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Execution of special geotechnical works - Soil nailing

Ausführung von besonderen geotechnischen Arbeiten - Bodenvernagelung

Exécution des travaux géotechniques spéciaux Clouage

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Execution of special geotechnical works - Soil nailing

Exécution des travaux géotechniques spéciaux - Clouage

Ausführung von Arbeiten im Spezialtiefbau -Bodenvernagelung

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EUROPEAN COMMITTEE FOR STANDARDIZATION COMITÉ EUROPÉEN DE NORMALISATION EUROPÄISCHES KOMITEE FÜR NORMUNG

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EN 14490:2010 (E)

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Foreword

This document (EN 14490:2010) 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of an identical text or by endorsement, at the latest by December 2010, and conflicting national standards shall be withdrawn at the latest by December 2010.

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 remit of CEN/TC 288 is the standardisation of the execution procedures for geotechnical works (including testing and control methods) and of the required material properties. CEN/TC 288/WG 13 has been charged with the preparation of EN 14490 in the subject area of soil nailing.

The document has been prepared to stand alongside EN 1997-1, *Eurocode 7: Geotechnical design.* "Design considerations" of this European Standard deals only with those matters which should be taken into account during the execution stage of soil nailing so that the design of the soil nailing system may be fulfilled. This European Standard, however, provides full coverage of the construction and supervision requirements.

This European Standard has been drafted by a working group comprising delegates from ten countries and the comments of these countries have been taken into account.

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

1 Scope

1.1 This European Standard establishes general principles for the execution, testing, supervision and monitoring of soil nailing.

Soil nailing is a construction technique, used to enhance/maintain the stability of a soil mass by 1.2 installation of reinforcing elements (soil nails). Typical examples of soil nailing are given in Annex A.

The scope of soil nailing applications considered in this European Standard includes the installation and 1.3 testing of soil nails and associated operations, required when stabilising existing and newly cut slopes and faces in soil, existing earth retaining structures, embankments, existing tunnels and the excavated facing of new tunnels in soil.

1.4 Soil nailing may be used to form part of a hybrid construction. This European Standard is relevant only to the soil nailing aspect of such constructions.

Techniques, such as reinforcement of ground by vertical inclusions (sheet piles, bored or driven piles, 1.5 or other elements) and stabilisation with rock bolts, prestressed ground anchors or tensions piles are not covered by this European Standard.

1.6 Guidance on practical aspects of soil nailing and aspects on design, durability and testing is given in informative Annexes A, B and C, respectively.

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 Full document (including any amendments) applies. 20

EN 196-1, Methods of testing cement — Part 1: determination of strength

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 1537, Execution of special geotechnical work — Ground anchors

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

EN 1997-1:2004, Eurocode 7: Geotechnical design — Part 1: General rules

EN 1997-2:2007, Eurocode 7 — Geotechnical design — Part 2: Ground investigation and testing

EN 10025-2, Hot rolled products of structural steels — Part 2: Technical delivery conditions for non-alloy structural steels

EN 10079, Definition of steel products

EN 10080, Steel for the reinforcement of concrete — Weldable reinforcing steel — General

EN 10138 (all parts), Prestressing steels

EN 10210 (all parts), Hot finished structural hollow sections of non-alloy and fine grain steels

EN 10219 (all parts), Cold formed welded structural hollow sections of non-alloy and fine grain steels

EN 10244 (all parts), Steel wire and wire products - Non-ferrous metallic coatings on steel wire

EN 10245 (all parts), Steel wire and wire products — Organic coatings on steel wire

EN 13251:2000, Geotextiles and geotextile-related products — Characteristics required for use in earthworks, foundations and retaining structures

EN 13670, Execution of concrete structures

EN 14487-1, Sprayed concrete — Part 1: Definitions, specifications and conformity

EN 14488 (all parts), Testing sprayed concrete

EN ISO 1461, Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods (ISO 1461:2009)

Terms, definitions and symbols 3

3.1 Terms and definitions

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

3.1.1

rds/sisteringee. 14490-2010 3.1.1 bearing plate fr: plaque d'appui de: Kopfplatte plate connected to the head of the soil nail to transfer a component of load from the facing or directly from the ARDR -ailcatalogist ground surface to the soil nail

3.1.2

desian life fr: durée de service de: Entwurfslebensdauer service life in years required by the design

https:// 3.1.3 drainage system fr: système de drainage de: Dränagesystem series of drains, drainage layers or other means to control surface and ground water

3.1.4 facing fr: parement de: Frontausbildung covering to the exposed face of the reinforced ground that may provide a stabilising function to retain the ground between soil nails, provide erosion protection and have an aesthetic function

3.1.5 facing drainage fr: drainage de parement de: Dränage der Frontausbildung system of drains used to control water behind the facing

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3.1.6 facing system fr: système de parement de: Frontausbildungssystem assemblage of facing units used to produce a finished facing of reinforced ground 3.1.7 facing unit fr: élément de parement de: Frontausbildungselement discrete element used to construct the facing 3.1.8 flexible facing fr: parement flexible de: bedingt nachgiebige Frontausbildung flexible covering which assists in containing soil between the nails 3.1.9 ground fr: terrain de: Baugrund soil, rock and fill existing in place prior to the execution of the construction works rds/sist/019ce 2020 14490-2010 14490-2010 hard facing fr: parement rigide de: starre Frontausbildung stiff covering, for example sprayed concrete, precast concrete section or cast *in-situ* concrete 3.1.10 itenaileatalog 649782424 3.1.11 production nail fr: clou de l'ouvrage de: Bauwerksnagel soil nail which forms part of the completed soil nail structure https://stant Ageai 3.1.12 reinforcing element fr: élément de renforcement de: Bewehrungselement generic term for reinforcing inclusions inserted into ground 3.1.13 reinforced ground fr: massif renforcé, sol cloué de: bewehrter Boden ground that is reinforced by the insertion of reinforcing elements 3.1.14

sacrificial nail fr: clou sacrificiel

de: Sondernagel

soil nail installed in the same way as the production nails, solely to establish the pullout capacity but not forming part of the soil nail structure

3.1.15 soft facing

fr: parement souple

de: vollkommen nachgiebige Frontausbildung

soft facing has only a short-term function to provide topsoil stability while vegetation becomes established

3.1.16

soil nail

fr: clou

de: Bodennagel

reinforcing element installed into the ground, usually at a sub-horizontal angle, that mobilises resistance with the soil along its entire length

3.1.17

soil nail construction fr: ouvrage en sol cloué

de: Vernagelungsbauwerk

work that incorporates soil nails, and can have a facing and/or a drainage system

3.1.18

soil nail system

fr: système de clouage de sol

de: Bodennagelsystem

reinforcing element which may include joints and couplings, centralisers, spacers, grouts and corrosion protection

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protection 3.1.19 test nail fr: clou d'essai de: Prüfnagel nail installed by the same method as the production nails for the purpose of verifying the pullout capacity and durability, and could be forming a part of the structure https://standards.tella anua cash chang

3.1.20 proof load

fr: chargement d'essai

de: Prüflast

load applied in the testing

3.2 Symbols

- 3.2.1 elongation of a metallic reinforcement. A_{at}
- 3.2.2 f_{Y} yield strength of steel.
- 3.2.3 debonded nail length. L_{db}
- 3.2.4 proof load (maximum load to which the nail is subjected during the test). p_{p}
- 3.2.5 P_{o} datum load.
- 3.2.6 Rt load at which pullout failure occurs.

3.2.7 characteristic value of the structural tensile resistance of the test soil nail or any of the extension $R_{t,k}$ pieces.

3.2.8 $R_{t0.1,k}$ characteristic value of the 0,1 % yield resistance of the test soil nail or any of the extension pieces.

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- **3.2.9** s_1 , s_2 measured nail displacement at time t_1 and t_2 respectively.
- **3.2.10** *s*_r residual nail displacement.
- **3.2.11** *s*_o initial nail displacement.
- **3.2.12** t_1 , t_2 measurements taken at time t_1 and t_2 .

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 shall be provided, requirements (in accordance with EN 1997-1) in particular, but not limited to the following:

- a) details of the soil nailing project and the construction sequence and programme;
- b) site investigation report, incorporating geotechnical classification and engineering properties of the ground in which the soil nails are to be located;
- c) information regarding all other boundary conditions, including underground services, existing foundations (and their sensitivity) and requirements relevant to the location and performance of the soil nails;
- d) details of ownership of the ground into which the soil nails are to be installed;
- e) details of any agreement required to gain access to ground into which the soil nails are to be installed.
- 4.1.2 The information regarding the site conditions shall cover:
- a) site investigation data about the ground conditions for execution of the soil nailing works according to EN 1997-1 and EN 1997-2;
- b) the geometry of the site (boundary conditions, topography, access, slopes, headroom restrictions);
- c) the existing surface of underground structures, services, known contamination and archaeological constraints;
- d) the environmental restrictions, including noise, vibration, pollution;
- e) the future ongoing activities, such as de-watering, tunnelling, deep excavations;
- f) where the site may be subject to tidal working or flooding, cold climatic conditions or allied restrictions, details of such restrictions;
- g) details of expected groundwater levels, perched water levels and fluctuations;
- h) the conditions of buildings, roads and services adjacent to the work, including any necessary surveys.

4.2 Special features

- **4.2.1** Design aspects shall cover, where relevant:
- a) definition of the Geotechnical Category and the design life of the works;
- b) assessment of the site investigation data with respect to the design assumptions;

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- c) overall design of the soil nailing works;
- d) the relevant temporary phases of execution;
- e) specification of the soil nailing system;
- f) any other items in the design to which special requirements exist during execution.
- **4.2.2** Execution information shall include the following:
- a) specification regarding the working procedures and sequence;
- b) definition of the reporting procedure to deal with unforeseen circumstances, or with any conditions revealed or considered during construction, which appear to be worse than those assumed in the design;
- c) definition of the reporting procedure, if an observational method of design is adopted or monitoring is required;
- d) specified levels, co-ordinates and tolerances shall be shown on plans, or in the specification, together with the positions, levels and co-ordinates of fixed reference points at or near the work construction site;
- e) definition of tolerable limits of the effects of soil nailing (deformations, settlements, noise, vibrations, grouting loss) on existing and proposed structures;
- f) the location of main grid lines for setting out.
- **4.2.3** Testing, supervision and monitoring information shall cover, where relevant:
- a) a schedule of any trials and testing and acceptance procedures, for materials incorporated in the soil nail structure;
- b) a schedule of preliminary trials (if required) and of relevant tests and control;
- c) the results from the evaluation of trials and tests;
- d) if necessary, specification regarding sacrificial nails;
- e) a specification for monitoring the effects of soil nailing on adjacent structures and services and for interpreting the results.

5 Geotechnical investigation

5.1 General

5.1.1 The geotechnical investigation shall fulfil the requirements of EN 1997-1 and EN 1997-2.

NOTE Indications are given in EN 1997-2:2007, Annex B on the depth and the contents of geotechnical investigations.

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

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.

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

5.2 Special aspects of soil nailing

The interaction between the nail and the ground shall be considered. The site investigation shall 5.2.1 establish (or confirm) the nature and the mechanical characteristics of the ground in order to assess the soil nail interface properties directly or by comparable experience.

5.2.2 Stability of the face during construction shall be considered, with special respect to geotechnical, hydro-geological and hydrological conditions (see 9.3.4).

Excavation tests should be performed to evaluate the stability during construction, if bulk excavation is 5.2.3 to take place.

If necessary on account of site conditions, specific instrumentation (inclinometers, piezometers, etc.) 5.2.4 should be installed.

An assessment of the aggressiveness of ground and groundwater shall be established in order to 5.2.5 define the durability requirements of the soil nail material with respect to design life, see Annex B.

Materials and products 6

6.1 General

- Ten Standards, reliands 6.1.1 A soil nail construction can involve the following material components for: - A Contractor of the second s TDSisten 1490-201
- a) soil nail system;
- facing system; b)
- drainage system. C)

6.1.2 All requirements on materials and products shall be specified in advance for the works, based on a European or a National standard. Where no appropriate European or National standard exists, its application shall comply with the manufacturer's recommendations and with the relevant acceptance certification. The compliance with the specified requirements shall be documented during execution.

6.1.3 All requirements on materials shall be specified in advance. The compliance with the specified requirements shall be documented during execution.

6.1.4 Materials and products used in the soil nail, the facing and the drainage systems shall be mutually compatible.

Material and products shall exhibit the properties necessary to ensure that they satisfy the design life 6.1.5 of the structure and that the serviceability limits are not exceeded.

Newly developed materials may be used, provided that the performance of the system and durability 6.1.6 of the materials have been proven.

Soil nails systems 6.2

6.2.1 General

Soil nail systems are produced using a wide range of materials and configurations. The following subclauses describe the main components that may be required to produce a soil nail system. Examples of soil nail systems are given in Annex A.

6.2.2 Reinforcing element

6.2.2.1 General

6.2.2.1.1 The reinforcing element of the nail is usually produced from metals (typically steel) and to a lesser extent from other materials, such as fibre reinforced plastics, geo-synthetics or carbon fibre.

NOTE The reinforcing element may be a solid bar, a hollow bar, an angle bar or some other form of cross-section.

6.2.2.1.2 When nails are to be grouted, they may be ribbed or profiled to improve the effective bond with the grout.

6.2.2.1.3 All reinforcing elements shall exhibit the stress/strain properties, durability and soil-reinforcement interaction properties required by the design.

6.2.2.2 Metallic reinforcing element

6.2.2.2.1 All metallic reinforcement used shall conform to 6.1.2 in particular (no entire enumeration):

- a) a metallic reinforcement needs an elongation (A_{gt}) of at least 5 % at failure;
- b) a solid steel bar, used as a reinforcing element, shall conform to EN 10080;
- c) a hollow steel bar, used as a reinforcing element, shall conform to EN 10210 (all parts) or EN 10219 (all parts);
- d) a hot rolled steel product, used as a reinforcing element, shall conform to EN 10025-2;
- e) pre-stressed steel products, used as a reinforcing element, shall conform to EN 10138 (all parts).

6.2.2.2.2 The reinforcing element shall have a minimum thickness, which guarantees its mechanical behaviour during the entire design life.

6.2.2.2.3 When using a steel reinforcement element, consideration should be taken to design life due to corrosion, see Annex B.

6.2.2.2.4 Coatings and compounds for corrosion protection shall comply with the design specifications. The continuity of the protection, close to the connection elements shall comply with the design specifications.

6.2.2.2.5 The corrosion protection of high strength steel and pre-stressing steel shall be in accordance with EN 1537.

NOTE The steel can be classified as high-strength steel if it has $f_y > 600$ MPa and if no other information is available.

6.2.2.2.6 If a steel reinforcing element is galvanised, the hot dip galvanised coating shall comply with the requirements of EN ISO 1461.

6.2.2.3 Non-metallic reinforcing element

6.2.2.3.1 Other materials may be used as a soil nail reinforcing element provided they comply with 6.1.2.

6.2.2.3.2 Other materials used shall have ductile behaviour.

6.2.2.4 Joints and couplings

6.2.2.4.1 Joints and couplings can govern the strength of the soil nail system.