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Execution of special geotechnical works - Micropiles

Ausführung von besonderen geotechnischen Arbeiten (Spezialtiefbau) - Pfähle mit kleinen Durchmessern (Mikropfähle)

Exécution de travaux géotechniques spéciaux - Micropieux

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English version

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Ausführung von besonderen geotechnischen Arbeiten
(Spezialtiefbau) - Pfähle mit kleinen Durchmessern
(Mikropfähle)

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EUROPÄISCHES KOMITEE FÜR NORMUNG

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Foreword

This document (EN 14199:2005) has been prepared by Technical Committee CEN/TC 288 "Execution of special geotechnical works", the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2005, and conflicting national standards shall be withdrawn at the latest by September 2005.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

The general scope of CEN/TC 288 is the standardisation of the execution procedures for geotechnical works, including testing and control methods, and the required material properties. WG 8 has been charged with the subject area of micropiles.

The document has been prepared to stand along side EN 1997-1. Clause 7 of this Standard covers design aspects of micropiles.

It has been drafted by a working group comprising delegates from 14 countries and is based on the review of national and international codes of practice.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

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1 Scope

1.1 This document establishes general principles for the execution of micropiles.

They are for:

- drilled micropiles a shaft diameter not greater than 300 mm;
- driven micropiles a shaft diameter or a maximum shaft cross sectional extension not greater than 150 mm.

1.2 Micropiles are structural members to transfer actions to the ground and may contain bearing elements to transfer directly or indirectly loads and or to limit deformations. Their shaft and base resistance may be improved (mostly by grouting) and they may be constructed with (see Figure 1):

- uniform cross section (straight shaft); or
- telescopically changing shaft dimensions;
- shaft enlargements; and/or
- base enlargement.

1.3 Other than practical considerations, there are no limitations regarding, length, rake (definition of rake, see Figure 2), slenderness ratio or shaft and base enlargements.

1.4 The provisions of the document apply to (see Figure 3):

- single micropiles;
- micropile groups, <https://standards.iteh.ai/catalog/standards/sist/14367741-36f6-430a-8d8d-6b45126b99a0/sist-en-14199-2005>
- reticulated micropiles;
- micropile walls.

1.5 The micropiles which are the subject of this document can be installed into the ground using drilling, driving or a combination of these methods.

1.6 The material of micropiles covered by this document can be:

- steel or other reinforcement materials;
- grout, mortar or concrete;
- a combination of above.

1.7 Micropiles may be used for:

- working under restricted access and/or headroom conditions;
- foundations of new structures (particularly in very heterogeneous soil or rock formations);
- reinforcing or strengthening of existing structures to increase the capacity to transfer load to depth with acceptable load settlement characteristics, e.g. underpinning works;
- reducing settlements and/or displacements;

- forming a retaining wall;
- reinforcing of soil to form a bearing and/or retaining structure;
- improving slope stability;
- securing against uplift;
- other applications where micropile techniques are appropriate.

1.8 Mixed-in-place columns and timber piles are not included in this document. Columns constructed by jet grouting are covered by EN 12716. Ground anchors are covered by EN 1537.

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.

EN 197-1, *Cement - Part 1: Composition, specifications and conformity criteria for common cements*.

EN 206-1: *Concrete - Part 1: Specification, performance, production and conformity*.

EN 791, *Drill rigs – Safety*.

EN 934-2, *Admixtures for concrete, mortar and grout - Part 2: Concrete admixtures - Definitions, requirements, conformity, marking and labelling*.

EN 996, *Piling equipment – Safety requirements*. [SIST EN 14199:2005
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EN 1008, *Mixing water for concrete - Specification for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industry, as mixing water for concrete*

EN 1536:1999, *Execution of special geotechnical work - Bored piles*.

EN 1537:1999, *Execution of special geotechnical work - Ground anchors*.

EN 1991-1, *Eurocode 1: Basis of design and actions on structures – Part 1: Basis of design*.

EN 1992-1-1, *Eurocode 2: Design of concrete structures - Part 1: General rules and rules for buildings*

EN 1993-1-1, *Eurocode 3: Design of steel structures - Part 1-1: General rules and rules for buildings*

EN 1993-5, *Eurocode 3: Design of steel structures – Part 5: Piling*.

EN 1994-1-1, *Eurocode 4: Design of composite steel and concrete structures - Part 1-1: General rules for buildings*.

EN 1997-1:2004, *Eurocode 7: Geotechnical design – Part 1: General rules*.

EN 10025, *Hot-rolled products of non-alloy structural steels*.

EN 10080, *Steel for the reinforcement of concrete weldable ribbed reinforcing steel B 500 - Technical delivery conditions for bars, coils and welded fabric*

prEN 10138-4, *Prestressing steels - Part 4: Bars*.

EN 10210, *Hot finished structural hollow sections of non-alloy and fine grain structural steels.*

EN 12699:2000, *Execution of special geotechnical works - Displacement piles.*

EN 12794, *Precast concrete foundation piles.*

EN ISO 11960, *Petroleum and natural gas industries - Steel pipes for use as casing or tubing for wells (ISO 11960:2004)*

3 Terms and definitions

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

3.1

micropile

fr: micropieu

de: Mikropfahl

piles which have a small diameter (smaller than 300 mm shaft diameter for drilled piles and not greater than 150 mm shaft diameter or maximum shaft cross sectional extension for driven piles)

3.2

enlarged base

fr: base élargie

de: Fussaufweitung

base of the micropile formed to have a cross section greater than that of its shaft

3.3

shaft diameter

fr: diamètre du fût

de: Pfahldurchmesser

diameter of the part of the micropile between the head and the base:

- a) for micropiles constructed with casing: equal to the external diameter of the casing;
- b) for micropiles constructed without casing: equal to the maximum diameter of the drilling tool, the maximal cross sectional extension of the driving tool;
- c) for prefabricated micropiles: equal to the external diameter or cross sectional extension.

3.4

preliminary micropile

fr: micropieu préliminaire

de: Vorversuchs-Mikropfahl (Probepfahl 1)

micropile installed before the commencement of the main piling works or section of the works for the purpose of establishing the suitability of the chosen type of micropile and/or for confirming the design, dimensions and bearing capacity

3.5

trial micropile

fr: micropieu de faisabilité

de: Eignungsversuchs-Mikropfahl (Probepfahl 2)

micropile installed to assess the practicability and suitability of the construction method for a particular application

3.6
test micropile
fr: micropieu d'essai
de: Abnahmeversuchs-Mikropfahl (Probepfahl 3)
micropile to which a load is applied to determine the resistance and deformation characteristics of the micropile and the surrounding ground

3.7
working micropile
fr: pieu de fondation
de: Bauwerksmikropfahl
micropile which is part of a structure

3.8
integrity test
fr: essai d'intégrité
de: Integritätsprüfung
test carried out on an installed micropile for the verification of soundness of micropile components

3.9
static load test
fr: essai de chargement statique
de: statische Probelastung
loading test where a micropile is subjected to chosen axial and/or lateral forces at the micropile head for the analysis of its capacity and deformation characteristics

3.10
maintained load test (ML test)
fr: essai de chargement par palier
de: lastgesteuerte Probelastung
static loading test in which a test micropile has loads applied in incremental stages, each of which is held constant for a certain period or until micropile motion has virtually ceased or has reached a prescribed limit

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3.11
constant rate of penetration test (CRP test)
fr: essai de chargement à vitesse d'enfoncement constante
de: weggesteuerte Probelastung
static load test in which a test micropile is forced into the ground at a constant rate and the force is measured

3.12
dynamic load test
fr: essai de chargement dynamique
de: dynamische Probelastung
loading test where a dynamic force is applied on the micropile for analysis of micropile bearing capacity and deformation characteristics

3.13
grout
fr: coulis
de: Zementmörtel
a setting material, usually cement and water, containing sometimes additives or a limited amount of fine aggregates, which transfers load from the bearing element or the micropile shaft to the ground and/or contributes to corrosion protection

3.14
mortar
fr: mortier
de: Verpressmörtel/Feinkornbeton
concrete with very small aggregates (< 8 mm)

3.15**driving****fr: fonçage****de: Einbringen/Eintrieben**

method to bring the micropile into the ground to the required depth, such as hammering, vibrating, pressing, screwing or by a combination of these or other methods

3.16**drilling****fr: forage****de: Bohren**

method of removing the soil or rock in an intermittent or continuous process

3.17**casing****fr: tubage****de: Verrohrung**

tube used to support the micropile hole during the construction of a micropile. The casing can be permanent or temporary. Permanent casing may act as a load bearing element and/or as a corrosion protection

3.18**liner****fr: gaine, chemise****de: Hülse, Mantelrohr**

a tube, generally of thin steel sheet or plastic, forming at least part of the shaft of a micropile, e.g. used for the protection of micropile shafts in soft or aggressive grounds or to reduce negative skin friction

3.19**drive tube****fr: tube de fonçage****de: Vortreibrohr / Rammrohr**

steel tube used to displace the ground during the formation of a driven cast in place micropile. The drive tube is withdrawn during grouting or concreting

3.20**micropile joint****fr: assemblage, connexion de micropieu****de: Verbindung**

means of joining lengths of bearing elements either by welding or by mechanical joints

3.21**coupler****fr: manchon****de: Koppelement / Muffe**

an external device for joining lengths of bar or tube which comprise reinforcement or bearing element

3.22**nipple****fr: mamelon****de: Nippel**

an internal device for joining lengths of tubes which comprise reinforcement or bearing element

3.23**centralizer****fr: centreur****de: Zentrierer**

device to locate reinforcement centrally in a borehole or casing

3.24

spacer

fr: écarteur

de: Abstandhalter

device to ensure the required grout, mortar or concrete cover or the distance between reinforcing elements

3.25

load bearing element

fr: élément porteur

de: Tragglied

element of steel or other material that is capable of transmitting the load from the structure to the ground

3.26

drilling fluid/mud

fr: fluide de forage, boue de forage

de: Spülflüssigkeit, Bohrspülung

water or a suspension of bentonite, polymers or clay, in water with or without cement and other additions, for stabilization of borehole walls and for flushing

3.27

tube-à-manchettes

fr: tube à manchettes

de: Manschettenrohr

a regularly slotted sleeved tube through that grout injections are possible using a packer device

3.28

working level

fr: niveau de travail

de: Arbeitsebene

level of the platform on which the piling rig works

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3.29

clients technical representative

fr: représentant technique du client

de: Technischer Bauherrvertreter

represents the client and is fully acquainted with all aspects of the works related to the use of micropiles including specialist knowledge of micropile technology

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3.30

grouting

fr: injection sous pression

de: Verpressen

pumping of grout or concrete into the borehole with a pressure which is higher than the hydrostatic pressure

3.31

multi-stage grouting

fr: injection sous pression répétée

de: Nachverpressen

high pressure grouting through a tube-à-manchettes, special valves or post-grouting tubes after the grout previously placed in the borehole has set

3.32

filling

fr: remplissage gravitaire

de: Verfüllen

grouting under no applied fluid pressure other than the height of grout fluid. Sometimes referred to as gravity grouting or as tremie grouting

4 Information needed for the execution of the works

4.1 General

4.1.1 Prior to the execution of the work, all necessary information and site investigation data shall be available.

4.1.2 This information should include:

- a) any legal or statutory restrictions;
- b) the location of main grid lines for setting out;
- c) the conditions of structures, roads, services, etc.:
 - 1) adjacent to the work, including any necessary surveys;
- d) a suitable quality management system, including supervision, monitoring and testing.

4.1.3 The information regarding the site conditions shall cover where relevant:

- a) the geometry of the site (boundary conditions, topography, access, slopes, headroom restrictions ...);
- b) the existing underground structures, underground and aerial services, obstructions, known contaminations and archeological constraints;
- c) the environmental restrictions, including noise, vibration, pollution;
- d) the future or ongoing construction activities such as dewatering, tunnelling, deep excavations.

4.2 Special features for micropiles:

4.2.1 The following additional site informations shall be made available in the project documentation and be on site before commencement of the micropile works, where applicable:

- working platform levels;
- location of site datum;
- chemical aggressiveness of ground and/or groundwater (= exposure class according to EN 206-1);
- climatic conditions;
- possibility of stray electric current;
- potential instability of the ground;
- presence of existing piles, anchors, and/or other artificial obstructions in the ground (as for example wood, steel, etc. ...).

4.2.2 The following items shall be investigated during design and shall be made available for execution where relevant:

- all necessary or relevant information for the production of the working drawings and method statements, where required;

- necessity, extent and procedure for any survey of the conditions of structures, roads, services, etc. adjacent to the works area. Where a survey is necessary it shall be carried out and be available prior to the commencement of the works;
- the allocation of design, execution and supervision activities and responsibilities of all the parties involved. They shall be clearly specified in the project specifications;
- previous experience with micropiles or other foundations or underground works on or adjacent to the site;
- acceptable deformation of adjacent structures;
- dimensions and composition of existing foundations and floors;
- condition, stability and acceptable deformation of structures to be underpinned;
- existing drainage and groundwaterlowering systems.

4.3 List of activities

Design and execution should include, as appropriate, the following activities:

NOTE The order shown does not necessarily represent a time sequence.

- a) assessment of the design assumptions with respect to the site investigation data and construction feasibility;
- b) execution of preliminary or trial micropiles if required and of the tests on these micropiles;
- c) evaluation of the results obtained from preliminary and/or trial micropiles;
- d) definition of the construction sequence of a micropile taking account of c);
- e) directives regarding the construction sequence if required;
- f) instruction to all parties involved of key items in the design criteria to which special attention should be directed;
- g) specifications for monitoring the effects of micropile construction on underpinned and/or adjacent structures (type and accuracy of instruments, frequency of measurement) and for interpreting the results;
- h) definition of tolerable limits regarding the influence of micropile installation works on underpinned and/or adjacent structures;
- i) provision of construction drawings;
- j) specifications for control tests during execution and for micropile tests.

5 Geotechnical investigation

5.1 General

5.1.1 The general investigation shall fulfil the requirements of EN 1997-1.

5.1.2 The geotechnical investigation report shall be available in time, to allow for reliable design and execution of the special geotechnical works (micropiles).

5.1.3 The geotechnical investigation shall be checked to see whether it is sufficient for the design and execution of the special geotechnical works (micropiles).

5.1.4 If the geotechnical investigations are not sufficient, a supplementary investigation shall be conducted.

5.2 Specific requirements

5.2.1 When determining the extent of geotechnical investigation, relevant experience which has been collected during the execution of comparable foundation works under similar conditions and/or at adjacent sites shall be taken into account.

NOTE Reference to relevant experience in this matter is acceptable if appropriate means of verification are taken (e.g. by penetration tests, pressuremeter or other tests).

5.2.2 The soil characteristics shall be determined by in situ tests and/or laboratory tests over the depth of the micropiles and to a depth beneath the base depending on the nature of the ground and on the type of the micropile (end bearing and/or friction bearing).

5.2.3 The geotechnical investigation shall demonstrate for end bearing micropiles that any competent foundation stratum is not immediately underlain by a soft stratum with a possibility of a punching failure or unacceptable settlements.

5.2.4 The following information, when relevant for the execution of micropiles, shall be given in the geotechnical investigation report:

- a) piezometric levels of all water-tables of the soil and rock layers. Where appropriate, the piezometric levels in the various water-tables existing on the site should be monitored separately and over a sufficient period of time to estimate the highest piezometric levels which may occur during the installation of the micropiles. Particular attention shall be paid to artesian conditions and rapid underground water flows;
- b) presence of coarse highly permeable soils or cavities (natural or artificial) which may cause sudden losses of drilling fluid and instability of the borehole, and thus may require special measures;
- c) presence, strength and deformation characteristics of soft layers, such as very soft clay or peat, which may cause difficulties during execution or loading of micropiles (deformation or instability of the borehole, risk of buckling);
- d) presence of cobbles and boulders or other underground obstructions which may cause difficulties for the installation and thus may require special methods or tools for penetration (passing through) or removal;
- e) the level and the slope of rock surface, the thickness and extent of any existing weathered rock, the presence of fissures or cavities;

NOTE In some cases it may also be necessary to determine the strength or hardness of the rock.

- f) chemical aggressiveness of groundwater, soil or rock that can affect the properties of grout, mortar or concrete and steel;
- g) presence, extent, thickness and nature of contaminated soil or waste that can influence the disposal of the spoil generated and that may require special measures for the protection and safety of the work force;
- h) degradation of soil or rock properties when in contact with water.