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Geotechnical investigation and testing — Field testing —

Part 5:
Prebored pressuremeter test

Reconnaissance et essais géotechniques — Essais en place —

Partie 5: Essai au pressiomètre en préforage

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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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation of 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 www.iso.org/iso/foreword.html.

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).

This second edition cancels and replaces the first edition (ISO 22476-5:2012), which has been technically revised.

The main changes are as follows:

— the title of the part has been modified;

— a reference loading programme with cyclic loading has been added;

— calibration procedures have been developed.

A list of all parts in the ISO 22476 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Geotechnical investigation and testing — Field testing —

Part 5: Prebored pressuremeter test

1 Scope

This document is applicable to pressuremeter tests using cylindrical flexible probes placed in pre-existent boreholes using testing procedures other than the Menard procedure.

Pressuremeter tests following the Menard procedure are provided in ISO 22476-4.

NOTE A high-pressure flexible pressuremeter probe which contains transducers for the measurement of radial displacements is also known as flexible dilatometer probe or high-pressure dilatometer probe.

This document applies to tests performed in any kind of grounds, starting from soils, treated or untreated fills, hard soils and soft rocks, up to hard and very hard rocks, either on land or offshore.

The parameters derived from this test can include stiffness, strength, initial in-situ stress state and consolidation properties.

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.

EN 16228-1, *Drilling and foundation equipment – safety – Part 1:Common requirements*

EN 16228-2, *Drilling and foundation equipment – safety – Part 2: Mobile drill rigs for civil and geotechnical engineering, quarrying and mining*

ISO 10012, *Measurement management systems — Requirements for measurement processes and measuring equipment*

ISO 14689, *Geotechnical investigation and testing — Identification, description and classification of rock*

ISO 22475-1, *Geotechnical investigation and testing — Sampling methods and groundwater measurements — Part 1: Technical principles for the sampling of soil, rock and groundwater*

ISO 22476-4, *Geotechnical investigation and testing — Field testing — Part 4: Prebored pressuremeter test by Ménard procedure*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions 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/

3.1.1
pressuremeter probe
cylindrical flexible probe which can be expanded by the application of hydraulic pressure and/or pressurised gas

Note 1 to entry: Pressuremeter probes contains means of measurement of its radial displacements or volume.

3.1.2
flexible dilatometer probe
high-pressure dilatometer probe
high-pressure flexible pressuremeter probe which contains transducers for the measurement of radial displacements

3.1.3
pressuremeter control unit
set of suitable devices capable of supplying fluid and/or gas pressure to the probe, to control and take readings of the probe's pressure, radial displacements or volume of the measuring cell

3.1.4
connecting line
cable that connects the control unit to the probe, delivers fluid and/or gas pressure in the measuring and guard cells

3.1.5
pressuremeter test pocket
circular cylindrical cavity formed in the ground to receive a *pressuremeter probe* (3.1.1)

3.1.6
pressuremeter test
process of expanding the pressuremeter probe so as to pressurize the flexible membrane against the pocket wall and so measure pressure, radial displacements or volume as a function of time during the expansion test

Note 1 to entry: See Figure 1.

3.1.7
pressuremeter sounding
series of pressuremeter tests in a borehole

3.1.8
seating pressure
pressure during the expansion of the pressuremeter at which the pressuremeter membrane contacts the pocket wall

3.1.9
controlling parameter
variable used to define the loading programme of the test according to a pre-determined programme and recorded in the control unit

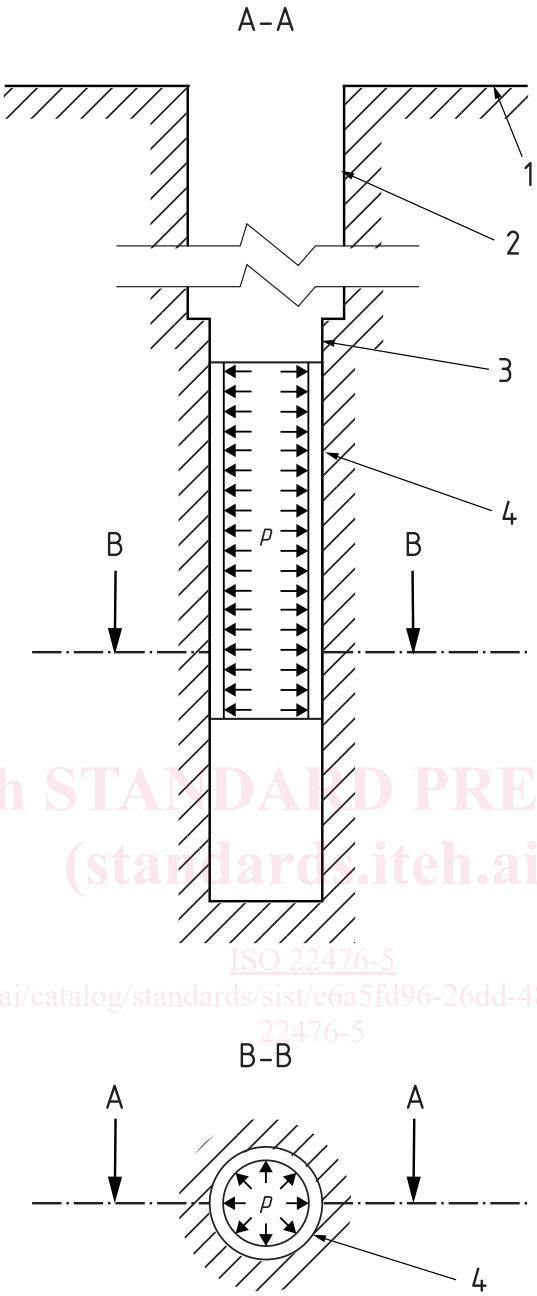
Note 1 to entry: This variable can be the pressure, the radius displacement or the injected volume.

3.1.10
radial displacement
change in pressuremeter probe radius/diameter or in cavity wall displacement

3.1.11
pressuremeter curve
graphical plot of pressure versus the associated cavity wall displacement or measuring cell volume

3.1.12
pressuremeter shear modulus
G_{PBP}
shear modulus obtained from the pressuremeter curve

Note 1 to entry: See 6.3



Key

1	ground surface
2	borehole wall
3	pocket
4	expanding pressuremeter probe
P	applied pressure
A-A	axial section
B-B	cross section

Figure 1 — Example of a prebored pressuremeter test

3.1.13
depth of test
distance between the ground level and the centre of the expanding length of the pressuremeter probe measured along the borehole axis

Note 1 to entry: See Figure 2.

3.1.14
operator
qualified person who carries out the test

3.1.15
phase
section of the loading or expansion program characterized by a controlling parameter, a loading rate and a loading direction

3.1.16
loop
sequence of the loading or expansion program including at least an unloading phase and a reloading phase, and possibly an intermediate hold phase

3.2 Symbols and abbreviations

For the purposes of this document, the symbols in Table 1 apply.

Table 1 — Symbols

Symbol	Description	Unit
a	Corrected equipment radial displacement or volume loss coefficient, taking into account calibration cylinder self-deformability	$mm.MPa^{-1}$ or $cm^3.MPa^{-1}$
a_r	Raw equipment radial displacement or volume loss coefficient	$mm.MPa^{-1}$ or $cm^3.MPa^{-1}$
a_{cc}	Radial displacement or equivalent volume loss taking into account calibration cylinder self-deformability	$mm.MPa^{-1}$ or $cm^3.MPa^{-1}$
d_{cc}	Calibration cylinder inside diameter	mm
d_c	Initial external diameter of the pressuremeter probe	mm
E_{PBP}	A Young modulus derived from a prebored pressuremeter test	MPa
G	Shear modulus	MPa
G_{L1}	First loading pressuremeter shear modulus	MPa
G_{PBP}	Pressuremeter shear modulus	MPa
G_{Ri}	A reloading pressuremeter shear modulus	MPa
G_{sys}	Apparent shear modulus of the equipment or system during unloading-reloading loops	MPa
G_{Ui}	An unloading pressuremeter shear modulus	MPa
G_{URi}	An unloading/reloading pressuremeter shear modulus	MPa
k_f	Creep parameter in reference loading programme C	mm
L_{FD}	Expanding length of the pressuremeter probe	mm
p	Corrected pressure	MPa

Table 1 *(continued)*

Symbol	Description	Unit
$p_{1.1}$	Constant full relief pressure for loops in reference loading programme A	MPa
p_e	Pressure loss associated with membrane stiffness	
p_i	Corrected reversal pressure before loop *i*	MPa
p_{mean}	Average corrected pressure in reference loading programme D	MPa
p_{min}	Minimum corrected pressure in reference loading programme D	MPa
p_{max}	Maximum corrected pressure in reference loading programme D	MPa
p_r	Pressure as read at the measuring unit	MPa
p_s	Seating pressure	MPa
r	Corrected radius	mm
r_1	Corrected radius at time t_1 in reference loading programme C	mm
r_2	Corrected radius at time t_2 in reference loading programme C	mm
r_e	Radius correction	mm
r_s	Nominal cavity radius	mm
t	Time	min
T	Period in reference loading programme D	min
t_1	Time 1 in reference loading programme C	min
t_2	Time 2 in reference loading programme C	min
ΔV	Corrected injected volume	cm^3
ΔV_e	Injected volume correction	cm^3
ΔV_r	Injected volume, as read at the control unit	cm^3
V	Total volume	cm^3
z	Test depth	m
δ	Corrected radial displacement	mm
δ_e	Radial displacement correction	mm
δ_r	Radial displacement, as read at the control unit	mm
δ_s	Radial displacement corresponding to the seating pressure	mm
Δd_r	Increase of diameter, as read at the control unit	mm
Δd	Corrected diameter increase	mm
Δp_r	Pressure increment, as read at the control unit	MPa
Δp	Corrected pressure increment	MPa
ε_c	Cavity strain	-
ν	Poisson's ratio	-

4 Equipment

4.1 General

The test with the pressuremeter is performed by the expanding of a pressuremeter membrane placed in the ground (see Figure 1). The pressure and the associated expansion of the probe are measured and recorded so as to obtain a pressure-expansion relationship for the ground as tested.

The equipment to carry out pressuremeter tests shall consist of the components shown in Figure 2.

The following components are mandatory:

— pressuremeter probe (no. 8 in Figure 2);

— connecting line (no. 6 in Figure 2);

— signal cable (no. 5 in Figure 2);

— displacement or volume measuring unit (no. 2 in Figure 2);

— pressure control unit (no. 3 in Figure 2);

— pressure source (no. 4 in Figure 2).

— setting rods (no.1 in Figure 2).

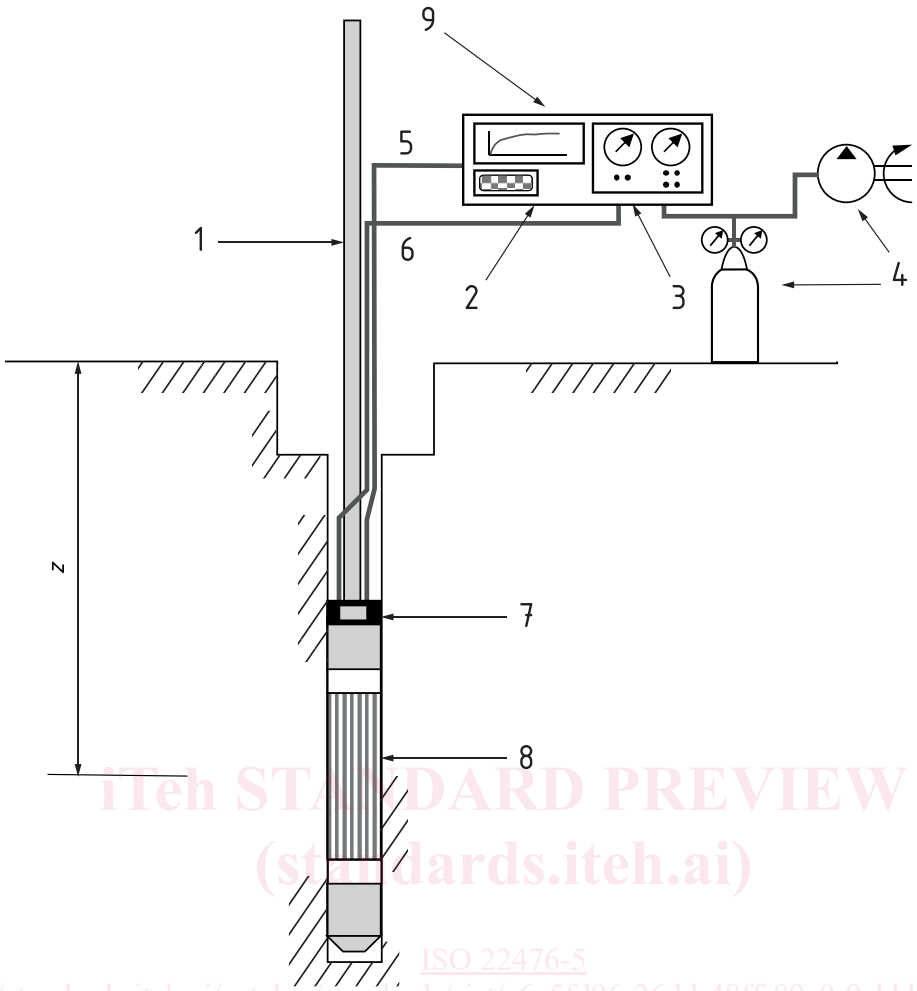
The following components may be added to allow orientation of the instrument if needed:

— data logger (no. 9 in Figure 2);

— sediment collection tube (no. 13 in Figure 3);

— pore pressure measuring system;

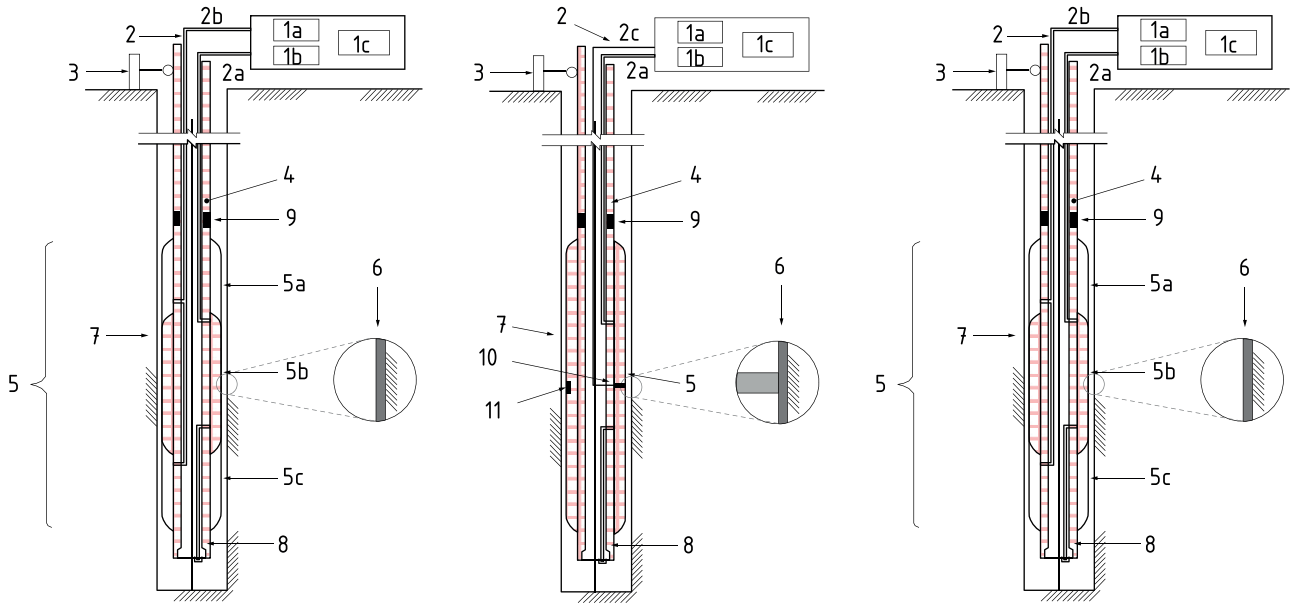
— accelerometer or geophones to perform shear wave velocity measurements.



Key

1	setting rods	6	connecting line
2	displacement or volume measuring unit	7	probe rode coupling sediment collection tube
3	pressure control unit	8	pressuremeter probe
4	pressure source	9	data logger
5	signal cable	*z*	test depth

Figure 2 — Schematic diagram of pressuremeter equipment



a) Tri-cellular or monocellular probe with expansion followed through the volume of central cell

b) Monocellular probe with displacement measured inside the membrane

c) Monocellular probe with displacement measured at the cavity wall

Key

1	control unit (CU):	1a	pressurization, differential pressurization (if any) and injection devices
		1b	pressure and displacement or volume measuring devices
		1c	acquisition, storage and printing out of the data (required for CU type B and C)
2	connecting lines:	2a	line for liquid injection
		2b	line for gas injection
		2c	signal cable
3	depth measurement system		
4	setting rods		
5	pressuremeter probe	5a	upper guard cell
		5b	central measuring cell
		5c	lower guard cell
6	ground		
7	pressuremeter test pocket		
8	probe body, hollow		
9	probe rod coupling		
10 and 11	displacement transducers		
12	metal insert at the extremities of the displacement transducers		
13	membrane clamping ring		
14	sediment collection tube		
15	pressure transducer (if applicable)		
16	compass (if applicable)		

Figure 3 — Sketch of pressuremeter probes