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Geotechnical investigation and testing — Geotechnical monitoring by field instrumentation —

Part 7: Measurement of strains: Strain gauges

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

Partie 7: Mesure des déformations : jauges de déformation

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Foreword

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This document was prepared by Technical Committee ISO/TC 182, *Geotechnics*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 341, *Geotechnical Investigation and Testing,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

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 7:
Measurement of strains: Strain gauges

1 Scope

This document specifies the measurement of strain by means of strain gauges and strainmeters 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 is applicable to:

— performance monitoring of

  — 1-D structural members such as piles, struts, props and anchor tendons;

  — 2-D structural members such as foundation plates, sheet piles, diaphragm walls, retaining walls and shotcrete/concrete tunnel linings;

  — 3-D structural members such as gravity dams, earth- and rock-fill dams, embankments and reinforced soil structures;

— checking geotechnical designs and adjustment of construction in connection with the observational design procedure;

— evaluating stability during or after construction.

With the aid of a stress-strain relationship of the material, strain data can be converted into stress and/or forces (for 1-D members; see ISO 18674-8) or stresses (for 2-D and 3-D members, see ISO 18674-5).

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 strain measuring instruments 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*

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 terminology databases for use in standardization at the following addresses:

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

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

3.1
strain gauge
field instrument for measuring strain

Note 1 to entry: The strain is sensed over the full length of the gauge, commonly by a vibrating wire sensor (VW), an electrical resistance strain gauge sensor or an Fibre Bragg Grating sensor (FBG) with optical sensing).

Note 2 to entry: Typical configurations are strain gauges mounted to a surface of a steel member [see 3.3 and Figures 1 a), 1 b), 3 a) and 3 b)], strain gauges embedded in concrete [see 3.4 and Figure 1 c)], or FBG integrated into the structure or fixed onto the surface [see Figure 3 b)].

Note 3 to entry: A series of FBG sensors with a single lead cable is called an FBG array (see Figure 4).

Note 4 to entry: For mechanical strain gauges, see Reference [3].

Note 5 to entry: Distributed fibre optic strain measurements (DFOS) are not subject to this document, as this new technology is still under intensive development and change. Usage principles and examples for DFOS are given in Annex B.

3.2
strainmeter
strain gauge for measuring strain by means of a displacement measurement

Note 1 to entry: The strain is sensed over the defined gauge length of the strainmeter (see Figure 2)

Note 2 to entry: An extensometer with a defined gauge length, for example a probe extensometer (see ISO 18674-2) has the function of a strainmeter.

Note 3 to entry: A typical configuration is a continuous chain of strainmeters embedded in fill, soil or concrete.

Note 4 to entry: Alternative terms for a strainmeter used in practice are “fill extensometer”, “soil strainmeter”, “soil extensometer”, “embankment extensometer” or “linear continuous extensometer“

Note 5 to entry: The term strainmeter is sometimes (incorrectly) used for specific strain gauge sensors, e.g. rebar strainmeter

3.3
surface-mounted strain gauge
strain gauge designed for attachment at the surface of a structural member

Note 1 to entry: There are different types of instruments for surface-mounting: spot-weldable, arc welded and adhesive bonded strain gauges.

3.4
embedment strain gauge
strain gauge for the embedment in a medium

Note 1 to entry: Typically, the medium is mortar, grout, reinforced concrete, shotcrete or mass concrete.

Note 2 to entry: See Figure 1 c).

3.5
instrumented reinforcement bar
piece of reinforcement bar into which a strain gauge is integrated

Note 1 to entry: When installed alongside the structural reinforcement, this is commonly known as a "sister bar".

Note 2 to entry: When installed as part of the structural reinforcement this is commonly known as a "rebar strain meter".

Note 3 to entry: Sister bars and rebar strain meters measure the same parameter: overall strain in a reinforced concrete element. The difference in their use is that when using sister bars the overall steel area in the structural element increases slightly leading to a reduction of the actual strain at the measuring section.

Note 4 to entry: See Figure 5.

3.6
gauge length
L
initial length over which the strain is measured by the strain gauge or initial length over which the displacement is measured by a strainmeter

Note 1 to entry: For vibrating wire strain gauges and strainmeters the length is defined by the mounting blocks, end plates or anchors.

Note 2 to entry: For a Fiber Bragg Grating (FBG) strain gauge, depending on the mounting, the gauge length is either the length of the grating or the distance between the mounting blocks / end plates, anchors or spots of adhesive (see Figures 3 and 4)

4 Symbols

Table 1 lists all symbols and subscripts used in this document.

Table 1 — symbols

Symbol	Definition	Unit
A	area	m^2
C_T	thermo optic coefficient	MHz/°C
C_ε	strain transfer coefficient	MHz/%
D	diameter	m
d	distance	m
E	Young's modulus	Pa
F	normal force	N
H	height	m
L	gauge length	m
s	spacing between strain gauge sensing element and steel surface	mm
T	temperature	°C
t_{web}	web thickness	mm
W	width	m
α_T	coefficient of linear thermal expansion	K^{-1}
ΔT_i	change in temperature at location i	°C
$\Delta\varepsilon_i$	change in strain at location i	- [a]
$\Delta\nu_{bi}$	change in Brillouin peak frequency at location i	MHz
ε	strain	- [a]
ε_{ax}	axial strain	- [a]
ε_μ	micro strain	µm/m
ν_b	Brillouin peak frequency	MHz
σ	stress	Pa

[a] Strain and strain changes are expressed as an elongation per m, so m/m, resulting in a dimensionless parameter.