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Geotechnical investigation and testing — Geotechnical monitoring by field instrumentation —

Part 3: Measurement of displacements across a line: Inclinometers

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

Partie 3: Mesurages des déplacements perpendiculairement à une ligne par inclinomètre

Reference number
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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.

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 voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

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

A list of all parts in the ISO 18674 series can be found on the ISO website.

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Geotechnical investigation and testing — Geotechnical monitoring by field instrumentation —

Part 3: Measurement of displacements across a line: Inclinometers

1 Scope

This document specifies the measurement of displacements across a line by means of inclinometers carried out for geotechnical monitoring. General rules of performance monitoring of the ground, of structures interacting with the ground, of geotechnical fills and of geotechnical works are presented in ISO 18674-1.

This document also refers to deflectometers (see Annex B) to supplement inclinometers for the determination of horizontal displacements across horizontal measuring lines.

NOTE In general, there are two independent displacement components acting across measuring lines. Inclinometers allow the determination of the two components for vertical measuring lines. For horizontal lines, inclinometers are limited to the determination of the vertical component only.

If applied in conjunction with ISO 18674-2, this document allows the determination of displacements acting in any direction.

This document is applicable to:

— checking geotechnical designs in connection with the Observational Design procedure;

— monitoring of geotechnical structures prior to, during and after construction (e.g. natural slopes, slope cuts, embankments, excavation walls, foundations, dams, refuse dumps, tunnels);

— deriving geotechnical key parameters (e.g. from results of pile load tests or trial tunnelling);

— identification and monitoring of active shear planes in the ground.

NOTE 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 inclinometers as part of the geotechnical investigation and testing in accordance with References [1] and [2].

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*

ISO 18674-2:2016, *Geotechnical investigation and testing — Geotechnical monitoring by field instrumentation — Part 2: Measurement of displacements along a line: Extensometers*

ISO 22475-1:2006, *Geotechnical investigation and testing — Sampling methods and groundwater measurements — Part 1: Technical principles for execution*

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3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 18674-1 and ISO 18674-2 and the following apply.

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

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
inclinometer
system for monitoring displacements across a measuring line by means of inclination measurements in the field

Note 1 to entry: The system essentially consists of an instrument with one or more *tilt sensors* (3.2), a guide tube, a means to measure the position of the instrument in the guide tube and a read-out device.

Note 2 to entry: Data from inclinometers require evaluation, which can be done using proprietary software or spreadsheets.

3.2
tilt sensor
gravity-activated electric sensor for inclination measurements

3.3
probe inclinometer
system comprising a probe with one or more built-in *tilt sensors* (3.2) for step-by-step measurements of the inclination on a measuring line

Note 1 to entry: Also known as a traversing inclinometer.

Note 2 to entry: Vertical probe inclinometers measure displacements in horizontal directions.

Note 3 to entry: Horizontal probe inclinometers measure displacements in vertical directions (settlements or heave).

Note 4 to entry: An alternative to horizontal probe inclinometers is a hydrostatic probe system.

Note 5 to entry: See also Reference [3].

3.4
in-place inclinometer
IPI
inclinometer system comprising a single element, or a series of elements, with one or more built-in *tilt sensors* (3.2) in each element, for measurement of the inclination at specific locations on a measuring line without removing the instrument

Note 1 to entry: In-place inclinometers exist which can measure at all inclinations, but when in near-horizontal position, deflections from the azimuth cannot be measured.

3.5
uniaxial inclinometer
system for inclination measurements in a single plane

Note 1 to entry: Common for horizontal measuring lines.

3.6
biaxial inclinometer
system for inclination measurements in two planes 90° to each other

Note 1 to entry: Common for vertical measuring lines.

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3.7
inclinometer casing
guide tube appropriate to the inclinometer system being used

Note 1 to entry: Commonly, the inner side of inclinometer casings have four longitudinal keyways. Commercially available casings differ with regard to material, dimension, type of coupling, number of keyways etc. (see 5.4).

Note 2 to entry: The corners of casings with square section can be considered as keyways.

3.8
gauge length
L
distance between adjacent contact points of the instrument

Note 1 to entry: For *probe inclinometers* (3.3), *L* is commonly 0,5 m or 1,0 m.

3.9
base length
distance between adjacent measuring points used in the evaluation procedure

Note 1 to entry: For *probe inclinometers* (3.3), the base length is equal to the *gauge length* (3.8).

4 Symbols

Symbol	Name	Unit
A	measuring plane of the probe which coincides with the plane of the guide wheels	—
a	lateral displacement component in Plane A	m
B	measuring plane of the inclinometer probe normal to Plane A	—
b	lateral displacement component in Plane B	m
d	depth, distance	m
F	subscript for follow-up measurement	—
h	height with respect to sea level	m
i	number of a measuring point	—
L	gauge length of an inclinometer or deflectometer probe	m
l	distance between measuring points	m
n	total number of measuring points along a measuring line	—
R	subscript for reference measurement	—
t	elapsed time	s
t_F	date and time of a follow-up measurement	—
t_R	date and time of a reference measurement	—
u, v, w	displacement component in x-, y- and z-direction, respectively	m
x, y, z	local coordinates of a guiding tube or borehole	m
α	tilt angle of the probe axis in Plane A	° (degree)
β	tilt angle of the probe axis in Plane B	° (degree)
ψ	angle between guide tube coordinate x and plane A of the inclinometer	° (degree)
θ, ρ	auxiliary quantities	° (degree)

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