INTERNATIONAL STANDARD

ISO 22476-1

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Geotechnical investigation and testing — Field testing —

Part 1: Electrical cone and piezocone penetration test

Reconnaissance et essais géotechniques — Essais en place —

Partie 1: Essais de pénétration au cône électrique et au piézocône

Reference number
ISO 22476-1:2012(E)

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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.

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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ISO 22476-1 was prepared by the European Committee for Standardization (CEN) Technical Committee CEN/TC 341, *Geotechnical investigation and testing*, in collaboration with Technical Committee ISO/TC 182, *Geotechnics*, Subcommittee SC 1, *Geotechnical investigation and testing*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

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

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

— *Part 2: Dynamic probing*

— *Part 3: Standard penetration test*

— *Part 4: Ménard pressuremeter test*

— *Part 5: Flexible dilatometer test*

— *Part 7: Borehole jack test*

— *Part 9: Field vane test*

— *Part 10: Weight sounding test* [Technical Specification]

— *Part 11: Flat dilatometer test* [Technical Specification]

— *Part 12: Mechanical cone penetration test (CPTM)*

Introduction

The electrical cone penetration test (CPT) consists of pushing a cone penetrometer using a series of push rods into the soil at a constant rate of penetration. During penetration, measurements of cone resistance and sleeve friction are recorded. The piezocone penetration test (CPTU) also includes the measurement of pore pressures around the cone. The test results can be used for interpretation of stratification, classification of soil type and evaluation of engineering soil parameters. Two International Standards define cone penetration tests: ISO 22476-1 defines CPT and CPTU practice using electronic transducers; ISO 22476-12 defines CPT practice using mechanical measuring systems.

“Cone resistance” is the term used in practice and in this part of ISO 22476, although “cone penetration resistance” is a more correct description of the process.

The test results of this part of ISO 22476 are specially suited for the qualitative and/or quantitative determination of a soil profile together with direct investigations (e.g. sampling according to ISO 22475-1 [2]) or as a relative comparison of other *in situ* tests.

The results from a cone penetration test are used to evaluate:

— stratification;

— soil type;

— geotechnical parameters such as

  — soil density,

  — shear strength parameters, and

  — deformation and consolidation characteristics.

Geotechnical investigation and testing — Field testing —

Part 1: Electrical cone and piezocone penetration test

1 Scope

This part of ISO 22476 deals with equipment requirements, the execution of and reporting on electrical cone and piezocone penetration tests.

NOTE 1 This part of ISO 22476 fulfills the requirements for electrical cone and piezocone penetration tests as part of geotechnical investigation and testing according to EN 1997-1 [3] and EN 1997-2 [4].

Within the electrical cone and piezocone penetration test, two subcategories of the cone penetration test are considered:

— electrical cone penetration test (CPT), which includes measurement of cone resistance and sleeve friction;

— piezocone test (CPTU), which is a cone penetration test with the additional measurement of pore pressure.

The CPTU is performed like a CPT with the measurement of the pore pressure at one or several locations on the penetrometer surface.

NOTE 2 CPT or CPTU can also be used without measurement of sleeve friction, but this is not covered in this part of ISO 22476.

This part of ISO 22476 specifies the following features:

a) type of cone penetration test, according to Table 1;

b) application class, according to Table 2;

c) penetration length or penetration depth;

d) elevation of the ground surface or the underwater ground surface at the location of the cone penetration test with reference to a datum;

e) location of the cone penetration test relative to a reproducible fixed location reference point;

f) pore pressure dissipation tests.

NOTE 3 This part of ISO 22476 covers onshore and nearshore CPT. For extra requirements for offshore CPT, see NORSOK G-001 [8].

2 Normative references

The following referenced documents are indispensable for the application 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 8503, *Preparation of steel substrates before application of paints and related products — Surface roughness characteristics of blast-cleaned steel substrates*

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

3 Terms, definitions and symbols

3.1 Terms and definitions

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

3.1.1

average surface roughness
Ra
average deviation between the real surface of the cone penetrometer and a medium reference plane placed along the surface of the cone penetrometer

3.1.2

cone
conical shaped bottom part of the cone penetrometer and the cylindrical extension

NOTE 1 When pushing the penetrometer into the ground, the cone resistance is transferred through the cone to the load sensor.

NOTE 2 This part of ISO 22476 assumes that the cone is rigid, so when loaded its deformation is very small relative to the deformation of other parts of the cone penetrometer.

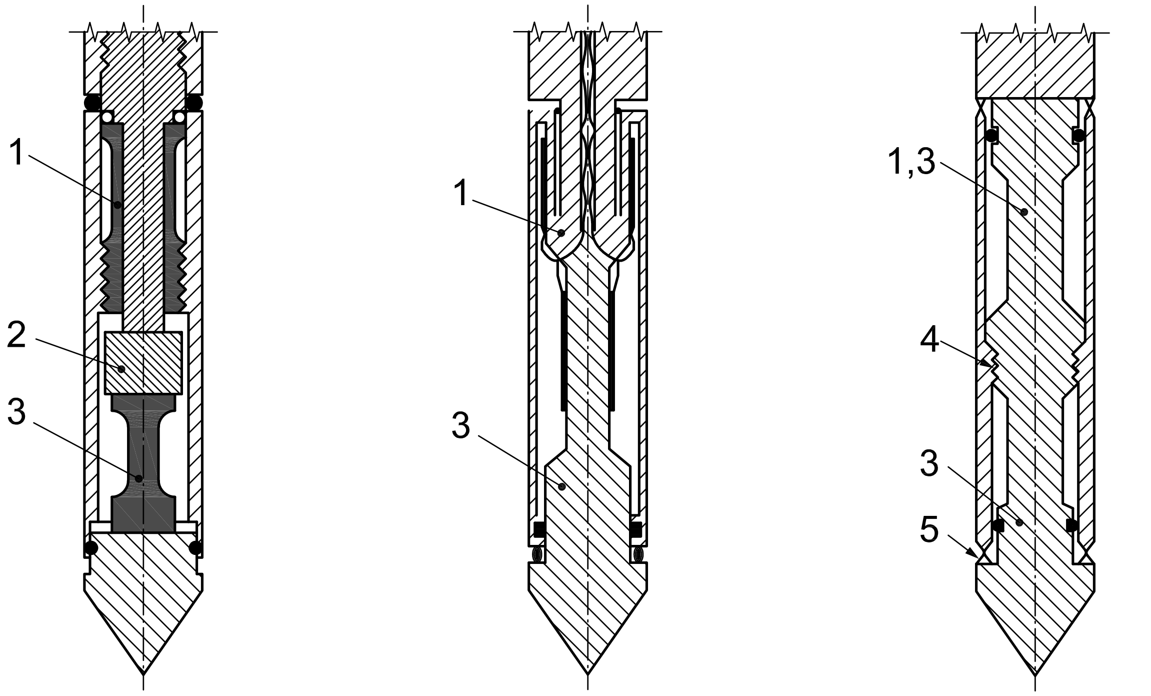
3.1.3

cone penetration test
CPT
pushing of a cone penetrometer at the end of a series of cylindrical push rods into the ground at a constant rate of penetration

3.1.4

cone penetrometer
assembly containing the cone, friction sleeve, any other sensors and measuring systems as well as the connection to the push rods

NOTE An example of a cone penetrometer is shown in Figure 1; for other filter locations, see Figure 2.



a) Cone resistance and sleeve friction load cells in compression

b) Cone resistance load cell in compression and sleeve friction load cells in tension

c) Subtraction type cone penetrometer

Key

1 sleeve load cell
2 point load cell overload protection device
3 cone load cell
4 thread
5 soil seal

Figure 1 — Cross section of an example of a cone penetrometer

3.1.5

cone resistance
cone penetration resistance

3.1.6

corrected cone resistance
q_t
measured cone resistance, q_c, corrected for pore pressure effects

3.1.7

corrected friction ratio
R_{ft}
ratio of the measured or corrected sleeve friction to the corrected cone resistance measured at the same depth

NOTE Usually the measured sleeve friction is used; however, if available, the corrected sleeve friction is used.

3.1.8

corrected sleeve friction

f_t

measured sleeve friction, f_s, corrected for pore pressure effects

3.1.9

dissipation test

measurement of the pore pressure change with time during a pause in pushing while holding the cone penetrometer stationary

3.1.10

electrical cone penetration test

cone penetration test where forces are measured electrically in the cone penetrometer

3.1.11

excess pore pressure

Δu_1, Δu_2, Δu_3

pore pressure in excess of the ambient pore pressure at the level of the filter caused by the penetration of the cone penetrometer into the ground:

$$\Delta u_1 = u_1 - u_0 \quad (1)$$

$$\Delta u_2 = u_2 - u_0 \quad (2)$$

$$\Delta u_3 = u_3 - u_0 \quad (3)$$

3.1.12

filter element

porous element in the cone penetrometer that transmits the pore pressure to the pore pressure sensor, maintaining the geometry of the cone penetrometer

3.1.13

friction ratio

R_f

ratio of the measured sleeve friction to the measured cone resistance at the same depth

3.1.14

friction reducer

local and symmetrical enlargement of the diameter of a push rod to obtain a reduction of the friction along the push rods

3.1.15

friction sleeve

section of the cone penetrometer where friction between the soil and the sleeve is measured

3.1.16

***in situ* equilibrium pore pressure**
u_o
original *in situ* pore pressure at filter depth

3.1.17

inclination
angular deviation of the cone penetrometer from the vertical

3.1.18

initial pore pressure
u_i
measured pore pressure at the start of the dissipation test

3.1.19

measured cone resistance
q_c
division of the measured force on the cone, Q_c, by the projected area of the cone A_c:

$$q_c = Q_c / A_c \qquad (4)$$

3.1.20

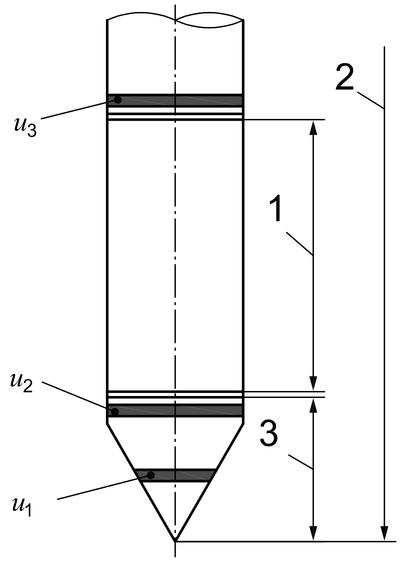
measured pore pressure
u_1, u_2, u_3
pressure measured in filter element during penetration and dissipation testing

NOTE The pore pressure can be measured at several locations as follows (see Figure 2):

u_1 on the face of the cone;

u_2 on the cylindrical section of the cone (preferably in the gap between the cone and the sleeve;

u_3 just behind the friction sleeve.



Key

1 friction sleeve

2 cone penetrometer

3 cone

Figure 2 — Locations of pore pressure filters

3.1.21

measured sleeve friction

f_s

division of the measured force acting on the friction sleeve, F_s, by the area of the sleeve, A_s:

$$f_s = F_s / A_s \quad (5)$$

3.1.22

measuring system

all sensors and auxiliary parts used to transfer and/or store the electrical signals generated during the cone penetration test

NOTE The measuring system normally includes components for measuring force (cone resistance, sleeve friction), pressure (pore pressure), inclination, clock time and penetration length.

3.1.23

net area ratio

a

ratio of the cross-sectional area of the load cell or shaft, A_{st}, of the cone penetrometer above the cone at the location of the gap where fluid pressure can act, to the nominal cross-sectional area of the base of the cone, A_c

NOTE See Figure 6.

3.1.24

net cone resistance

q_n

measured cone resistance corrected for the total overburden soil pressure

3.1.25

net friction ratio

R_{fn}

ratio of the sleeve friction to the net cone resistance measured at the same depth

3.1.26

normalized excess pore pressure

U

excess pore pressure during a dissipation test compared to the initial excess pore pressure

NOTE See 7.4.

3.1.27

penetration depth

z

vertical depth of the base of the cone, relative to a fixed point

NOTE See Figure 3.

3.1.28

penetration length

l

sum of the lengths of the push rods and the cone penetrometer, reduced by the height of the conical part, relative to a fixed horizontal plane

NOTE 1 See Figure 3.

NOTE 2 The fixed horizontal plane usually corresponds to the level of the ground surface (on shore or off shore). This can be different from the starting point of the test.