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Geotechnical investigation and testing — Field testing —

Part 6: Self-boring pressuremeter test

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Partie 6: Essai pressiométrique autoforé

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Foreword

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Geotechnical investigation and testing — Field testing —

Part 6: Self-boring pressuremeter test

1 Scope

This document specifies the equipment requirements, execution of and reporting on self-boring pressuremeter (SBP) tests.

NOTE This document fulfils the requirements for self-boring pressuremeter test as part of the geotechnical investigation services according to EN 1997-1 and EN 1997-2.

Tests with the self-boring pressuremeter cover the measurement in situ of the deformation of soils and weak rocks by the expansion and contraction of a cylindrical flexible membrane under pressure.

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

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

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

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

3.1
self-boring pressuremeter
SBP
equipment used to carry out a *self-boring pressuremeter test* (3.5), including the *self-boring head* (3.3) used to drill the test pocket into the ground and the *pressuremeter* (3.2) used to carry out the expansion

Note 1 to entry: An SBP includes a probe composed of a *self-boring head* (3.3) and a *pressuremeter* (3.2) , an hydraulic pump or other source of pressure, a test Control Unit (CU), pressure lines and wires to connect the probe to the CU and a data logger which is either built into the CU or attached to it. The SBP is drilled into the ground using the integral self-boring head at its lower end in such a way that the probe replaces the material it removes, creating its own test hole, and minimises the disturbance to the soil outside the instrument.

3.2
pressuremeter
cylindrical expanding part of the equipment used to carry out a pressuremeter test excluding the means necessary to place the pressuremeter probe into the ground

3.3
self-boring head
part of the equipment used to drill the test pocket as the probe is advanced into the ground

Note 1 to entry: A self-boring head includes a boring tool: i.e. a rotating cutter or a high pressure jet arrangement, housed in a cutting shoe attached at the probe end.

3.4
self-boring pressuremeter sounding
series of sequential operations necessary to perform self-boring pressuremeter testing at a given location

Note 1 to entry: See 3.1.

EXAMPLE Pushing the self-boring pressuremeter, activating the self-boring head (see 5.3) and then performing pressuremeter tests (see Clause 6).

3.5
self-boring pressuremeter test
process of expanding the self-boring pressuremeter probe so as to press the flexible membrane against the borehole wall and so measure the associated displacement as a function of pressure and time

3.6
self-boring pressuremeter curve
graphical plot of pressure versus the measured displacement

3.7
depth of test
distance between the ground level and the centre of the expanding length of the *self-boring pressuremeter* (3.1) measured along the borehole axis

Note 1 to entry: See Figure 1.

3.8
operator
qualified person who carries out the probe insertion and the test

4 Symbols

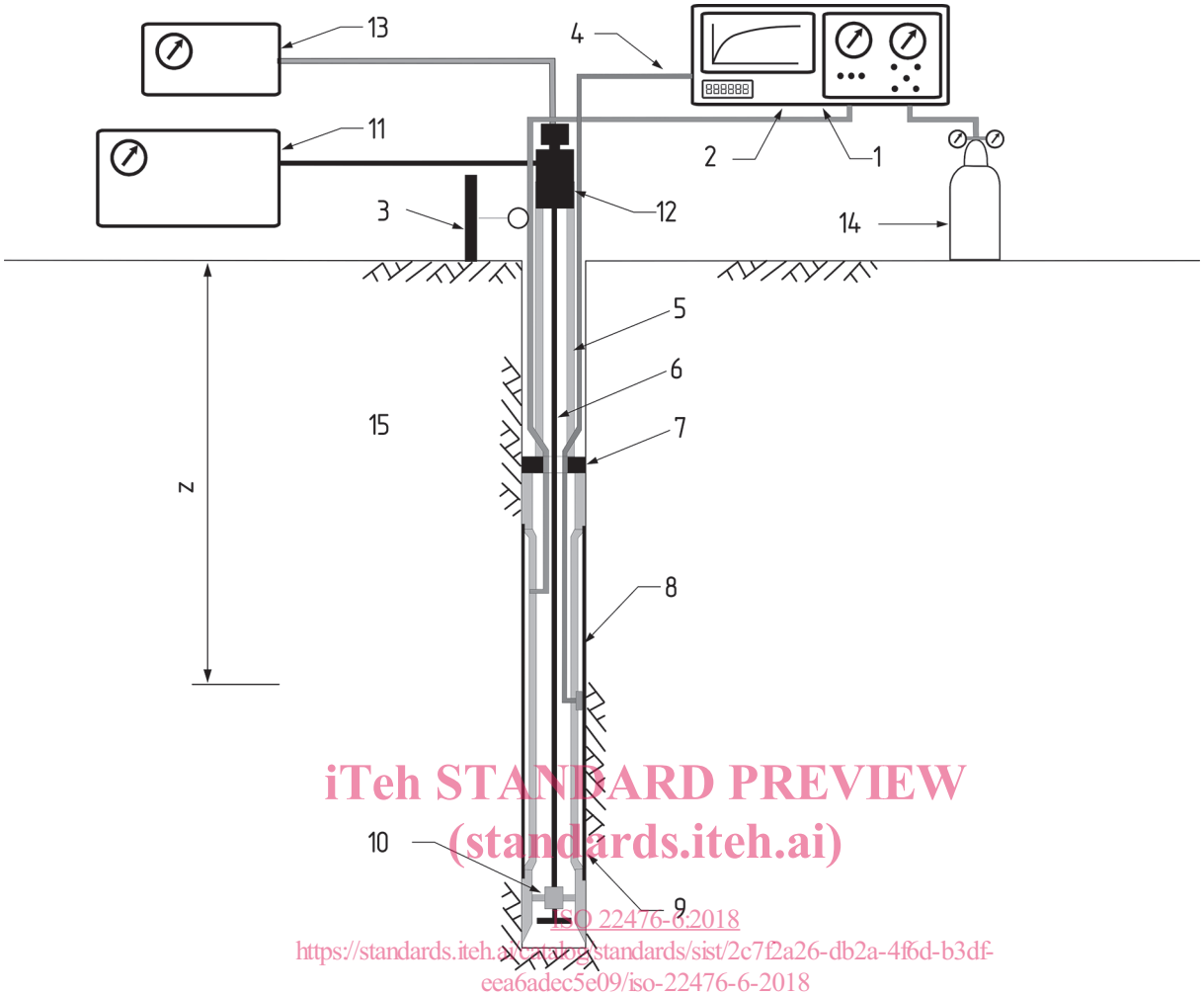
Symbol	Description	Unit
a	pressure coefficient of the displacement	$mm.MPa^{-1}$
b	membrane stiffness coefficient of the displacement	$MPa.mm^{-1}$
d	corrected displacement at the borehole wall	mm
d_a	apparent displacement during the membrane compression calibration	mm
d_c	calculated cylinder expansion during the membrane compression calibration	mm
d_i	internal diameter of the calibration cylinder	mm
d_p	outside diameter of the cutting shoe	mm
d_r	displacement as read at the measuring unit	mm
d_{so}	initial outside diameter of the measuring cell	mm
d_s	outside diameter of the measuring cell	mm
e	thickness of the calibration cylinder	mm
h	distance between the cutting tool and the cutting edge	mm
l_c	length of calibration cylinder	mm
l_g	distance between the displacement transducer and the membrane clamping ring	mm
l_s	expanding length	mm

Symbol	Description	Unit
p	applied pressure after correction	MPa
p_c	pressure at the origin of the segment exhibiting the slope b	MPa
p_{max}	maximum applied pressure	MPa
p_r	pressure as read at the measuring unit	MPa
r	measured cavity radius	mm
r_0	initial radius	mm
u_s	pore pressure	mm
t	time	s
V	measured cavity volume	mm^3
V_0	initial volume	mm^3
z	test depth	m
Δd	diametral displacement of the borehole wall	mm
Δp	change of the applied pressure	MPa
ε_v	volumetric strain	—
ε_r	radial strain	—
ν	Poisson's ratio	—

5 Equipment

5.1 General

The self-boring pressuremeter equipment is shown in operation in Figure 1.



Key

1	CU	9	hollow probe body
2	acquisition, display and storage of the data	10	self-boring head
3	depth measurement system	11	power supply for the cutter drive unit (if required)
4	connecting lines	12	cutter drive unit (if required)
5	handling rods	13	flushing or jetting fluid supply
6	cutter drive rods (if required)	14	pressure source for expansion
7	probe to rod coupling	15	ground
8	central measuring cell	*z*	test depth

Figure 1 — Schematic diagram of the self-boring pressuremeter equipment

The CU includes:

— equipment to pressurize and so to inflate the probe;

— a device which permits the direct reading and the automatic recording of the parameters to be measured: time, pressure and volume or radial displacement.

The pressure applied to the membrane is measured by one or more electric transducers (see Figure 2). The pressure transducers are located:

— above the ground surface, or

— inside the probe, less than 1 m above the centre of the expanding length.

The displacement transducers for the membrane are located in the centre of the expanding length.

The outside diameter d_{so} of the self-boring pressuremeter when deflated shall normally be the same as that of the cutting shoe d_p.

Use of an oversized cutting shoe shall be reported and taken into account during the analysis of the results.

One or more pore pressure transducers can be located through the membrane in the centre of the expanding length.

It is also necessary to have some means of measuring the depth of the test with appropriate accuracy.

5.2 Self-boring pressuremeter probe

The self-boring pressuremeter probe consists of a hollow core to allow the drill rods (if used) for self-boring operation and carry flush returns to the surface. Flexible hoses and passages are used to inject the proper fluids (gas or liquid) to inflate the central measuring cell whose expansion is monitored by three or more electronic transducers or volume measurement (Figure 2). The probe is fitted with a central cell membrane and may also be fitted with a Chinese lantern protective device to prevent damage from sharp inclusions in the soil. The probe shall be capable of a volumetric expansion of at least 25 % of the initial volume V_0.

The central measuring cell, with an outside diameter d_s and a length l_s, can expand radially in a borehole and apply a uniform pressure to the borehole wall. This central measuring cell shall have a minimum slenderness l_s/d_{so} of 4,0 [7][10]. This cell is inflated by injecting a liquid which is assumed to be incompressible or by gas pressure.

The probe also includes:

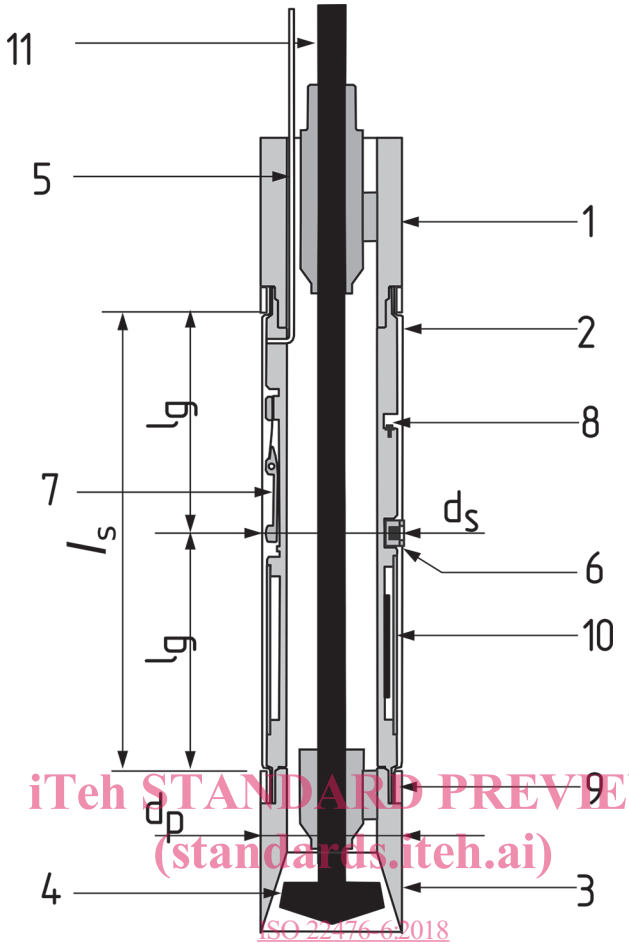
a) The core on its outside curved surface usually bears a pattern of grooves which distribute the liquid in the central cell under the flexible membrane. Over the core is fitted the membrane and the Chinese lantern protective cover. The top of the core is threaded and couples to the string of rods handling the probe from ground level.

b) The central cell membrane isolates the fluid from the space under the Chinese lantern protective cover.

c) Fluid lines connect the probe to the pressure and displacement CU.

d) The expansion of the membrane can be monitored by electric transducers. At least three displacement transducers should be available to monitor the mean surface but also any non-circular deformation of the membrane.

e) The pore pressure in the ground can be monitored by one or more electric transducers placed approximately at mid-height of the expanding length.



Key

1	hollow probe body	7	displacement transducers
2	membrane	8	pressure transducer
3	cutting shoe	9	membrane clamping ring
4	cutting tool	10	electronic signal conditioning
5	pressure line	11	setting and cutter drive rods
6	one pore pressure transducer		

Figure 2 — Example of a self-boring pressuremeter probe

5.3 Self-boring head

The self-boring head is the lower part of the probe with an outside diameter d_p. It has a sharp cutting edge with the taper on the inside and as the probe is steadily and slowly advanced into the ground by pushing, the soil that enters it is cut up and removed to the surface through the interior of the probe body by the action of either (Figure 3):

— a rotating cutter,

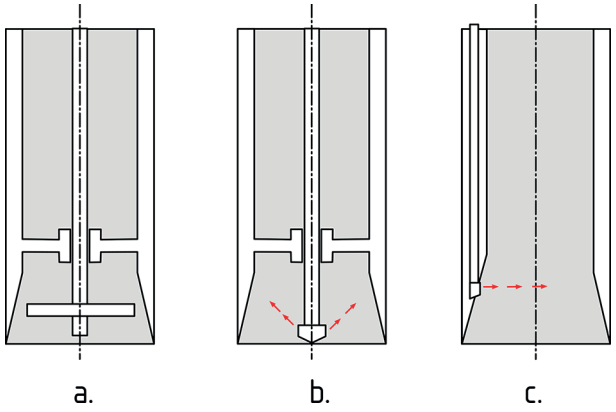
— an upward pressurised water jet, or

— a lateral pressurised water jet.

The rotating cutter can be in a shape of a rock roller bit, a full face cutter, a flat blade or a stirring paddle (disc).

Use of percussion on rotating cutter shall be reported.

To identify the influence of tool wear on SBP tests, it may be appropriate to check and report the status of the initial and final wear of the tool and/or shoe. For this purpose, the dimensions of the tools at the beginning and end of the drilling can be measured, where feasible, and reported (according to ISO 22476-15). The change or replacement of any equipment shall be reported as well.



Key

a. rotating cutter
b. upward pressurised water jets
c. lateral pressurised water jets

Figure 3 — Self-boring head

The distance h between the cutting tool or the nozzle and the cutting edge is a function of the nature of the soil (Figure 4) as defined in Annex B.

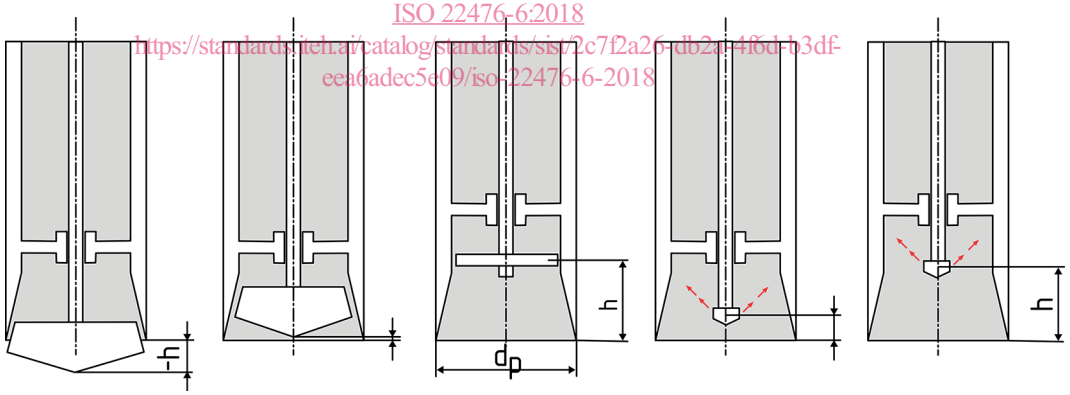


Figure 4 — Distance between the cutting tool and the cutting edge

When the ground becomes stiffer a lower value of h is used (see Annex B). For hard soils and soft rocks, a negative value of h may be used, hence the rotating tool protubing from the cutting edge. The tool shall not be entirely outside of the cutting shoe.

NOTE The influence of ratio h/d_p is highlighted in References [7],[8] and[9].

5.4 Pressure and displacement CU

The pressure and displacement CU permits the reading of liquid or gas pressure and displacement as a function of time and controls the probe expansion and contraction. The pressure may be controlled manually or automatically.