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Geotechnical investigation and testing — Testing of geotechnical structures —

Part 5: Testing of grouted anchors

Reconnaissance et essais géotechniques — Essais des structures géotechniques —

Partie 5: Essais de tirants d'ancrage

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Contents

Page

Foreword

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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).

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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.

This document was prepared by Technical Committee ISO/TC 182, *Geotechnics*.

A list of all the parts in the ISO 22477 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document, together with EN 1997-1 and EN 1537, form the trinity in which:

— EN 1997-1 defines the design requirements for grouted anchors, including the limits of proof load and limiting criteria by testing of grouted anchors, which may be specified in the national annex (for EN 1997-1) or a similar national application document for ISO countries;

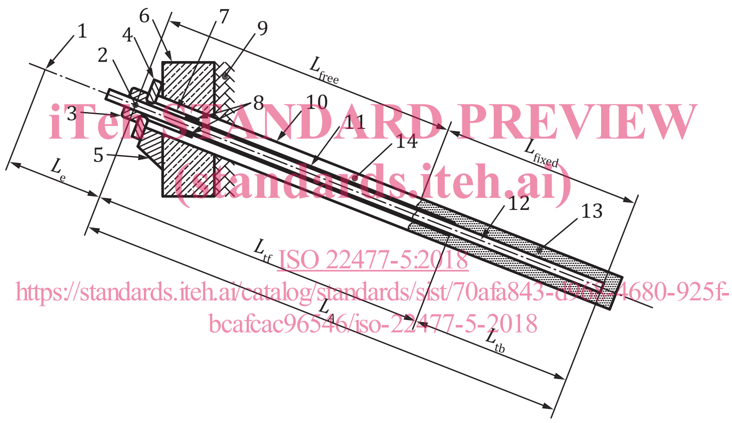
— EN 1537 defines the execution of grouted anchors;

— this document defines the testing of grouted anchors.

The document has been structured so that common items are given in Clauses 1 to 7. The different test specific loading procedures, measurements, checks and presentation of test results for the three test methods (Test Method 1, 2 and 3) have been placed in three separate clauses. The determination of the fundamental characteristics: creep rate, load loss, critical creep load and the apparent tendon free length are not test specific and for this reason these have been placed in Annexes A to D.

Yield stress and tensile strength for typical anchor steels appear in Annex E.

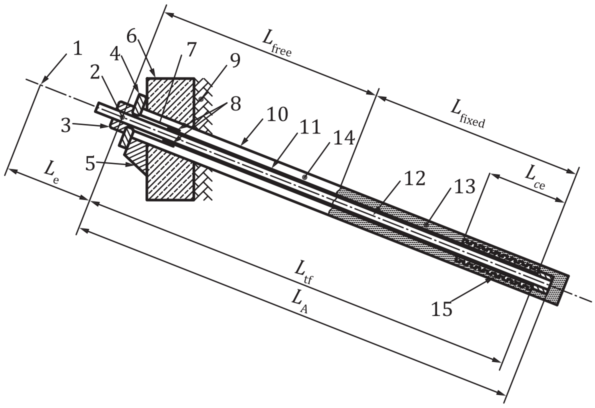
Figures 1 and 2 illustrate the two main types of grouted anchors considered in EN 1537.



Key

1 anchorage point at jack during stressing
2 anchorage point at anchor head in service
3 tensioning element at anchor head (nut or barrel and wedge)
4 bearing plate
5 load transfer block
6 structural element
7 trumpet or anchor head tube
8 O-ring
9 soil/rock
10 borehole
11 debonding sleeve
12 tendon
13 fixed length grout body
14 free length filling where appropriate

Figure 1 — Sketch of a bond type ground anchor — details of anchor head and head protection omitted



Key

1 anchorage point at jack during stressing
2 anchorage point at anchor head in service
3 tensioning element at anchor head (nut or barrel and wedge)
4 bearing plate
5 load transfer block
6 structural element
7 trumpet or anchor head tube
8 O-ring
9 soil/rock
10 borehole
11 debonding sleeve
12 tendon
13 fixed length grout body
14 free length filling where appropriate
15 compression element

Figure 2 — Sketch of a compression type ground anchor — details of anchor head and head protection omitted

Geotechnical investigation and testing — Testing of geotechnical structures —

Part 5:
Testing of grouted anchors

1 Scope

This document establishes specifications for the execution of tension tests to be carried out on an anchor grouted in the ground, as defined in EN 1997-1 and EN 1537. Three methods of testing are recognized by this document. Test Method 1 involves cyclic tension loading with measurement of displacement at the load stages; Test Method 2 involves cyclic tension loading with measurement of load loss at the load stages; and Test Method 3 involves step-loading with measurement of displacement under successive maintained tension loads.

This document provides specifications for the experimental devices, the measurement apparatus, the test procedures, the definition and presentation of the test results and the content of records.

NOTE This document does not provide specification for the size of the proof load and the limiting criteria. These aspects reside in EN 1997-1 or its national annex for CEN countries and in similar national application documents for this test standard for ISO countries.

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.

EN 1537:2013, *Execution of special geotechnical works — Ground anchors*

EN 1997-1:2004+A1:2013, *Eurocode 7: Geotechnical design — Part 1: General rules*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 1997-1 and EN 1537 and the following 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/

3.1.1
acceptance test
load test to confirm that an individual anchor conforms with its acceptance criteria

Note 1 to entry: Refer to EN 1997-1.

3.1.2
anchor tendon resistance
ultimate tensile resistance of the anchor tendon

3.1.3
critical creep load
load corresponding to the end of the first pseudo-linear part of the "α versus load diagram"

Note 1 to entry: Refer to Annex C for the determination of the critical creep load.

3.1.4
geotechnical ultimate limit state resistance
ultimate resistance of the ground-grout interface or pull-out resistance

Note 1 to entry: The ground-grout interface resistance is the load at which the creep rate α meets the limiting criterion in the form of a specific creep rate α_{ULS} or the vertical asymptote of the creep rate versus load curve, (that is an infinite creep rate).

Note 2 to entry: For Test Method 2 load loss is used as criterion instead of creep rate, refer to EN 1997-1.

3.1.5
serviceability limit state resistance
load at which the creep rate α meets the limiting criterion in the form of a specific creep rate α_{SLS}

Note 1 to entry: Also defined as the load corresponding to a characteristic point — the knee point — on the creep rate versus load curve, termed the critical creep load.

Note 2 to entry: Refer to EN 1997-1.

3.1.6
investigation test
load test to establish the geotechnical ultimate resistance of an anchor and to determine the characteristics of the anchor in the working load range

Note 1 to entry: Refer to EN 1997-1.

3.1.7
production anchor
anchor that forms part of the anchored structure

Note 1 to entry: Also referred to as a working anchor.

Note 2 to entry: Not suitable for investigation tests.

3.1.8
proof load
maximum test load to which an anchor is subjected in a particular load test

3.1.9
suitability test
load test to confirm that a particular anchor design will be adequate in particular ground conditions

Note 1 to entry: Refer to EN 1997-1.

3.1.10
test anchor
sacrificial anchor installed for testing purposes only

3.2 Symbols

A_t Cross-sectional area of anchor tendon

E_t elastic modulus of anchor tendon

f friction loss as a percentage of P_p

f_{tk} characteristic tensile strength, also referred to as f_{uk} in EN 1993 (all parts)

$f_{t0,1k}$ characteristic yield stress corresponding the 0,1 % yield strain = f_{yk}

$f_{t0,2k}$ characteristic yield stress corresponding the 0,2 % yield strain = f_{yk}

k_l load loss

$k_{l;ULS}$ permissible cumulative loss of load over specified time period, used to determine ultimate limit state resistance of an anchor

$k_{l;SLS}$ permissible cumulative loss of load over specified time period, used to determine serviceability limit state resistance of an anchor

L_{app} apparent tendon free length

L_{ce} length of compression element (refer to EN 1537)

L_e external length of tendon measured from the tendon anchorage in the anchor head to the anchorage point in the stressing jack (refer to EN 1537)

L_{fixed} fixed anchor length

L_{free} free anchor length

L_{tb} tendon bond length

L_{tf} tendon free length

P_a datum load

P_c critical creep load

P_o anchor lock-off load

P_p proof load

$R_{ULS:m}$ measured value of the geotechnical resistance of an anchor complying with the ultimate limit state criteria

$R_{SLS:m}$ measured value of the geotechnical resistance of an anchor complying with the serviceability limit state criteria

s tendon end displacement

t time

α slope of “creep displacement vs. decimal logarithm of time” plot, creep rate, creep displacement rate

α_{ULS} limit criterion of α in ULS

α_{SLS} limit criterion of α in SLS

α_1 limit of α by test method 1

α_3 limit of α by test method 3

ΔP difference between proof load and datum load

ΔP_f friction loss

Δs measured displacement of the tendon end produced by load increment ΔP

Δs_{el} measured displacement of the tendon end at proof load P_p minus displacement after de-loading to datum load P_a

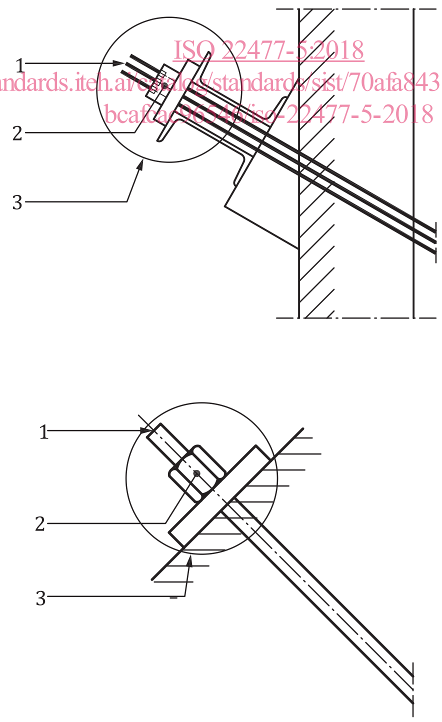
4 Equipment

4.1 Test loading set-up

The principal components of a test loading system are a stressing device, a reaction system and equipment for the measurement and recording of loads or pressures, displacement and time. Other equipment may include devices for the measurement and recording of ambient temperature.

The test loading system shall be designed to operate safely up to the proof load.

When using Test Method 2 or if an independent datum point is not available (at the tendon end, Figure 3) then the structural movement shall be monitored (see Figure 5, key 8).



Key

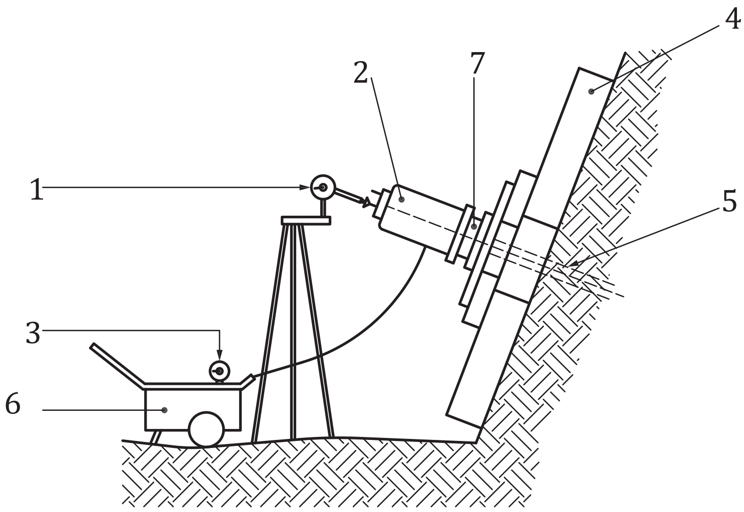
1 tendon end

2 anchorage point, provided by wedges on strand anchor or nut on bar anchor

3 anchor head

Figure 3 — Anchor head details for strand and bar anchors

NOTE Schematic illustrations of loading systems are presented in Figures 4, 5 and 6. Where possible it is better to measure the load between the loading device and the bearing plate to avoid the determination of the friction in the jack.



Key

1 displacement monitoring of tendon end

2 stressing device

3 load monitoring system (pressure gauges)

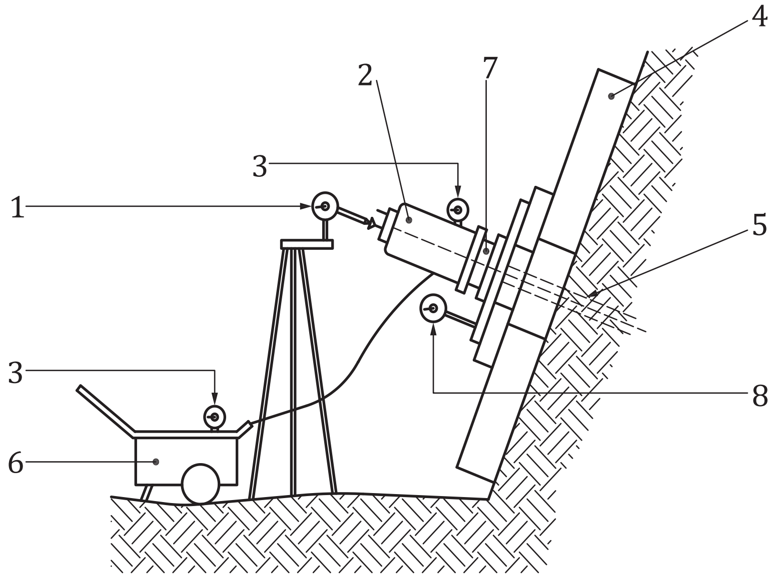
4 reaction system/structure

5 tendon

6 hydraulic system (pump)

7 load cell (optional)

Figure 4 — Schematic illustration showing typical method of measuring tendon displacement from an independent datum



Key

1 displacement monitoring of the tendon end

2 stressing device

3 load monitoring system (pressure gauges)

4 reaction system/structure

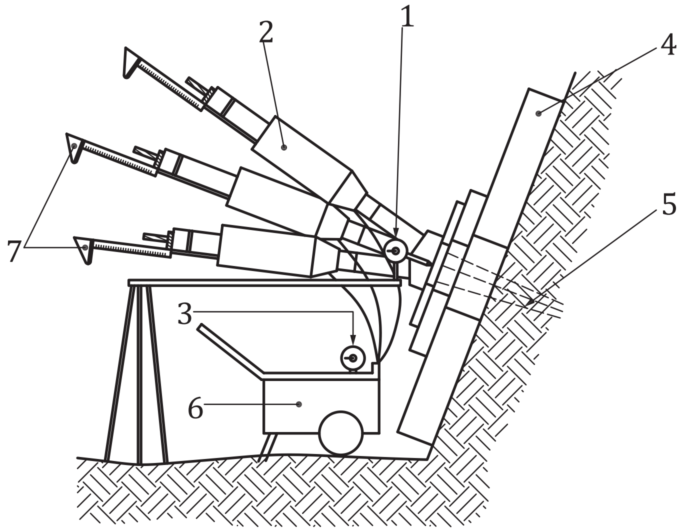
5 tendon

6 hydraulic system (pump)

7 load cell to measure load loss

8 displacement monitoring of the reaction structure, mounted on separate tripod (not shown)

Figure 5 — Schematic illustration showing typical method of measuring tendon load loss using a pressure gauge, with reaction system deformation measurement from an independent datum



Key

1 independent displacement monitoring of structure (two dial gauges on centre axis, each side of bearing plate)

2 multiple jacks acting as stressing device for staggered anchors

3 load monitoring system (pressure gauge)

4 reaction system/structure

5 tendon

6 hydraulic system (pump)

7 displacement monitoring system, comprising long stroke digital Vernier gauge or similar

Figure 6 — Schematic illustration showing typical method of measuring tendon displacement on staggered free lengths, using long stroke Vernier gauge

4.2 Reaction system

The reaction system shall be designed to resist the proof load in accordance with the relevant European standards.

The reaction system should be designed not to impose excessive loads to the ground, which may cause detrimental deformation or settlement.

In the case of load loss measurement, monitoring of the reaction system shall be performed to determine the displacement of the reaction structure itself during testing.

4.3 Loading device

The loading device, normally a hydraulically operated jack, should have a capacity at least 10 % greater than the proof load.

The extension of the jack should be greater than the sum of the elongation of the tendon under the proof load, and the displacement of the reaction system. In cases where a single jack cannot provide the necessary extension, suitable equipment (e.g. multiple jacks placed in series) shall be used.

The equipment (hydraulic jack, pumping unit, etc.) shall be capable of safely tensioning the tendon smoothly and axially, in accordance with the test procedure. The load shall be applied or released in a controlled manner without any shocks.

With the exception of anchors with staggered free lengths, stressing equipment for bar and strand tendons shall tension the complete tendon as a single unit. The stressing equipment for anchors with staggered free lengths shall comply with EN 1537:2013, 8.4.5.

