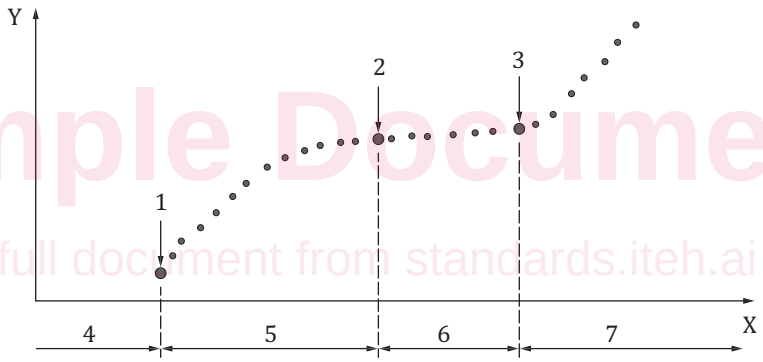
**3.1.10**
**instrument data sheet**
manufacturer's document containing instrument technical specifications

**3.1.11**
**initial measurement**
first measurement after installation (see Figure 1)

**3.1.12**
**zero measurement**
measurement carried out after stabilization of installation effects (see Figure 1)

Note 1 to entry: The zero measurement is often taken as reference for subsequent measurements, as it is commonly related to local space and time coordinates.

Note 2 to entry: The zero measurement is commonly carried out with increased measuring effort, e.g. repetition of measurements, to provide a reliable datum for subsequent measurements.






**Key**
1 initial measurement
2 zero measurement
3 reference measurement
4 installation period
5 stabilization period
6 period of baseline measurements
7 construction period
X time
Y reading

**Figure 1 — Definition of distinct measuring points during a geotechnical monitoring project in the period up to and including the construction phase**

**3.1.13**
**baseline measurements**
measurements carried out, subsequent to the zero measurement, over a period of time before any construction starts, to help in the definition of changes that occur from causes other than construction

EXAMPLE Seasonal changes in groundwater levels, tidal and moisture content changes, climatic changes such as temperature, and incidence of sunlight.

**3.1.14**
**reference measurement**
measurement which serves as reference base for previous and subsequent measurements

Note 1 to entry: The reference measurement is also known as datum measurement.

Note 2 to entry: A new reference measurement is often used for a new construction phase.

Note 3 to entry: The reference measurement is often derived from several measurements.

**3.1.15**
**value change measurement**
difference between a measurement and the reference measurement

**3.1.16**
**point measurement**
measurement of a physical parameter at a point

EXAMPLE Displacement of a measuring point; force of an anchor at its head; stress state in the ground; porewater pressure in an embankment; water discharge rate at the downstream toe of a dam.

**3.1.17**
**line measurement**
measurement of a physical parameter along a line

EXAMPLE Inclinometer measuring survey of a borehole.

## 3.2 Symbols



For the purpose of this document, the symbols of Table 1 apply.



**Table 1 — Symbols**

| Symbol | Name | Unit |
|---|---|---|
| $d$ | borehole diameter | m |
| $i$ | number of measurement, measurement direction, or measuring point | - |
| $l$ | distance | m |
| $u, v, w$ | displacement component in x-, y-, z- direction, respectively | m |
| $u$ | porewater pressure | Pa |
| $x, y, z$ | local coordinates | m |
| $z_w$ | piezometric level | m |
| $\alpha$ | angle, inclination | Degree or mm/m |
| $\varepsilon_n$ | strain normal to measuring plane | - |
| $\varepsilon_x\ \varepsilon_y\ \varepsilon_z$ | normal strain with reference to borehole coordinates | - |
| $\gamma_{xy}\ \gamma_{yz}\ \gamma_{zx}$ | shear strain with reference to borehole coordinates | - |
| $\sigma_1\ \sigma_2\ \sigma_3$ | principal stress | Pa |
| $\sigma_n$ | normal stress with reference to measuring plane | Pa |
| $\sigma_x\ \sigma_y\ \sigma_z$ | normal stress components with reference to borehole coordinates | Pa |
| $\tau_{xy}\ \tau_{yz}\ \tau_{zx}$ | shear stress components with reference to borehole coordinates | Pa |

NOTE Symbols with more than one meaning (e.g. u) are distinguishable in the context of their use.

# 4 Principal requirements

## 4.1 Geotechnical monitoring in connection with geotechnical design

Geotechnical monitoring shall be designed, implemented, and evaluated in connection with the geotechnical design.

NOTE Figure C.1 shows the position of geotechnical monitoring in connection with the design and the construction of geotechnical structures; see also "observational method" in EN 1997–1: 2004, 2.7.

## 4.2 Geotechnical monitoring in connection with specific questions

Each geotechnical monitoring project shall be based on at least one specific question that is to be answered. The question shall be formulated at the start of the monitoring project and actualized throughout the project with the aid of information from the measurements.

NOTE Monitoring of construction procedures and long-term monitoring of existing safety-sensitive structures are included.

## 4.3 Requirements of a geotechnical monitoring project

**4.3.1** In a geotechnical monitoring project, all items as defined in 3.1.4 shall be considered in the sequence described in 4.3.2 to 4.3.7.

**4.3.2** Within the initiation and preliminary design phase, reference shall be made to the geotechnical issue to be addressed. The key parameters shall be identified and their expected range estimated. The accuracy and the uncertainty with which the key parameters are to be measured and their geotechnically tolerable limits shall be specified.



**4.3.3** Within the conceptual design phase, a concept shall be developed on how to measure the key parameters of the geotechnical issue under consideration.

NOTE Aspects for consideration are the principal type of the instruments, frequency of measurements, redundancy in the system, the anticipated operation time of the monitoring system, and potential risks associated with monitoring.

**4.3.4** Within the specification design phase, the monitoring concept shall be refined and transferred into a comprehensive monitoring programme. Aspects which shall be considered are the instrument selection based on instrument data sheets (Annex A) together with expected field performance and the specification of the instrument installation procedure.

NOTE 1 The monitoring plan includes the specification of the measuring procedure, the location of the monitoring points, the monitoring schedule, and the type of data collection (manual reading or data logging with or without remote data access).

NOTE 2 The measuring procedure might encompass the measuring principle (physical base of the measurement, e.g. vibrating wire principle) and of the measuring method (e.g. compensation method, digital/analogue method).

NOTE 3 Field instruments comprise a large variety of sensors with different measuring principles which all have their specific advantages and disadvantages depending on the type of application. Examples of sensors with different measuring principles are vibrating wire, current-loop, inductive, capacitive, resistance strain gauge, and fibre-optical sensors.

**4.3.5** Within the installation and data collection phases, it shall be ensured that

— the instrument system is installed as early as possible prior to construction for baseline measurements (see Figure 1),

— the installation is carried out in such a way as to achieve good conformance of the measuring instruments,