INTERNATIONAL STANDARD

ISO 22476-12

First edition
2009-05-15

Geotechnical investigation and testing — Field testing —

Part 12: Mechanical cone penetration test (CPTM)

Reconnaissance et essais géotechniques — Essais en place —

Partie 12: Essai de pénétration statique au cône à pointe mécanique

Reference number
ISO 22476-12:2009(E)

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Published in Switzerland

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

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.

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.

ISO 22476-12 was prepared by the European Committee for Standardization (CEN) Technical Committee CEN/TC 341, in collaboration with ISO Technical Committee 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 2: Dynamic probing*
- *Part 3: Standard penetration test*
- *Part 4: Ménard pressuremeter test*
- *Part 5: Flexible dilatometer test*
- *Part 7: Borehole jack test*
- *Part 10: Weight sounding test* [Technical Specification]
- *Part 11: Flat dilatometer test* [Technical Specification]
- *Part 12: Mechanical cone penetration test (CPTM)*

Electrical cone and piezocone penetration tests, self-boring pressuremeter test, full displacement pressuremeter test, and field vane test are to form the subjects of future parts 1, 6, 8 and 9.

Introduction

The mechanical cone penetration test (CPTM) consists of pushing a cone penetrometer, by means of a series of push rods, into the soil at a constant rate of penetration. During penetration, measurements of cone penetration resistance, total penetration resistance and/or sleeve friction can be recorded. The test results can be used for interpretation of stratification, classification of soil type and evaluation of geotechnical parameters.

Cone resistance is the term used in practice; however, *cone penetration resistance* is a more accurate description of the process, and is the term used in this part of ISO 22476.

Geotechnical investigation and testing — Field testing —

Part 12:
Mechanical cone penetration test (CPTM)

1 Scope

This part of ISO 22476 specifies a mechanical cone penetration test (CPTM), including equipment requirements, execution and reporting. The results from such geotechnical testing are especially suited to the qualitative and/or quantitative determination of a soil profile — together with direct investigations — or as a relative comparison with other *in situ* tests.

The results from a cone penetration test can in principle be used to evaluate stratification, soil type, and geotechnical parameters such as soil density, shear-strength parameters and deformation and consolidation characteristics.

This part of ISO 22476 specifies the following features:

— type of cone penetration test (see Table 1);

— application class (see Table 2);

— penetration length or penetration depth;

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

— location of the cone penetration test relative to a reproducible fixed location reference point.

NOTE The planning and evaluation of an investigation programme and the application of its results to design are covered by EN 1997-1 and EN 1997-2.

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 (all parts), *Preparation of steel substrates before application of paints and related products — Surface roughness characteristics of blast-cleaned steel substrates*

ISO 10012:2003, *Measurement management systems — Requirements for measurement processes and measuring equipment*

3 Terms, definitions, symbols and abbreviated terms

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

3.1 Terms and definitions

3.1.1
average surface roughness
R_a
average deviation between the real surface of the probe and a medium reference plane placed along the surface of the probe

3.1.2
cone
conically shaped bottom part of the cone penetrometer

NOTE When the penetrometer is pushed into the ground, the cone penetration resistance is transferred through the cone by inner rods to the measuring device at ground level.

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

3.1.3.1
electrical CPT
CPTU
cone penetration test in which forces are measured electrically in the cone penetrometer

NOTE Electrical CPT and piezocone (CPTU) tests are to form the subject of a future part 1 of ISO 22476.

3.1.3.2
mechanical CPT
CPTM
CPT where forces are measured mechanically or electrically at ground level

3.1.4
cone penetrometer
assembly containing cone, friction sleeve (optional), connection to the push rods and measuring devices for the determination of the cone penetration resistance and, if applicable, the total resistance and/or local side friction

3.1.5
cone penetration resistance
cone resistance
resistance to the penetration of the cone

3.1.6
continuous penetration testing
test method in which cone penetration resistance is measured while cone and push rods are moving continuously until stopped for the addition of a push rod

3.1.7
discontinuous penetration testing
test method in which cone penetration resistance and, optionally, sleeve friction are measured during a penetration stop of the push rods

3.1.8
force acting on the friction sleeve
F_s
force that will be obtained by subtracting the measured force on the cone from the measured force on the cone and friction sleeve

3.1.9
friction ratio
R_f
ratio of sleeve friction to cone penetration resistance measured at the same depth, expressed as a percentage:

$$R_f = \frac{f_s}{q_c} \times 100\ \%$$

NOTE In some cases the inverse of the friction ratio, called the *friction index*, is used.

3.1.10
friction reducer
local and symmetrical enlargement of the diameter of a push rod to reduce the friction along the push rods

3.1.11
friction sleeve
section of the cone penetrometer where sleeve friction is determined

3.1.12
inner rods
solid rods sliding inside the push rods and transferring the forces from the cone and, optionally, the friction sleeve, to the measuring system

3.1.13
measured cone penetration resistance
q_c
division of the measured force , Q_c, on the cone by the cross-sectional area, A_c:

$$q_c = \frac{Q_c}{A_c}$$

NOTE The measured cone penetration resistance obtained from a mechanical CPT can differ from that obtained from an electrical CPT.

3.1.14
measured sleeve friction
f_s
force , F_s, acting on the friction sleeve divided by the area of the sleeve, A_s:

$$f_s = \frac{F_s}{A_s}$$

NOTE The measured sleeve friction obtained from a mechanical CPT test can be different from the value obtained from an electrical CPT test.

3.1.15
measured total penetration force
Q_t
force needed to push cone and rods together into the soil

3.1.16
measuring system
all sensors and auxiliary parts used to transfer and/or store the signals generated during the cone penetration test

NOTE The force on the cone and, if applicable, the total penetration resistance and/or sleeve friction are measured with manometers or with electrical load sensors.

3.1.17
penetration depth
z
depth of the base of the cone, relative to a fixed horizontal plane

See Figure 1.

NOTE 1 It is expressed in metres.

NOTE 2 With mechanical CPT, penetration depth cannot be determined, as there is no inclinometer measurement for depth correction.

3.1.18
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

See Figure 1.

NOTE 1 It is expressed in metres.

NOTE 2 The fixed horizontal plane usually corresponds with a horizontal plane through the ground surface at the location of the test.

3.1.19
push rod
part of a string of rods for the transfer of forces to the cone penetrometer

3.1.20
thrust machine
equipment that pushes the cone penetrometer and rods into the ground at a constant rate of penetration

NOTE The required reaction for the thrust machine can be supplied by dead weights and/or soil anchors.

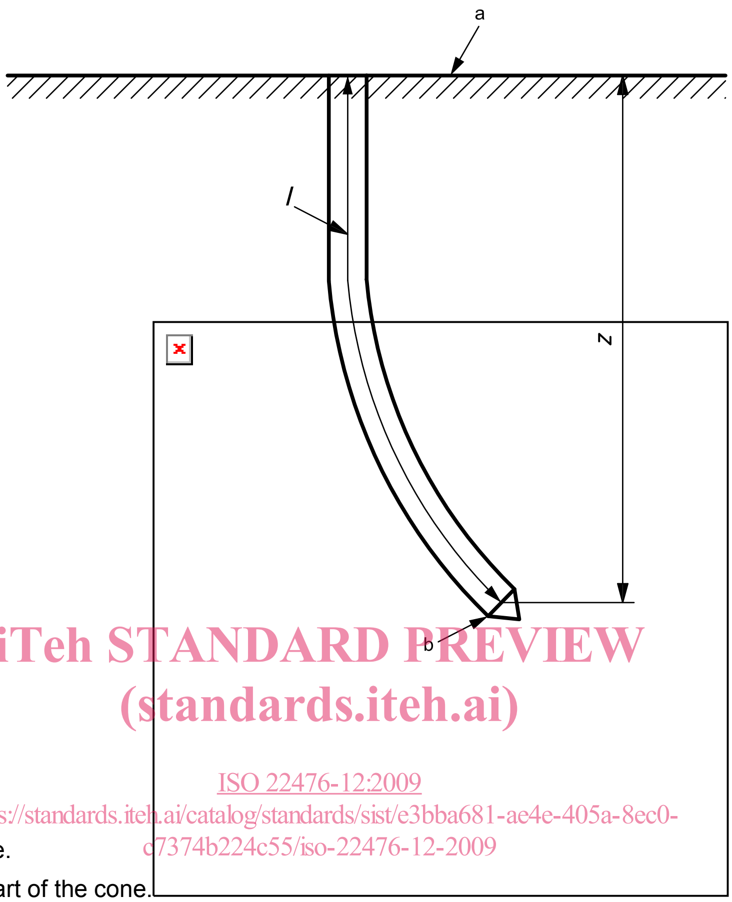
3.1.21
total side friction force
Q_{st}
force needed to overcome the side friction on the push rods, when these are pushed into the ground

NOTE The total side friction force is obtained by subtracting the force on the cone (Q_c) from the measured total penetration force (Q_t):

$$Q_{st} = Q_t - Q_c$$

3.1.22
zero drift
absolute difference between the zero readings of a measuring system at the start and after completion of a cone penetration test

3.1.23
zero reading
stable output of a measuring system when there is zero load on the sensor, i.e. the parameter to be measured has a value of zero, while any auxiliary power supply required to operate the measuring system is switched on



Key

z penetration depth, m

l penetration length, m

[a] Fixed horizontal plane.

[b] Base of the conical part of the cone.

Figure 1 — Penetration length and depth

3.2 Symbols and abbreviated terms

A_c	cross-sectional projected area of cone	mm^2
A_s	cross-sectional area of friction sleeve	mm^2
d_c	diameter of cylindrical upper part of cone	mm
d_2	diameter of friction sleeve	mm
F_s	axially measured force on friction sleeve	kN
f_s	measured sleeve friction	MPa
h_c	height of conical part of cone	mm
h_e	length of cylindrical extension of cone	mm
l	penetration length	m
l_s	length of friction sleeve	mm
M1, M2, M4	types of cone penetrometer	—
Q_c	axially measured force on cone	kN
Q_{st}	total side friction force	kN
Q_t	measured total penetration force	kN
q_c	measured cone penetration resistance	MPa
R_a	average surface roughness	µm
R_f	friction ratio	%
TM1 … TM4	test methods 1 to 4	—
t	time	s
z	penetration depth	m

4 Equipment

4.1 Cone penetrometer load sensors

The cone penetrometer has no internal load sensors, as measurements are made at ground level. The axis of all parts of the cone penetrometer shall be coincident.

4.2 Tolerances

The dimensional tolerances mentioned in this clause are operational tolerances. Manufacturing tolerances should be stricter.

The tolerance on surface roughness is a manufacturing tolerance.