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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

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ISO/TS 22476-11 was prepared by Technical Committee ISO/TC 182, *Geotechnics*, Subcommittee SC 1, *Geotechnical investigation and testing*.

ISO/TS 22476 consists of the following parts, under the general title *Geotechnical investigation and testing — Field testing*:

— *Part 1: Electrical cone and piezocone penetration tests*

— *Part 2: Dynamic probing*

— *Part 3: Standard penetration test*

— *Part 4: Ménard pressuremeter test*

— *Part 5: Flexible dilatometer test*

— *Part 6: Self-boring pressuremeter test*

— *Part 7: Borehole jack test*

— *Part 8: Full displacement pressuremeter test*

— *Part 9: Field vane test*

— *Part 10: Weight sounding test*

— *Part 11: Flat dilatometer test*

— *Part 12: Mechanical cone penetration test*

— *Part 13: Plate loading test*

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Foreword

This document CEN ISO/TS 22476-11:2004 has been prepared by Technical Committee CEN/TC 341 “Geotechnical investigation and testing”, the secretariat of which is held by DIN, in collaboration with Technical Committee ISO/TC 182 “Geotechnics”.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to announce this Technical Specification: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.

EN ISO 22476 *Geotechnical investigation and testing - Field testing* has the following parts:

- Part 1: Electrical cone and piezocone penetration tests
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- Part 5: Flexible dilatometer test
- Part 6: Self-boring pressuremeter test (TS)[1)]
- Part 7: Borehole jack test
- Part 8: Full displacement pressuremeter test (TS) [1)]
- Part 9: Field vane test
- Part 10: Weight sounding test (TS)[1)]
- Part 11: Flat dilatometer test (TS)[1)]
- Part 12: Mechanical cone penetration test
- Part 13: Plate loading test.

1) TS Technical Specification.

Introduction

The flat dilatometer test covers the determination of the in situ strength and deformation properties of fine grained soils using a blade shaped probe having a thin circular steel membrane mounted flush on one face.

Results of flat dilatometer tests are mostly to obtain information on soil stratigraphy, in situ state of stress, deformation properties and shear strength.

The basis of the 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, at selected depths or in a semi-continuous manner, 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 membane reaches 1,10 mm.

The flat dilatometer test is most appropriate in clays, silts and sands where particles are small compared to the size of the membrane.

1 Scope

This Technical Specification comprises requirements for ground investigations by means of the flat dilatometer test (DMT) as part of the geotechnical investigation services according to prEN 1997-1 and prEN 1997-2.

2 Normative references

Not applicable.

3 Terms and definitions

For the purposes of this Technical Specification, the following terms and definitions apply

3.1
dilatometer blade (dilatometer probe)
blade –shaped steel probe that is inserted into the soil to run a flat dilatometer test

3.2
membrane
circular steel membrane that is mounted flush on one face of the blade and is expanded when applying a gas pressure at its back

3.3
switch mechanism
apparatus housed inside the blade, behind the membrane, capable of activating and disconnecting an electric contact which in turn sets on and off an audio and/or visual signal when the membrane expands and reaches two preset deflections equal to 0,05 mm and 1,10 mm respectively

3.4
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

3.5
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

3.6
earth wire
wire connecting the control unit to the earth

3.7
pressure source
pressurized gas tank filled with any dry nonflammable and noncorrosive gas

3.8
membrane calibration
procedure to determine the membrane calibration pressure equal to the suction and the pressure that is applied in air to the back of the membrane to retract its centre to 0,05 mm expansion or to expand it to 1,10 mm respectively

3.9
dilatometer profiling
execution of a sequence of dilatometer tests from the same station at ground level along a vertical direction at closely spaced intervals with depth increments ranging between 150 mm and 300 mm

3.10
A-pressure
pressure (P_A) that is applied to the back of the membrane to expand its centre 0,05 mm in soil

3.11
B-pressure
pressure (P_B) that is applied to the back of the membrane to expand its centre 1,10 mm in soil

3.12
A-membrane-calibration-pressure
suction, (Δp_A) recorded as a positive value, that must be applied to the back of the membrane to retract its centre to the 0,05 mm deflection in air

3.13
B-membrane-calibration-pressure
pressure (Δp_B) that must be applied to the back of the membrane to expand its centre to the 1,10 mm deflection in air

3.14
$\Delta p_{A;\ avg}$ and $\Delta p_{B;avg}$
averaged values of the membrane calibration pressure obtained from the respective values of ΔP_A and ΔP_B measured before and after each dilatometer profiling or single dilatometer test

3.15
$Z_{m\ -}$ pressure
gauge pressure deviation from zero when venting the blade to atmospheric pressure

3.16
soil pressure
p_0
soil pressure against the membrane when it is flush with the blade (e.g. at zero expansion), see Figure 1

NOTE The term "contact pressure" is also used.

3.17
soil pressure
p_1
soil pressure against the membrane when its centre is expanded 1,10 mm (see Figure 1)

3.18
in situ pore water pressure prior to blade insertion
u_0
in situ pore water pressure prior to blade insertion at the elevation of the centre of the membrane

3.19
in situ effective vertical stress
σ'_{vo}
vertical stress prior to blade insertion at the elevation of the centre of the membrane

3.20
dilatometer material index
I_{DMT}
index related to the type of soil

3.21
dilatometer horizontal stress index
K_{DMT}
index related to the situ horizontal stress

3.22
dilatometer modulus
E_{DMT}
parameter related from theory to the modulus of elasticity of the soil

4 Equipment

4.1 Dilatometer equipment

The equipment shall comprise of the following items:

— dilatometer blade with suitable threader adaptor to connect to push rods;

— pneumatic-electrical cable;

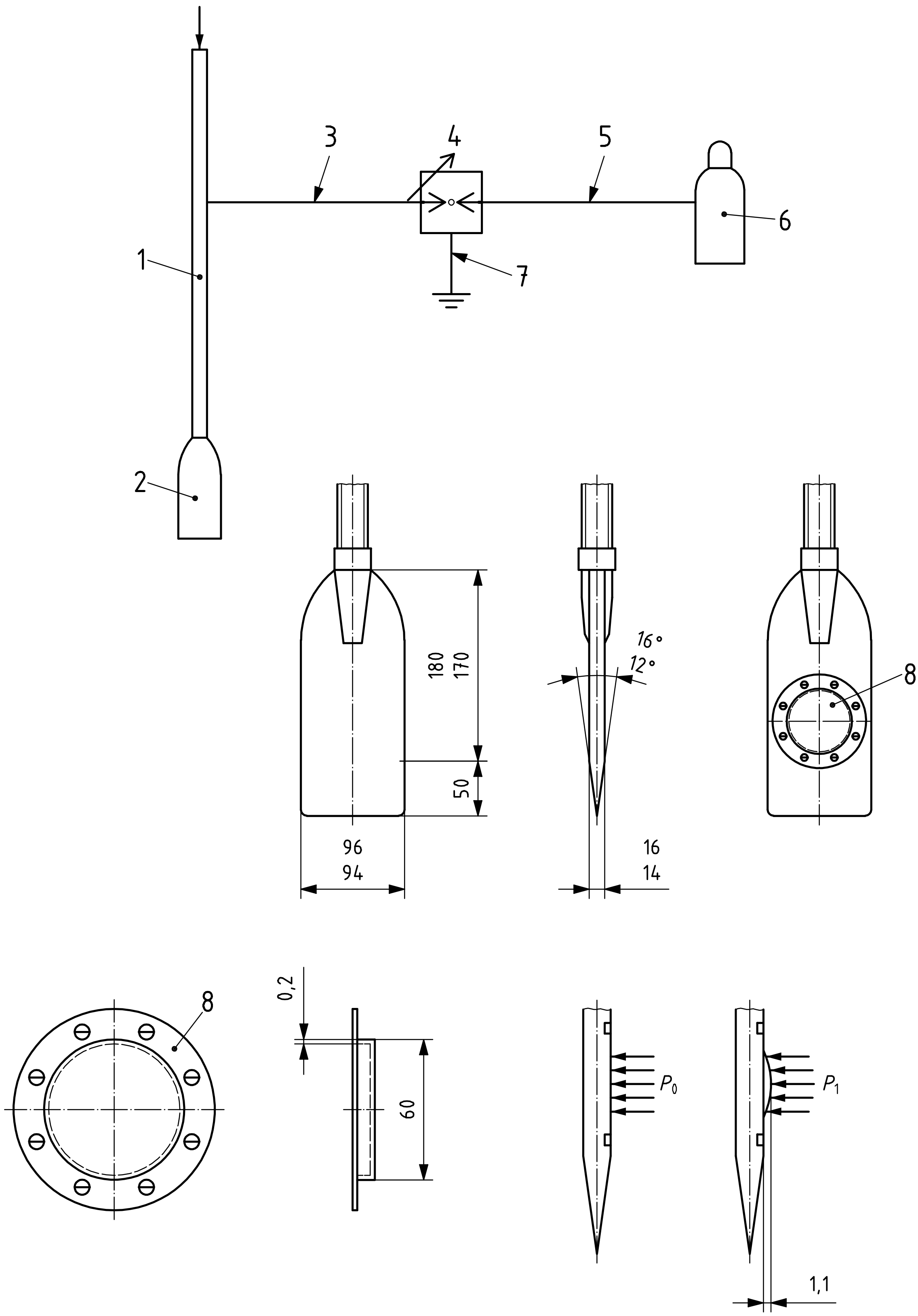
— earth wire;

— control and calibration unit;

— pressure source.

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

Dimensions in millimetres



Key

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

Figure 1 — Dilatometer equipment and definition of calculated in situ soil pressure (all measures in mm)

The pneumatic-electrical cable, which provides pneumatic and electrical continuity between the control unit and the dilatometer blade, shall have stainless steel connectors with wire insulators to prevent short circuit and washers to prevent gas leakage.

The control and calibration unit shall accomplish the following:

— it shall be earthed;

— it shall control the rate of gas flow while monitoring and measuring the pressure of gas transmittted from the control unit to the blade and the membrane;

— it shall signal the instants when the electric switch changes from on to off and vice versa.

The pressure measurement devices of the control and calibration unit shall allow 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.

The pressure source shall be provided with a suitable regulator, valves and pressure tubing to connect to the control unit.

4.2 Insertion apparatus

The equipment for inserting the dilatometer blade shall comprise:

— 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.

Penetration rates in the range of 10 mm/s to 30 mm/s should be applied. Driving should be avoided except when advancing the blade through stiff or strongly cemented layers which cannot be penetrated by static push.

Push rods shall be straight and resistant against buckling.

5 Test procedure

5.1 Calibration and checks

All the control, connecting and measuring devices shall be periodically checked and calibrated against a suitable reference instrument to assure that they provide reliable and accurate measurements.

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 control unit and the tubing shall be checked for leaks before starting a sequence of dilatometer profilings 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 shall be considered unacceptable and shall be repaired before testing begins.

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

5.2 Membrane calibration procedure

The membrane shall be calibrated to measure the values of the ΔP_A -suction and ΔP_B -pressure 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 profiling or even a single test.

If the values of the membrane calibration pressures ΔP_A and ΔP_B, obtained before penetrating the blade into the soil, fall outside the limits ΔP_A = 5 kPa to 30 kPa and ΔP_B = 5 kPa to 80 kPa respectively, the membrane shall be replaced before testing commences.

After a membrane has been replaced, the new one shall be exercised to improve the stability of the ΔP_A and ΔP_B values. Such exercising may consist in pressurizing the membrane in air to 500 kPa for a few seconds. Care should be taken to avoid overexpansion and permanent deformations of the membrane.

After any membrane calibration the values of ΔP_A and ΔP_B shall be promptly recorded. All the obtained values of ΔP_A and ΔP_B shall be available on site.

During calibration the audio and/or visual signal activated by the electric switch shall stop and return sharply and unambiguously while sensing the 0,05 mm and 1,10 mm expansions respectively.

When testing soft soils the membrane calibration procedure shall be performed more than once to assure that stable values of ΔP_A and ΔP_B, falling within the prescribed limits, are constantly determined.

5.3 Performing the test

After the blade has been inserted into the soil and advanced to 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 rate of gas flow to pressurize the membrane shall be such that the P_A- reading is obtained within 20 s from reaching the test depth and the P_B- reading is obtained within 20 s after the P_A- reading.

Once P_B- has been determined the membrane shall be depressurized immediately, in order to prevent further expansion and permanent deformations, and the blade advanced to the next test depth or retrieved to the ground surface.

Depending on the system used to advance the blade, the pneumatic-electric cable connected to the blade shall be pre-threaded through the push rods for protection or left outside, using a slotted adaptor to egress it, and taped to the rod every 1 m.

If a friction reducer is used to limit the thrust needed to advance the blade, it shall be located at least 200 mm above the centre of the membrane.

After the blade has been retrieved to the ground surface and the membrane calibration procedure performed the values of ΔP_A and ΔP_B shall be recorded and compared with those measured previously. If the values of ΔP_A and ΔP_b measured before inserting the blade into the soil and after retrieval to the ground surface differ by more than 25 kPa then the test performed between the two successive calibration procedures shall be discarded.

6 Test results

Results of flat dilatometer tests can be interpreted using well established correlations to determine the subsoil stratigraphy, the deformation properties of cohesionless and cohesive soils, the in situ state of stress and the undrained shear strength of cohesive soils.

The interpretation of the results of flat dilatometer tests requires 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 shall be determined from reliable pore water pressure measurements. 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.

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.

The soil pressure p_1 against the flat dilatometer membrane when its centre is expanded 1,10 mm shall be determined using the following relationship:

$$p_1 = p_B - \Delta P_{B;avg} - Z_m.$$

The soil pressure p_0 against the flat dilatometer membrane when its centre is flush with the blade shall be determined with a linear back extrapolation from the soil pressure against the membrane at the two preset deflections, 0,05 mm and 1,10 mm, hence using the following relationship:

$$p_0 = 1{,}05\ (P_A + \Delta P_{A;avg} - Z_m) - 0{,}05\ p_1.$$

The material index I_{DMT}, the horizontal stress index K_{DMT} and the dilatometer modulus E_{DMT} shall be calculated using the following relationships:

— $I_{DMT} = (p_1 - p_0) / (p_0 - u_0)$

— $K_{DMT} = (p_0 - u_0) / \sigma'_{v0}$

— $E_{DMT} = 34{,}7\ (p_1 - p_0)$

7 Report

7.1 Field report

The field report, signed by the operator in charge, shall contain the field logs and relevant observations made during the tests (weather conditions, interruption of operations, unusual events etc.).

7.2 Test report

In the test report, all DMT field investigations shall be reported about (field report, presentation of results etc.).

In addition the test report shall include the following information for identification and quality assurance purposes:

a) rig and rod types;

b) characteristics of systems used to advance the blade;

c) predrilling depth and system to support the borehole if any;

d) diameter and location of friction reducer if used;

e) thrust applied to the push rods and at the top of the blade if measured;

f) elevation of the groundwater table;

g) procedures to calculate the pore pressure against the membrane at each test elevation;

h) characteristics of the measuring system to obtain the in situ pore pressure when relevant;

i) zero readings of pressure measurement devices;

j) values of the ΔP_A - and ΔP_B -calibration-pressures measured before and after each dilatometer profiling or single test and corresponding average values;

k) tabulated output of values of P_A- and P_B-pressure-readings;

l) tabulated output of the calculated values of p_0- and p_1-pressure;

m) any relevant observation such as incidents, equipment damage during testing, repairs and replacements, details not included in the above list which may affect the interpretation of test results;

n) name and signature of the field manager.

Bibliography

EN 1997-1, *Eurocode 7: Geotechnical design — Part 1: General Rules.*

EN 1997-2, *Eurocode 7: Geotechnical design — Part 2: Ground investigation and testing.*

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