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Update on European and international geotechnical monitoring standards

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Abstract

On the occasions of the previous International Field Measurements in Geomechanics (FMGM) symposia in Boston 2007 and Berlin 2011, contributions were made on the issue of developing a set of international geotechnical monitoring standards. Efforts, initially undertaken under the auspices of DIN, the German Standardisation Organization (Bock & Thaher 2007), and subsequently of CEN, the European Standardisation Organization (Steiner 2011) were referred to. This paper presents an update on the process, covering the developments, which have taken place since 2011, the current state, and future perspectives.

It is foreseen that the set of the international geotechnical monitoring standards will consist of ten parts. Currently, the committee work is carried out by the authors of this paper, under the auspices of CEN, in co-operation with the International Standardization Organization (ISO). In 2013 it was decided to label the new standards as EN ISO 18674 under the heading of 'Geotechnical investigation and testing – Geotechnical monitoring by field instrumentation'. Since 2011, the first part, namely 'General rules', has been finalised and is expected to be published in 2015. Drafts for the following two parts are nearing completion:

- *Part 2 ISO 18674-2 'Measurement of displacements along a line: extensometers'.*
- *Part 3 ISO 18674-3 'Measurement of displacements across a line: inclinometers'.*

Drafting has commenced for Part 4 'Piezometers' and Part 5 'TPC - Total pressure cells'. The remaining five parts have yet to be started.

In various CEN and ISO enquiries, there was convincing evidence on the need for geotechnical monitoring standards in general, and its market relevance in particular. Voting results of these enquiries are presented. They are understood as strong support for the work of the committee.

1 Introduction

Free trading of goods and services across the various regions of the world is a major political and social issue, as is evidenced in the current debate on TTIP, the proposed Transatlantic Trade and Investment Partnership between the USA and the European Union (EU). Within Europe, such trading has already been in place for decades. A major factor for the success of that scheme is harmonised technical standards. From 1975, the member states of both the EU and the European Free Trade Association (EFTA) have developed a set of Eurocodes. In 1989, the European Commission and the member states agreed to transfer the preparation and publication of Eurocodes to the European Committee for Standardisation (CEN; Comité Européen de Normalisation), in order to provide Eurocodes with the status of European Standards (EN). Once established, Eurocodes are mandatory in all member states and any conflicting national standards are to be withdrawn.

The Eurocode fundamental to geotechnical engineering is Eurocode 7 'Geotechnical design' (European Standard 2007). It has been issued in two parts (see Figure 1):

- Part 1 (EN 1997-1): 'General rules', effective since 2004 (European Standard 2004).
- Part 2 (EN 1997-2): 'Ground investigation and testing', effective since 2007 (European Standard 2007).

The scope of EN 1997 is on the design principles (Part 1) and on the general requirements for ground investigation and laboratory and field testing (Part 2). However, it is left to a set of so-called execution standards, to cover the technical aspects of the various geotechnical tests, including instrumentation and execution of geotechnical construction works. The execution standards are thereby commonly a product of joint efforts of the European and international standardisation organisations CEN and ISO.

For the FMGM community, Part 1 of Eurocode 7 (European Standard 2004) is of principal importance as it refers to the 'observational method' as one of four possible geotechnical design options. That option is particularly indicated in cases where the prediction of geotechnical behaviour is difficult. It is the first time that the 'Observational method' has been established within an international regulatory framework.

This achievement, however, is not reflected in Part 2 of Eurocode 7 (European Standard 2007) which is to be used in conjunction with Part 1. In providing guidance for ground investigations and geotechnical laboratory and field testing, Part 2 is focussing on the requirements for the option 'geotechnical design by calculation'. It does not give any specific guidance for performance monitoring by field instrumentation, which in fact, is the key in the application of the 'Observational method'.

In view of the above inconsistency, an initiative developed in Germany to correct this situation. A set of national standards, entitled 'Geotechnical monitoring', was drafted by DIN, the German standardisation organisation, and published as DIN 4107-1 to 4 (Bock 2011). The real objective, however, was to introduce DIN 4107 into the European standardisation procedure under the auspices of CEN with the view to widening the scope of EN 1997-2 and to produce a set of EN ISO execution standards on geotechnical monitoring (Bock & Thaher 2007). In 2009, a European task group was set up (CEN/TC-341/WG1, TG-2) and a first account on the activities of that group was given to the FMGM community in Berlin (Steiner 2011). The FMGM 2015 contribution at hand provides an update of the work of the European task group in the period 2011 to 2014 (see Section 3).

The work generated some interest also beyond Europe. In the framework of the Vienna Agreement between CEN and ISO, some of the work of the European task group has now been transferred to a technical committee under ISO lead. This development will be considered in Section 4.

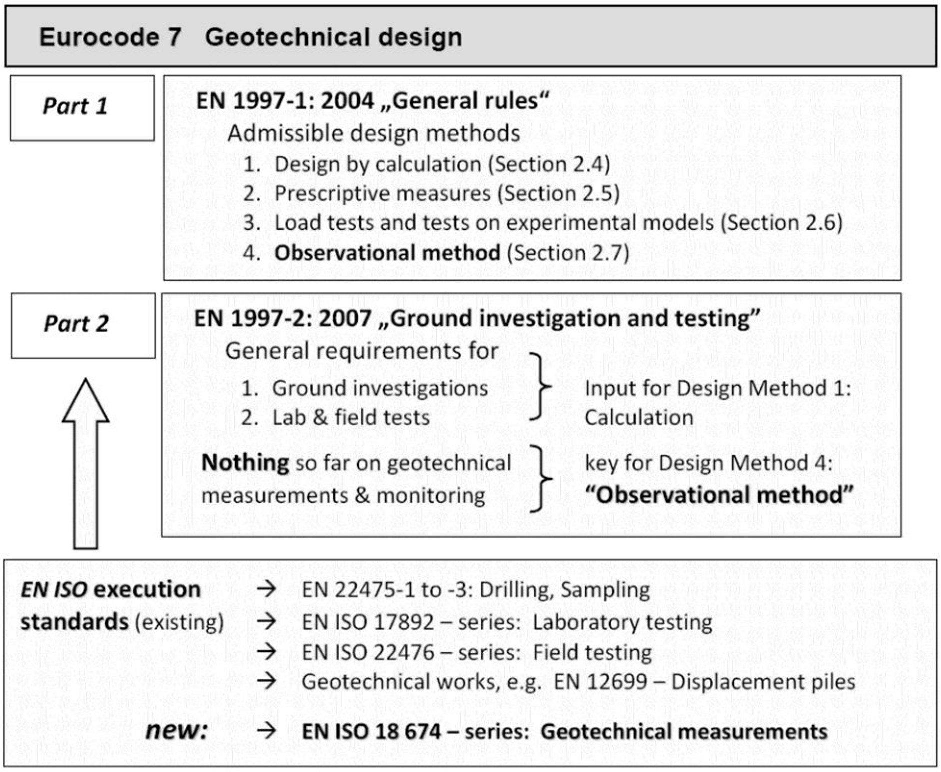

Figure 1 Structure and principal content of Eurocode 7 and input of EN ISO technical execution standards

2 Market relevance of geotechnical monitoring standards

In the years 1997 and 1998, there was a fierce debate in the USA on the need for geotechnical monitoring standards (for a review of that debate, see Bock & Thaher 2007). The debate was triggered by the ASTM Standard Test Method D 6230-98 on probe inclinometers (ASTM 1998). The publication caused Dunnicliff (1997) to voice criticism, not only of the particular inclinometer standard but also of some ASTM standardisation practices in geotechnical engineering in general. He considered *'prescriptive professional practice standards'* to be in potential conflict with engineering judgement, one of the key requisites of the engineering profession at large. He considered 'practice guides' or 'suggested methods' to be more appropriate (Dunnicliff 1997). Dunnicliff (1997) solicited the support of eminent geo-instrumentation engineers such as Gordon Green and Erik Mikkelsen and also of Ralph Peck, the original instigator of the 'Observational method' in 1969 (Peck 1969).

In the meantime, the reality of the global market requirements has virtually overpowered all of the previous misgivings against standardisation. This even applies to a comparatively very small market such as that of geotechnical instrumentation. Prior to embarking on the standardisation project on 'Geotechnical monitoring by field instrumentation', both CEN and ISO asked their national member bodies on the market relevance of, and a need for, the intended standards. The results of the enquiries are shown in Table 1. As can be seen, there was an overwhelming response in favour of such standards and not a single response was against it.

This positive vote is even more remarkable against the background of recent trends in European standardisation practice. After the implementation of the Eurocodes, it soon became evident that they were generally too sophisticated, too complex and too voluminous (all construction Eurocodes together have 58 parts, and encompass more than 5,000 pages). A widespread consent has developed that the first generation of Eurocodes is too academic, and does not reflect the needs of practitioners (Nußbaumer 2011). In early 2015, the EU Commission in Brussels committed EUR 4.5 million for Phase 1 of developing a set of second generation Eurocodes where the focus shall be on ease of use, simplification of design approaches, and reduction in the number of national choice options.

Table 1 CEN and ISO enquiries on market relevance of geotechnical monitoring

	Question put to CEN and ISO members	Answer of members			Date of enquiry
		yes	no	abstain	
Part 1: General rules	Market relevance (ISO members)	14	0	1	15 February 2013
	Possible acceptance as CEN standard	21	0	11	13 January 2014
	Possible acceptance as ISO standard	14	0	5	13 January 2014
Part 2: Extensometers	Market relevance (ISO members)	11	0	4	23 October 2014
	New work item proposal (CEN)	15	0	7	October 2014

3 Update on European (EN) geotechnical monitoring standards

In 2009, a task group 'Geotechnical monitoring' was set up by the CEN technical committee (TC) 341 which is one of the most significant European committees that is responsible for managing, implementing and vetting of all standards in Europe relating to 'Geotechnical Investigation and Testing'. In 2015, the CEN/TC 341 is chaired by John Powell from Geolabs Ltd in the UK; the secretary is held by Stephen Read from the British Standard Institution (BSI).

Currently, the members of Task Group 2 (TG-2) 'Geotechnical monitoring' are as listed in Table 2. All of them are the authors of the FMGM 2015 contribution at hand.

Table 2 Members of the Task Group 2 'Geotechnical Monitoring' of CEN/TC 341/WG1

Name	Country	Affiliation	Consulting	Services	Manufacturer	Administration	Universities
Steiner, Walter (Chairman)	Switzerland	B+S AG	×				none
Beth, Martin	France	Soldata Group	×	×			
Bock, Helmut	Germany	Q+S Consult	×				
Clegg, Martin	UK	Geosense Ltd.			×		
Golser, Johann	Austria	Geodata Group	×	×	×		
Möller, Björn	Sweden	FmGeo AB	×				
Pezzetti, Giorgio	Italy	SMAK s.a.s.	×	×			
Ridley, Andrew	UK	Geotechnical Observations Ltd.	×	×			
van der Salm, Rob	Netherlands	Fugro Geoservices b.v.	×	×			
Spalton, Chris	UK	Geosense Ltd.			×		
de Vos, Leen	Belgium	Flemish Government				×	
Welter, Philippe	Belgium	Service Public de Wallonie				×	
Wörsching, Holger	Switzerland	Solexperts AG	×	×	×		

Professionally, the majority of the TG-2 members are inclined toward consulting, providing services or manufacturing. Universities or other research institutions are currently not represented in TG-2. The group receives inputs from the national mirror groups and from the Working Group 1 ‘Drilling and sampling methods and groundwater measurements’ of CEN TC-341. That setting provides favourable conditions to develop documents, which are in tune with the intentions for the second generation of European standards.

TG-2 decided to initially develop a base document entitled ‘Geotechnical monitoring by field instrumentation — general rules’. That document is aimed to be applicable to any geotechnical instrumentation project, and is expected to become an input into the revised Eurocode 7, Part 2 (European Standard 2007). In the sense of Figure 1, subsequent geotechnical monitoring documents should focus on pertinent field instruments and be formulated as EN ISO execution standards. In total, some ten documents are foreseen by the group, as listed in Table 3.

Table 3 TG-2 Programme on ‘Geotechnical monitoring by field instrumentation’ and state as per March 2015

Part	Title	State as per March 2015
1	General rules	EN ISO 18674-1, to be issued in 2015
2	Displacement measurements along a line: Extensometers	Draft completed; to be issued in 2015 or 2016 as ISO 18674-2
3	Displacement measurements across a line: Inclinometers	Draft almost complete; to be issued as ISO 18674-3, most likely in 2016
4	Piezometers	Partially drafted; at working stage
5	Total pressure cells	Drafted; at working stage
6	Hydraulic settlement gauges	Not yet drafted
7	Strain gauges	Not yet drafted
8	Load cells	Not yet drafted
9	Geodetic monitoring instruments	Not yet drafted
10	Vibration monitoring instruments	Not yet drafted

EN ISO 18674-1 contains 31 pages. Its structure is reflected in the table of contents as follows (shortened):

Foreword

1. Scope
2. Normative references
3. Terms and symbols
4. Principal requirements
   - 4.1 Geotechnical monitoring in connection with geotechnical design
   - 4.2 Geotechnical monitoring in connection with specific questions
   - 4.3 Requirements of a geotechnical monitoring project
   - 4.4 Geodetic measurements
   - 4.5 Safety requirements
5. Requirements of a geotechnical monitoring system

5.1 General

5.2 Robustness

5.3 Influencing factors

5.4 Redundancy

5.5 Stability of sensor signals

5.6 Function check and calibration

6. Location of measuring points and geotechnical parameters

6.1 Location of measuring points

6.2 Measurement and monitoring of geotechnical parameters

7. Carrying out of the measurement

8. Data processing and verification

9. Reporting

9.1 Installation report

9.2 Monitoring report

Annex A (normative) Minimum requirements on content of instrument data sheets

Annex B (normative) Geotechnical measurements in boreholes

Annex C (informative) Field measurements in connection with the design and construction of geotechnical structures

Annex D (informative) Measurement and monitoring of geotechnical key parameters

D.1 Geotechnical key parameters and their measurement

D.2 Monitoring of geotechnical key parameters (value change measurements)

Annex E (informative) Types of instruments and monitoring methods commonly used

Bibliography

4 Update on international (ISO) geotechnical monitoring standards

Under the ‘Vienna Agreement’ (Figure 2), standards may be developed by either CEN or ISO. The lead role has to be determined. Under CEN Lead, only representatives from Europe participate in the preparation, whereas with ISO Lead, other member countries may also participate. Votes are usually cast in parallel for CEN and ISO. CEN standards become mandatory for Europe if a qualified majority of the CEN member bodies is in favour. In other countries, an ISO standard has to be declared a valid standard. Some countries, like USA do not participate in ISO standards.

China, Japan, Korea (Republic) and Malaysia are the ISO member countries that subscribe to the CEN/TC 341 topic of ‘Geotechnical Investigation and Testing’. Australia currently has an ‘observing’ status.

Due to interests expressed by some ISO members, the lead role on ISO 18674-2 has been transferred from the European group (CEN/TC 341, WG1, TG-2) to the mirror ISO group (ISO/TC 182, SC1, WG 4). At the time of publication, the chairman of ISO/TC 182 is Ferdinand Stölben, Stölben Drilling GmbH in Germany, and the secretary is hosted by the German Standardisation Organisation DIN in Berlin.

It is expected that the CEN committee members, as listed in Table 2, will also become members of the ISO group, and that the work of the group will continue essentially as before. However, the membership of that group is now principally open to any non-European ISO country, and competent persons from those countries would be welcomed by the group as ordinary, alternatively as corresponding, new members.

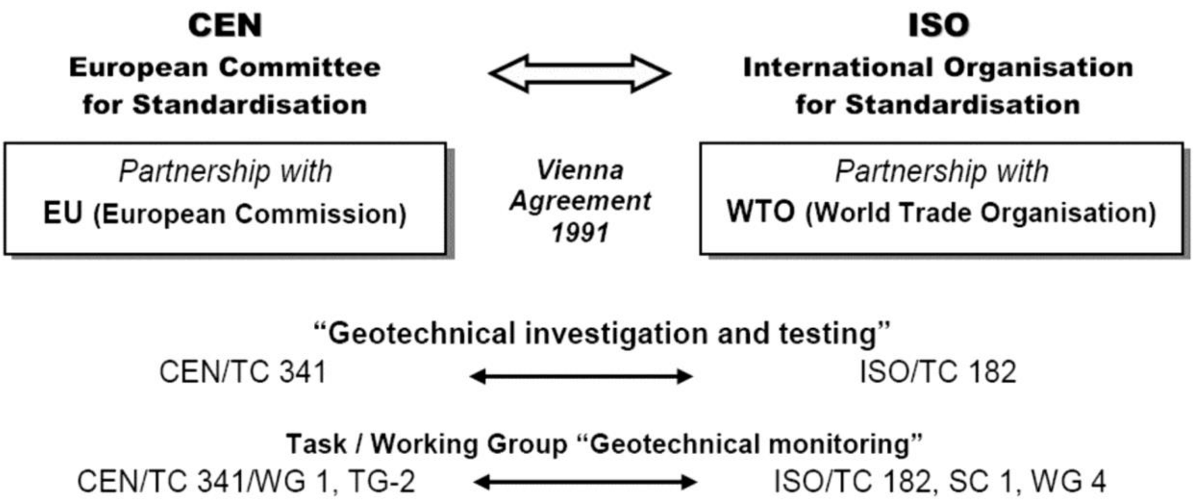

Figure 2 Cooperation between the European and the International Standardisation Organisations CEN and ISO and committee set-up for geotechnical monitoring

ISO 18674-2 entitled 'Displacement measurements along a line: Extensometers' was developed during nine meetings held between 2011 and 2014. It contains 45 pages of which 16 pages are on case study examples. Three types of extensometers are considered: In-place, probe and tape. The structure of the document is reflected in the table of contents as follows (shortened):

Foreword

1. Scope
2. Normative references
3. Terms and symbols
4. Instruments
   - 4.1 General
   - 4.2 In-place extensometer
   - 4.3 Probe extensometer
   - 4.4 Tape extensometer (convergence tape)
   - 4.5 Measuring range and accuracy
   - 4.6 Geo-engineering applications
5. Installation and measuring procedure
   - 5.1 Installation
   - 5.2 Measuring procedure
     - 5.2.1 Instrumentation check and calibration
     - 5.2.2 Measurement
6. Data processing and evaluation
7. Reporting

7.1 Installation report

7.2 Monitoring report

Annex A (normative) Measuring and evaluation procedure

A.1 In-place extensometer

A.2 Probe extensometer

A.3 Tape extensometer

Annex B (informative) Measuring examples

B.1 In-place multiple-point extensometer

B.2 Retrievable chain extensometer in pile load test

B.3 In-place chain extensometer

B.4 Single-point probe extensometer in embankment construction

B.5 Double-point probe extensometer in near-surface tunnelling

Bibliography

The above format is employed throughout the entire ISO 18674-2... 10 series on 'Geotechnical monitoring'. As shown in Figure 3, the format is equivalent to that of the EN ISO 22476 – series on geotechnical 'Field testing'.

ISO 22476 series on field testing Example: Flexible dilatometer test (EN ISO 22476-5)	**ISO 18674 series on geotechnical monitoring** Example: Extensometer (ISO 18674-2)
Foreword	Foreword
1 Scope	1 Scope
2 Normative references	2 Normative references
3 Terms, definitions and symbols	3 Terms and symbols
4 Equipment	4 Instruments
5 Test procedure	5 Installation and measuring procedure
6 Test results – interpretation of tests	6 Data processing and evaluation
7 Test report	7 Reporting
Annex (normative)	Annex (normative)
Annex (informative)	Annex (informative)
(a)	(b)

Figure 3 Comparison of the principal structure of the ISO standards on field testing; (a) and geotechnical monitoring (b)

5 Conclusion

In recognising the 'Observational method' as an appropriate design procedure for difficult geotechnical conditions and the necessity for verification of design assumptions by field measurements, the fundamental Eurocode 7 (European Standard 2007) 'geotechnical design' has opened the door for a wide range of applications of field instruments and geotechnical monitoring in ground engineering. It is now the responsibility of the FMGM community to consolidate this situation by developing adequate monitoring and field instrument standards for practical use in line with the 'Observational method'.

In 2010, a European task group, 'Geotechnical monitoring', was set up and, in the following years, drafted a number of monitoring and instrumentation standards. Publication of these standards will commence in 2015 within the EN ISO 18674 series. It is expected that the task group will be transformed into an international ISO working group, thus enhancing the relevance of the standardisation efforts to a worldwide level.

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