
**Geotechnical investigation and
testing — Field testing —**

**Part 11:
Flat dilatometer test**

*Reconnaissance et essais géotechniques — Essais en place —
Partie 11: Essai au dilatomètre plat*





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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 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.

ISO 22476-11 was prepared by the European Committee for Standardization (CEN) Technical Committee CEN/TC 341, *Geotechnical investigating and testing*, in collaboration with ISO Technical Committee TC 182, *Geotechniques*, in accordance with the agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This first edition of ISO 22476-11 cancels and replaces ISO/TS 22476-11:2005, which has been technically revised.

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

Geotechnical investigation and testing — Field testing —

Part 11: Flat dilatometer test

1 Scope

This document establishes guidelines for the equipment requirements, execution of and reporting on flat dilatometer tests.

NOTE This document fulfils the requirements for flat dilatometer tests as part of the geotechnical investigation and testing according to EN 1997-1 and EN 1997-2.

The basic flat dilatometer test consists of inserting vertically into the soil a blade-shaped steel probe with a thin expandable circular steel membrane mounted flush on one face and determining two pressures at selected depth intervals: the contact pressure exerted by the soil against the membrane when the membrane is flush with the blade and, subsequently, the pressure exerted when the central displacement of the membrane reaches 1,10 mm.

Results of flat dilatometer tests are used mostly to obtain information on soil stratigraphy, *in situ* state of stress, deformation properties and shear strength. It is also used to detect slip surfaces in clays. The flat dilatometer test is most applicable to clays, silts and sands, where particles are small compared to the size of the membrane.

2 Normative references

There are no normative references in this document.

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 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>

3.1.1

dilatometer blade

dilatometer probe

blade-shaped steel probe that is inserted into the soil to perform a flat dilatometer test

3.1.2

membrane

thin circular steel diaphragm that is mounted flush on one face of the blade and is expanded by applying a gas pressure at its back

3.1.3

switch mechanism

apparatus housed inside the blade, behind the membrane, capable of switching on and off an electric contact when the membrane expands and reaches two preset deflections equal, respectively, to 0,05 mm (*A-pressure* (3.1.10) reading) and 1,10 mm (*B-pressure* (3.1.11) reading)

3.1.4

signal

activation (signal on) or disconnection (signal off) by the switch mechanism between the blade and the membrane to detect two preset positions of the membrane equal to 0,05 mm and 1,10 mm

3.1.5

pneumatic-electric cable

cable that connects the control unit to the blade, delivers gas pressure at the back of the membrane and provides electric continuity between the control unit and the switch mechanism

3.1.6

control and calibration unit

set of suitable devices capable of supplying gas pressure to the back of the membrane and measuring the pressure when the switch mechanism activates and disconnects the electric contact behind the membrane

3.1.7

earth wire

wire connecting the control unit to the earth

3.1.8

pressure source

pressurized gas tank filled with any dry non-flammable and non-corrosive gas incorporating a pressure regulator

3.1.9

dilatometer sounding

sequence of dilatometer tests executed from the same station at ground level in a vertical direction at closely spaced intervals with depth increments ranging from 100 mm to 300 mm

3.1.10

A-pressure

A

pressure that is applied to the back of the membrane to expand its centre 0,05 mm against the soil

3.1.11

B-pressure

B

pressure that is applied to the back of the membrane to expand its centre 1,10 mm against the soil

3.1.12

C-pressure

C

pressure that is applied to the back of the membrane when the centre of the membrane returns to the A-pressure position during a controlled, gradual deflection following the B-pressure

3.1.13

A-membrane-calibration-pressure

ΔA

suction recorded as a positive value that is applied to the back of the membrane to retract its centre to the 0,05 mm deflection in air

3.1.14**B-membrane-calibration-pressure** ΔB

pressure that is applied to the back of the membrane to expand its centre to the 1,10 mm deflection in air

3.1.15**zero gauge value** Z_M

pressure gauge deviation from zero when venting the blade to atmospheric pressure

3.1.16**<A> soil pressure** p_0

corrected *A*-pressure ([3.1.10](#))

Note 1 to entry: The term “contact pressure” is also used.

3.1.17** soil pressure** p_1

corrected *B*-pressure ([3.1.11](#))

3.1.18**<C> soil pressure** p_2

corrected *C*-pressure ([3.1.12](#))

3.1.19***in situ* pore water pressure** u_0

water pressure prior to blade insertion at the depth of the centre of the membrane

3.1.20***in situ* effective vertical stress** σ'_{v0}

vertical stress prior to blade insertion at the depth of the centre of the membrane

3.1.21**dilatometer material index** I_D

index used to classify soils according to their response to the test

3.1.22**dilatometer
horizontal stress
index** K_D

index related to the *in situ* horizontal stress

3.1.23**dilatometer modulus** E_D

parameter related to the stiffness of the soil

3.1.24**pore pressure index** U_D

index related to the permeability of the soil

3.1.25

contraflexure time

t_{flex}

time corresponding to the inflection point of a dissipation curve

3.2 Symbols

Symbol	Name	Unit
E_D	dilatometer modulus	kPa
I_D	dilatometer material index	—
K_D	dilatometer horizontal stress index	—
U_D	pore pressure index	
A	A-pressure	kPa
B	B-pressure	kPa
C	C-pressure	kPa
p_0	corrected A-pressure	kPa
p_1	corrected B-pressure	kPa
p_2	corrected C-pressure	kPa
t_{flex}	contraflexure time	s
u_0	<i>in situ</i> pore pressure	kPa
Z_M	zero gauge value	kPa
ΔA	A-membrane-calibration-pressure	kPa
ΔB	B-membrane-calibration-pressure	kPa
σ'_{v0}	<i>in situ</i> effective vertical stress	kPa

4 Equipment

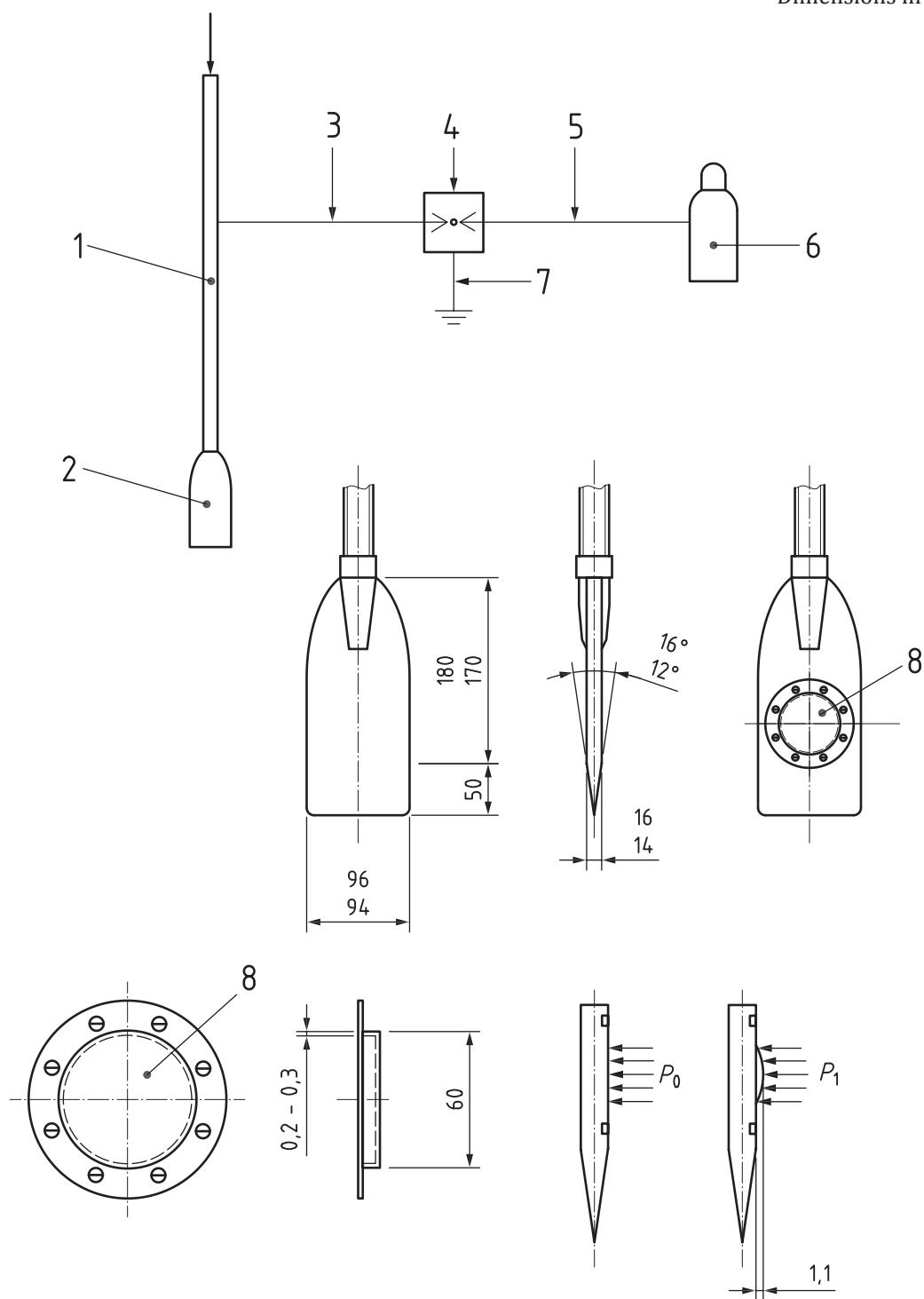
4.1 Dilatometer equipment

The equipment shall comprise the following items:

- dilatometer blade with suitable threaded adaptor to connect to push rods;
- membrane;
- control and calibration unit;
- pressure source;
- pneumatic-electrical cable;
- earth wire;
- calibration syringe;
- (optional) automated data acquisition system;
- (optional) load cell.

The dimensions of the blade, the membrane and the apex angle of the penetrating edge shall be within the limits shown in [Figure 1](#).

Dimensions in millimetres



Key

- | | | |
|----------------------------|--------------------------------------|--------------|
| 1 push rods | 4 control and calibration cable unit | 7 earth wire |
| 2 blade | 5 pressure tube | 8 membrane |
| 3 pneumatic electric cable | 6 pressure source | |

Figure 1 — Dilatometer equipment and soil pressure definition

The control and calibration unit shall have the following features:

- a socket for earthing;
- ability to control the rate of gas flow while monitoring and measuring the gas pressure transmitted from the control unit to the membrane;
- ability to perform controlled venting of the pneumatic circuit;
- ability to signal the instants when the electric switch changes from on to off and vice versa;
- pressure measurement devices able to determine the pressure applied to the membrane with intervals of 10 kPa and a reproducibility of 2,5 kPa at least for pressures lower than 500 kPa;
- pressure gauges having an accuracy of at least 0,50 %.

The pressure source shall be provided with a suitable regulator, valves and pressure tubing to connect to the control unit. The pressure regulator should not exceed the maximum allowable pressure of the gage.

The pneumatic-electrical cable shall have metal connectors with wire insulators to prevent short circuit and washers to prevent gas leakage.

The calibration syringe is used for calibration of membrane rigidity, at the beginning and at the end of the test.

If the equipment incorporates a system for automatic data acquisition, such system will

- register the gas pressure and the status of the electroacustical signal,
- have transducers with linearity and hysteresis error of no more than $\pm 0,50$ %,
- have an analog-to-digital conversion of at least 14 bit, and
- have an acquisition frequency of no less than 50 Hz.

4.2 Insertion apparatus

The equipment for inserting the dilatometer blade shall comprise

- a thrust machine to insert and advance the dilatometer blade into the soil;
- push rods with suitable adaptor to connect to the blade;
- hollow slotted adaptors for lateral exit of the pneumatic-electrical cable.

The thrust machine shall be capable of advancing the blade vertically with no significant horizontal or torsional forces. Drill rigs and CPT/CPTU rigs are frequently employed for the purpose. To increase the capacity of penetration, suitable dead loads and/or anchors may be used.

Push rods are required to transfer the thrust from the surface insertion equipment and shall be straight and resistant against buckling. Rods are also required to carry the pneumatic-electrical cable from the surface control unit to the dilatometer blade. It is recommended to use rods of 1 m length. Above the ground level, the rods should be guided to avoid buckling.

Frequently, push rods are the same as those used to push CPT/CPTu (see ISO 22476-1:2012) but other solutions are also possible.

To release the system of friction against the rods during the penetration phase, friction reducers may be used. Friction reducers are local increases in rod diameter. They are usually located in the first rod attached to the blade and shall be at least 200 mm above the membrane centre.

Penetration rates in the range of 10 mm/s to 30 mm/s should be applied, wherever it is possible. Driving may be used when advancing the blade through stiff or strongly cemented layers which cannot be penetrated by static push.

A suitable load cell may be placed between the blade and the push rods. Such cell would measure the thrust applied during the blade penetration. This measurement is not necessary for common interpretations of the test result but it may facilitate interpretation when using both DMT and CPT soundings on a site.

5 Test procedure

5.1 Maintenance and checks

All the control, connecting and measuring devices shall be periodically checked, at least once per year. In addition, measuring devices shall be periodically calibrated against a suitable reference instrument to ensure that they provide reliable and accurate measurements.

The parts of the instrument inside the membrane shall be kept perfectly clean to ensure proper electrical contacts. In particular, these components shall be completely free from dirt, grains, tissue or rust.

The dilatometer blade and membrane shall be checked before penetrating in the soil. The blade shall be mounted axially with the rods. It shall be planar and coaxial and have a sharp penetration edge. The membrane shall be clean of soil particles, free of any deep scratches, wrinkles or dimples and expand smoothly in air upon pressurization.

The maximum out of plane deviation of the blade, defined as the maximum clearance under a 150 mm long straight edge placed along the blade parallel to its axis, shall not exceed 0,5 mm; the maximum coaxiality error of the blade, defined as the deviation of the penetration edge from the axis of the rods to which the blade is attached, shall not exceed 1,5 mm.

The blade, the control unit and the pneumatic-electrical cable shall be checked for leaks before starting a sequence of dilatometer soundings by plugging the blade end of the pneumatic-electrical cable and checking for any pressure drop in the system. Leakage in excess of 100 kPa/min under 400 kPa pressure shall be considered unacceptable and shall be repaired before testing begins.

Continuity of the electrical circuit shall be checked, verifying that the off-on switch signal is sharply detected.

With the dilatometer equipment assembled and ready for testing, the switch mechanisms should be checked by hand pushing the membrane flush with the blade verifying that the audio and/or visual signals on the control unit are activated.

Before the test is carried out, the linearity of the push rods should be checked by one of the following methods:

- Holding the rod vertically and rotating it. If the rod appears to wobble, the straightness is not acceptable.
- Rolling the rods on a plane surface. If the rod appears to wobble, the straightness is not acceptable.
- Sliding a straight hollow tube which is slightly longer than the rod over the rod. If the rod can pass through the tube without jamming, the straightness is acceptable.

If any indications of bending appear, the use of the rods should be suspended.

Other methods of checking rod straightness may be used if they consistently result in similar results to those suggested above.

5.2 Membrane calibration procedure

Membrane calibration consist of measuring the values ΔA (suction) and ΔB (pressure) that correspond respectively to the external pressure which must be applied to the membrane, in free air, to collapse it against its seating and to the internal pressure which, in free air, lifts the membrane centre 1,10 mm from its seating.

Suction and pressure for membrane calibration should be imposed using the calibration syringe.

During calibration, the signal activated by the electric switch shall be identified unambiguously at the moment of the readings.

Membrane calibration shall be performed with the dilatometer equipment assembled and ready for testing immediately before inserting the blade into the soil and upon retrieval to the ground surface, both when running a dilatometer sounding or even a single test.

If the values of the membrane calibration pressures ΔA and ΔB , obtained before penetrating the blade into the soil, fall outside the limits $\Delta A = 5 \text{ kPa}$ to 30 kPa and $\Delta B = 5 \text{ kPa}$ to 80 kPa respectively, the membrane shall be replaced before testing.

After a membrane has been replaced, the new one shall be exercised to improve the stability of the ΔA and ΔB values. Such exercising shall consist in pressurizing five times the membrane in air to 400 kPa for a few seconds. Care shall be taken to avoid overexpansion and permanent deformations of the membrane.

After any membrane calibration, the values of ΔA and ΔB shall be promptly recorded. All the obtained values of ΔA and ΔB shall be available on site.

5.3 Flat dilatometer test

5.3.1 Operations before testing

The operator shall perform all the checks described in [5.1](#).

The pneumatic-electric cable connected to the blade shall be pre-threaded through the push rods. In some circumstances, it may be taped to the rod every 1 m after using a slotted adaptor to egress it.

The operator shall record the zero of the pressure gauge Z_M , with the gauge vented to the atmosphere.

The pressure source shall be connected to the control unit. It is recommended that the initial pressure level in the pressurizing circuit is set close to 3 MPa . This pressure may be later increased, if required, to take the A and B readings.

The earth wire should be connected to the control unit and properly earthed.

The operator shall perform a membrane calibration as described in [5.2](#).

5.3.2 Basic test procedure

On a DMT sounding, the test depth interval shall be typically of 200 mm . Smaller depth intervals (no less than 100 mm) may be prescribed to obtain a more detailed soil profile.

The blade shall be inserted vertically into the soil and advanced to the selected test depth. During the insertion, the electrical switch signal shall be on.

After reaching the selected test depth, the load applied to the push rods shall be released and the blade pressurized without delay to expand the membrane.

The gauge pressure at the time the acoustic or electrical signal stops is A . The gauge pressure at the time the signal resumes is B .

The pressurization rate shall be such that the A-pressure reading shall be obtained within approximately 15 s from reaching the test depth and the B-pressure reading within approximately 15 s after the A-reading. As a consequence, the rate of pressure increase shall be very slow in weak soils and faster in stiff soils.

Unless a C-pressure reading is acquired, the membrane shall be depressurized immediately after *B* has been determined, finishing the basic test procedure. The blade is then advanced to the next test depth or retrieved to the ground surface.

5.3.3 C-pressure readings

C-pressure readings may be taken as an extra measurement to aid in test interpretation.

To obtain C-pressure readings, the operator shall release the pressure slowly after the B-pressure reading and wait (approximately 30 s) until the pressure drops approaching the zero of the gauge. The C-pressure reading is obtained when the electrical signal resumes.

5.3.4 Operations after testing

After the blade has been retrieved to the ground surface, a membrane calibration procedure, according to [5.2](#), shall be performed again. The values of ΔA and ΔB shall be recorded and compared with those obtained before testing. If the values of ΔA and ΔB measured before inserting the blade into the soil and after retrieval to the ground surface differ by more than 25 kPa, then the sounding shall be discarded.

Immediately after the blade has been retrieved to the ground surface, any relevant sounding characteristics (water level, collapse depth; see [Clause 7](#)) shall be noted.

5.4 DMT dissipation test (DMTA)

DMT dissipation tests may be carried out at selected depths. A DMT dissipation test consists of stopping the blade at a given depth, then taking a timed sequence of A-pressure readings.

During the dissipation test, only the A-reading shall be taken, never expanding the membrane beyond the A-pressure position.

The time origin ($t = 0$) shall be the instant at which pushing is stopped. Then, without delay, the DMT operator shall slowly inflate the membrane to take the first A-reading. As soon as *A* is reached, the operator shall deflate the membrane and record the instant of this reading, together with the A-value.

The DMT operator shall continue to take additional A-readings to obtain reasonably spaced data points for a time-pressure curve. A factor of 2 increase in time at each A-reading shall be satisfactory (e.g. 0,5 min, 1 min, 2 min, 4 min, 8 min, 15 min, 30 min, etc. after stopping the blade). For each A-reading, the operator shall record the exact stopwatch time (which shall not necessarily coincide with the above values).

The time-dissipation curve shall be plotted as the A-pressure versus the log of the elapsed time for each reading. This curve shall normally assume an S-shape. For ease of interpretation, the dissipation test should not be stopped before the curve has flattened sufficiently to find its inflection point, t_{flex} .

5.5 DMT short dissipation test (DMTA-s)

Partially drained behaviour during the basic test procedure may be possible if test readings show I_D values below 0,2 and the soil contains a significant silt fraction. A shortened version of the dissipation test, DMTA-s, lasting only 1 min, may be performed to obtain an indication of partially drained conditions. If the A-readings show significant change (above 10 %) in the first 0,5 min of the test, partial drainage is likely. In those cases, usual test interpretation procedures are not valid and special corrections should be applied to the basic test procedure [\[6\]](#).

5.6 Safety requirements

National safety regulations shall be followed, e.g. regulations for

- personal health and safety during test execution,
- clean air, if working in confined spaces, and
- others that may be deemed relevant for the operation.

6 Test results

Results from a flat dilatometer test include primary and calculated results.

Primary test results comprise the pressures measured in the test corrected as follows.

The soil B-pressure shall be corrected to obtain the p_1 pressure using [Formula \(1\)](#):

$$p_1 = B - \Delta B - Z_m \quad (1)$$

The soil A-pressure p_0 shall be corrected to obtain the p_0 pressure using [Formula \(2\)](#):

$$p_0 = 1,05 (A + \Delta A - Z_m) - 0,05 p_1 \quad (2)$$

If measured, the soil C-pressure shall be corrected to obtain the p_2 pressure using [Formula \(3\)](#):

$$p_2 = C + \Delta A - Z_m \quad (3)$$

Calculated test results are the material index, I_D , the horizontal stress index, K_D , the dilatometer modulus, E_D and the pore pressure index, U_D . They shall be calculated using [Formulae \(4\) to \(7\)](#):

$$I_D = (p_1 - p_0) / (p_0 - u_0) \quad (4)$$

$$K_D = (p_0 - u_0) / \sigma'_{v0} \quad (5)$$

$$E_D = 34,7 (p_1 - p_0) \quad (6)$$

$$U_D = (p_2 - p_0) / (p_2 - u_0) \quad (7)$$

The calculated results of flat dilatometer tests require a knowledge of the *in situ* pore water pressure u_0 and the effective vertical stress σ'_{v0} prior to blade insertion. The value of u_0 at any test depth may be estimated from the location of the local water table, but shall be preferably determined from reliable pore water pressure measurements. In free-draining soils, a profile of C-pressure readings can also be used for this purpose. The value of σ'_{v0} at any test depth shall be estimated from the unit weight of the soil layers above that depth and the *in situ* pore pressure at the test depth. An estimate of the unit weight may be obtained from the DMT measures using appropriate correlations (see [Annex A](#)).

Primary and calculated test results can be interpreted using well-established correlations to determine the subsoil stratigraphy, the *in situ* state of stress, the strength and stiffness of soils. [Annex A](#) recalls some of these correlations.

When interpreting the results of flat dilatometer tests, the values of p_0 , p_1 , u_0 and σ'_{v0} shall correspond consistently to the same test location and membrane depth.

7 Report

7.1 General

The test results shall be reported to enable a third party to check and understand the results.

In the presentation of test results, the information should be easily accessible, for example, in tables or as a standard archive scheme. Presentation in digital form is permissible for easier data exchange.

[7.2](#) gives the information required in

- the field data sheets,
- the campaign report, and
- every sounding plot and table included in the campaign report.

The field data sheets shall be filled in as each sounding is undertaken and shall be filled in at the project site before the personnel and equipment are demobilized. During testing, any particulars or deviations from this document should be recorded. The campaign report shall include all the soundings, including tables and plots, and shall provide an overview of the site work, a description of the procedures adopted and all the information given in [7.2](#).

7.2 Reporting of test results

The following test reporting procedure is applicable to a dilatometer sounding in which flat dilatometer tests have been performed as described in [5.3](#). Reporting of dissipation tests ([5.4](#)) should follow the general principles given in [7.1](#).

7.2.1 General information

	Field data sheets	Campaign report	Every sounding plot and table
a Reference to this document	—	x	x
b Particulars or deviations from this document	x	x	—
c Company executing the test	—	x	x
d Name and signature of equipment operator executing the test	x	—	—
e Name and signature of field manager responsible for the project	—	x	—
f Groundwater elevation or other information used to estimate <i>in situ</i> water pressure for each DMT test	—	x	x
g Depth of pre-drilling (include method of drilling and any fluid used) casing or trenching, if applicable	x	x	—
h Type of materials encountered, if possible	x	x	—
i Depth of penetration and possible causes of interruptions (equipment breakdown, etc.)	x	x	x
j Stop criteria applied such as target depth, maximum thrust force/hard stratum	x	x	—

	Field data sheets	Campaign report	Every sounding plot and table
k Method of backfilling the hole, if applicable	x	—	—
l Observations made during the sounding, such as weather conditions, presence of stone, noise from push rods, incidents, buckled rods, significant changes in zero or reference settings, and other notable features which may affect the values recorded or the interpretation of the test data or the local <i>in situ</i> stresses	x	x	—
m Specific arrangements that deviate from the common setup of a thrust machine	x	x	—

7.2.2 Location of sounding

	Field data sheets	Campaign report	Every sounding plot and table
a Identification number of the sounding	x	x	x
b Elevation of the sounding	—	x	x
c Local or general coordinates of the sounding	x	x	x
d Reference system and tolerances	—	x	—

The contract shall specify who is responsible for providing the coordinates and levels of the investigation points.

7.2.3 Test equipment

	Field data sheets	Campaign report	Every sounding plot and table
a Geometry and dimensions of the dilatometer, as measured	x	—	—
b Type of thrust machine used, pushing capacity, associated jacking and anchoring systems	x	x	—
c Manufacturer of the dilatometer	x	x	—
d Identification number of the dilatometer	x	x	—
e Measuring range of the pressure gauges and zero offset when vented	x	x	—
f ΔA and ΔB blade calibrations (corrected for Z_m), before, during (as obtained), and after each sounding	x	x	x
g Type, diameter and linear weight of penetration rods	—	x	—
h Rod friction breaker diameter	x	x	—

7.2.4 Test procedure

	Field data sheets	Campaign report	Every sounding plot and table
a Date of sounding	x	x	x
b Start time of sounding	x	x	—
c Depth of each test with reference to the ground surface	x	x	x
d Orientation of the blade when sounding	x	—	—
e Method used to estimate total vertical stresses and pore pressure	—	x	—

7.2.5 Test results

	Field data sheets	Campaign report	Every sounding plot and table
a Tabulated output of the values A-, B- and (optional) C-pressure readings)	x	x	x
b Corrected test readings p_0 , p_1 , and (optional) p_2	x	x	x
c Estimated bulk specific gravity or unit weight of soil	x	x	x
d Estimated total vertical stress, <i>in situ</i> water pressure, and effective vertical stress	x	x	x

7.3 Presentation of results

All measured and calculated values of results should be presented graphically as profiles against depth.

In the graphical presentation of test results, the following axis scaling should be used:

— Penetration depth z :	1 scale unit = 1 m
— A and B (C optional)	1 scale unit = 400 kPa
— Corrected pressures p_0 , p_1 , and (optional) p_2	1 scale unit = 400 kPa
— <i>In situ</i> stresses (total, effective, pore water pressure)	1 scale unit = 100 kPa
— DMT material index, I_D	1 scale unit = 1/10 of Log_{10} scale
— DMT horizontal stress index, K_D	1 scale unit = 2,0
— DMT modulus, E_D	1 scale unit = 5,0 bar
— DMT pore pressure index, U_D	1 scale unit = 0,1

Different scaling may be used in the presentation if the recommended scaling is used in an additional plot. The recommended scaling can, for example, be used for general presentation, whereas selected parts may be presented for detailed studies, using a different scaling.

At least one graph should present side by side plots of corrected pressures (p_0, p_1, p_2), I_D , K_D E_D , against depth to assist in developing an understanding of the site.

If interpreted results are presented, the relations used for that interpretation should be clearly indicated, sourced and/or justified within the report.

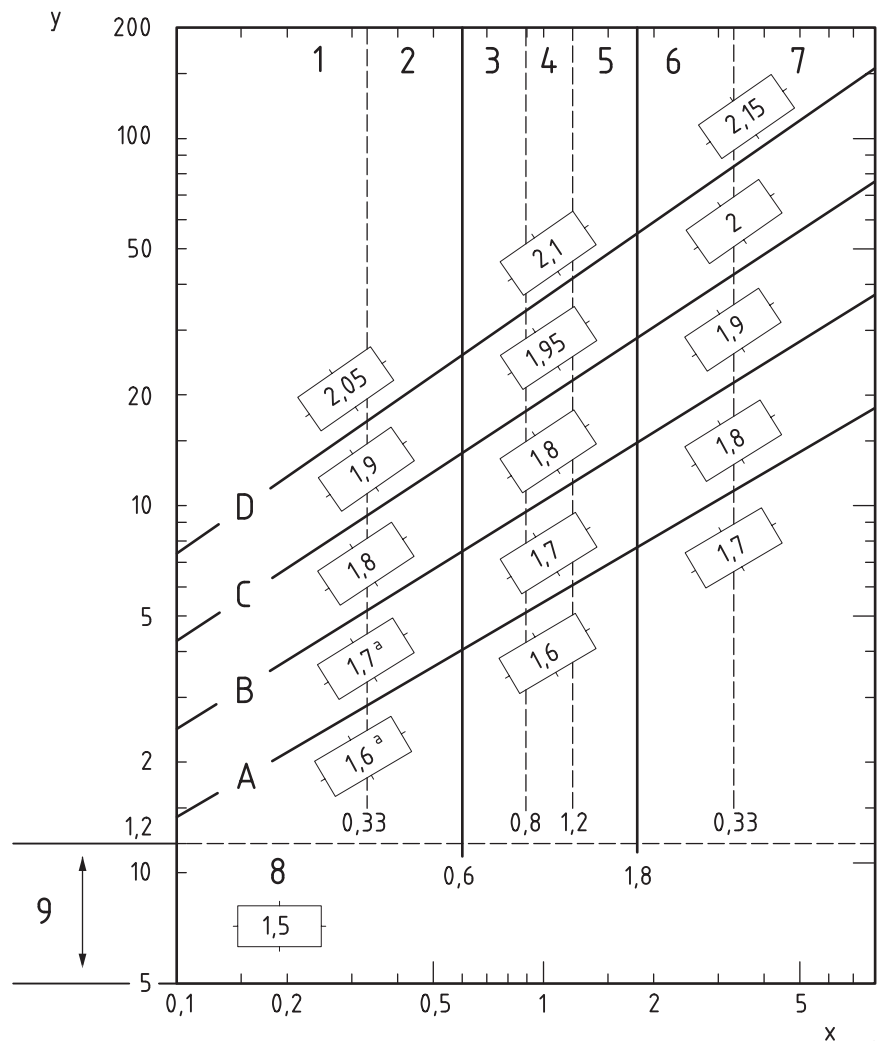
Annex A (informative)

Example interpretation formulae

Interpretation of DMT results in terms of different soil properties is based on a mixture of empirical and theoretical analysis. The nature of the soils being tested is the major factor affecting such interpretation. For non-cemented soils, [Table A.1](#) collects some widely accepted soil property correlations[4][5]. These correlations are included by way of example. Other correlations are available and may be more appropriate for a given test site.

Table A.1 — DMT interpretation formulae

Symbol	Description	Basic DMT reduction formula	
K_0	Coefficient of earth pressure at rest	$K_{0,DMT} = (0,5K_D)^{0,47-0,6}$	For $I_D < 1,2$
OCR	Overconsolidation ratio	$OCR_{DMT} = (0,5K_D)^{1,56}$	For $I_D < 1,2$
c_u	Undrained shear strength	$c_{u,DMT} = 0,22\sigma'_{v0}(0,5K_D)^{1,25}$	For $I_D < 1,2$
ϕ	Friction angle	$\phi_{safe,DMT} = 28^\circ + 14,6^\circ \log K_D - 2,1^\circ \log^2 K_D$	For $I_D > 1,8$
c_h	Horizontal coefficient of consolidation	$c_{h,DMT} \approx 7 \text{ cm}^2 / t_{flex}$	t_{flex} from A-log t DMT-A decay curve
k_h	Horizontal coefficient of permeability	$k_h = c_h \gamma_w / M_h$ ($M_h \approx K_0 M$)	
γ	Unit weight and description	(see Figure A.1)	
M	Vertical drained constrained modulus	$M_D = R_M E_D$ If $I_D \leq 0,6$ $R_M = 0,14 + 2,36 \log K_D$ If $I_D \geq 3$ $R_M = 0,5 + 2 \log K_D$ If $0,6 < I_D < 3$ $R_M = R_{M,0} + (2,5 - R_{M,0}) \log K_D$ with $R_{M,0} = 0,14 + 0,15(I_D - 0,6)$ If $I_D > 10$ $R_M = 0,32 + 2,18 \log K_D$ If $R_M < 0,85$ Set $R_M = 0,85$	



Key			
x	material index I_D	3	clayey silt
y	dilatometer modulus, E_D (bar)	4	silt
1	clay	5	sandy silt
2	silty clay	6	silty sand
		7	sand
		8	mud
		9	mud and/or peat
		a	If $PI > 50$, reduce E_D by 10 %.

Figure A.1 — Soil description and estimated γ/γ_w

The formula of the lines: $E_D = 10^{(n + m \log I_D)}$.

	m	n
A	0,585	1,737
B	0,621	2,013
C	0,657	2,289
D	0,694	2,564

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