SLOVENSKI STANDARD
SIST EN 14679:2005

01-oktober-2005

Izvedba posebnih geotehniļ nih del ï Globinsko meġanje

Execution of special geotechnical works - Deep mixing

Ausführung von besonderen geotechnischen Arbeiten (Spezialtiefbau) - Tiefreichende Bodenstabilisierung

Exécution des travaux géotechniques spéciaux - Colonnes de sol traité

Ta slovenski standard je istoveten z: **EN 14679:2005**

ICS:

93.020	Zemeljska dela. Izkopavanja. Gradnja temeljev. Dela pod zemljo	Earthworks. Excavations. Foundation construction. Underground works

SIST EN 14679:2005 **en**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 14679

April 2005

ICS 93.020

English version

Execution of special geotechnical works - Deep mixing

Exécution des travaux géotechniques spéciaux - Colonnes de sol traité

Ausführung von besonderen geotechnischen Arbeiten (Spezialtiefbau) - Tiefreichende Bodenstabilisierung

This European Standard was approved by CEN on 28 February 2005.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of 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 United Kingdom.

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

Management Centre: rue de Stassart, 36 B-1050 Brussels

Ref. No. EN 14679:2005: E

Contents

Page

Foreword

This document (EN 14679:2005) 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 October 2005, and conflicting national standards shall be withdrawn at the latest by October 2005.

The document has been prepared to stand alongside EN 1997-1 and prEN 1997-2. This document expands on design only where necessary, but provides full coverage of the construction and supervision requirements.

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 United Kingdom.

1 Scope

This document specifies general principles for the execution, testing, supervision and monitoring of deep mixing works carried out by two different methods: dry mixing and wet mixing.

Deep mixing considered in this document is limited to methods, which involve:

a) mixing by rotating mechanical mixing tools (see Annex A, Figure A.1) where the lateral support provided to the surrounding soil is not removed;

b) treatment of the soil to a minimum depth of 3 m;

c) different shapes and configurations, consisting of either single columns, panels, grids, blocks, walls or any combination of more than one single column, overlapping or not (see Annex A, Figures A.8 to A.12);

d) treatment of natural soil, fill, waste deposits and slurries, etc.;

e) other ground improvement methods using similar techniques exist (see A.3.5).

Guidance on practical aspects of deep mixing, such as execution procedures and equipment, is given in Annex A. Main applications are exemplified in Annex A, Figure A.14. Methods of testing, specification and assessment of design parameters, which are affected by execution, are presented in Annex B.

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 196-1, *Methods of testing cement — Part 1: Determination of strength*

EN 196-2, *Methods of testing cement — Part 2: Chemical analysis of cement*

EN 196-3, *Methods of testing cement — Part 3: Determination of setting time and soundness*

EN 196-4, *Methods of testing cement — Part 4: Quality determination of constituents*

EN 196-5, *Methods of testing cement — Part 5: Pozzolanicity tests for pozzolanic cement*

EN 196-6, *Methods of testing cement — Part 6: Determination of fineness*

EN 196-7, *Methods of testing cement — Part 7: Methods of taking and preparing samples of cement*

EN 196-8, *Methods of testing cement — Part 8: Heat of hydration — Solution method*

EN 196-21, *Methods of testing cement — Part 21: Determination of the chloride, carbon dioxide and alkali content of cement*

EN 197-1:2000, *Cement — Part 1: Composition, specification and conformity criteria for common cements*

EN 197-2:2000, *Cement — Part 2: Conformity evaluation*

EN 451, *Methods of testing fly ash*

EN 459-1, *Building lime — Part 1: Definitions, specifications and conformity criteria*

EN 459-2, *Building lime — Part 2: Test methods*

EN 791:1995, *Drill rigs — Safety*

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

prEN 1997-2, *Eurocode 7 — Geotechnical design — Part 2: Ground investigation and testing*

EN 12716, *Execution of special geotechnical works — Jet grouting*

ENV 1991, *Eurocode 1: Actions on structures*

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

EN ISO 14688-1, *Geotechnical investigation and testing — Identification and classification of soil — Part 1: Identification and description (ISO 14688-1:2002)*

EN ISO 14688-2, *Geotechnical investigation and testing — Identification and classification of soil — Part 2: Principles for a classification (ISO 14688-2:2004)*

EN ISO 14689-1, *Geotechnical investigation and testing — Identification and classification of rock — Part 1: Identification and description (ISO 14689-1:2003).*

3 Terms and definitions

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

3.1
admixture
fr: additif, addition de: Zusatzmittel
dispersant, fluidifier, retarding agent

3.2
binder
fr: liant de: Bindemittel
chemically reactive materials (lime, cement, gypsum, blast furnace slag, fly ash, etc.)

3.3
binder content
fr: teneur pondéral en liant de: Bindemittelgehalt
weight of dry binder introduced per unit volume of soil to be treated

3.4
binder factor
fr: dosage volumique de liant de: Bindemittelfaktor
ratio of the weight of dry binder introduced to the dry weight of the soil to be treated

3.5
blade rotation number
fr: nombre de rotation d'aile de: Flügelumdrehungszahl
total number of mixing blade rotations per m of shaft movement.

3.6
column
fr: colonne de: Säule
pillar of treated soil manufactured *in situ* by a single installation process using a mixing tool. The mixing tool and the execution process govern the shape and size of the cross section of a column

3.7
dry mixing
fr: malaxage par voie sèche de: Trockenmischverfahren
process consisting of mechanical disaggregation of the soil *in situ* and its mixing with binders with or without fillers and admixtures in dry powder form

3.8
filler
fr: fines inerte, charge inerte de: Füller
non-reacting material (sand, limestone powder etc.)

3.9
mixing energy
fr: energie de malaxage de: Mischungsenergie
resources used for operating machinery

3.10
mixing process
fr: processus de malaxage de: Mischvorgang
involves mechanical disaggregation of the soil structure, dispersion of binders and fillers in the soil

3.11
mixing tool
fr: outil de malaxage de: Mischwerkzeug
tool used to disaggregate the soil, distribute and mix the binder with the soil, consisting of one or several rotating units equipped with several blades, arms, paddles with/without continuous or discontinuous flight augers (see Annex A)

3.12
penetration (downstroke)
fr: enfoncement (descente de l'outillage) de: Abbohrvorgang
stage/phase of mixing process cycle, in which the mixing tool is delivered to the appropriate depth and initial mixing and fluidisation of the soil take place

3.13
penetration or retrieval speed
fr: vitesse d'enfoncement ou de remontée de: Abbohr- bzw. Ziehgeschwindigkeit
vertical movement per unit time of the mixing tool during penetration or retrieval

3.14
penetration or retrieval rate
fr: vitesse d'enfoncement ou de remontée par tour de: Abbohr- bzw. Ziehrate
vertical movement of the mixing tool per revolution of the rotating unit(s) during penetration or retrieval

3.15
retrieval (upstroke)
fr: remontée (montée de l'outillage) de: Ziehvorgang
stage/phase of mixing process cycle, in which the final mixing and retrieval of the mixing tool take place

3.16
restroke
fr: re-malaxage de: wiederholter Mischvorgang
restroke is an additional penetration and retrieval cycle of the mixing tool to increase the binder content and/or the column homogeneity

3.17
rotation speed
fr: vitesse de rotation de: Umdrehungsgeschwindigkeit
number of revolutions of the rotating unit(s) of the mixing tool per unit time

3.18
stroke
fr: malaxage de: Mischvorgang
one complete cycle of the mixing process

3.19
volume ratio
fr: teneur volumique en coulis de: Volumenverhältnis
ratio of the volume of slurry injected (in wet mixing) to the volume of soil to be treated

3.20
water/binder ratio
fr: rapport eau/liant de: Wasser-/Bindemittel-Verhältnis
weight of water added to the dry binder divided by the weight of the dry binder

3.21
wet mixing
fr: malaxage par voie humide de: Nassmischverfahren
process consisting of mechanical disaggregation of the soil *in situ* and its mixing with a slurry consisting of water, binders with or without fillers and admixtures

4 Information needed for the execution of the work

4.1 General

4.1.1 Prior to the execution of the work, all necessary information shall be provided.

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. adjacent to the work;

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 etc);

b) the existing underground structures, services, known contamination, and archaeological constraints;

c) the environmental restrictions, including noise, vibration, pollution;

d) future or ongoing construction activities, such as dewatering, tunnelling, deep excavations.

4.2 Particular requirements

4.2.1 The following information shall also be provided:

a) previous experience of deep mixing or special geotechnical works adjacent to the site, including the results of field tests to confirm the design;

b) underground contamination or hazards that can affect the execution method, the work safety or the discharge of excavation material from the site.

4.2.2 The following instructions shall be given:

a) reporting procedure for unforeseen circumstances, or conditions revealed that appear to be different from those assumed in the design;

b) reporting procedure, if an observational method of design is adopted;

c) notice of any restrictions such as construction phasing required in the design;

d) a schedule of any testing and acceptance procedures for materials incorporated in the works.

4.2.3 Any additional or deviating requirements falling within the permission clauses given in this document shall be established and agreed upon before the commencement of the works.

5 Geotechnical investigation

5.1 General

5.1.1 The depth and the extent of any investigations shall be sufficient to allow determination of the ground conditions in accordance with the requirements of EN 1997-1.

5.1.2 Laboratory and field investigations shall comply with prEN 1997-2 and the relevant European Standard EN 196-1 to -8, EN 196-21, EN 197-1 and -2, EN 451, EN 459-1 and -2, ENV 10080, EN 12716, EN 791 and EN ISO 14689-1).

5.1.3 Relevant experience of the execution of comparable deep mixing works under similar conditions in the vicinity of the site shall be taken into account when determining the extent of the site investigation.

5.1.4 The site investigation report shall be made available together with all relevant data known to affect the choice of method.

5.1.5 Boreholes or trial pits shall be suitably sealed not to affect groundwater movement and/or subsequent deep-mixed column construction and performance.

5.2 Specific information

5.2.1 Identification and classification of soil shall comply with EN ISO 14688-1 and EN ISO 14688-2.

5.2.2 Apart from the general geological description and the details listed in EN 1997-1, the site investigation report shall contain the following information regarding ground conditions for the execution of deep mixing:

a) the composition, lateral extent, thickness and firmness of the surface stratum, tree roots, fill, etc.;

b) presence of cobbles or boulders, cemented layers or underlying rock that can cause difficulties for the execution or could require special methods or tools;

c) presence of swelling soil (montmorillonite);

d) cavities, voids or fissures;

e) piezometric levels of groundwater, its variation and possible artesian pressure;

5.2.3 When relevant, the following additional information should be provided:

5.2.3.1 Physical and state characteristics:

a) consistency limits;

b) classification;

c) density;

d) grain size distribution;

e) mineralogy;

f) natural water content;

g) organic content.

5.2.3.2 Mechanical characteristics:

a) deformation and consolidation;

b) strength (shear, compressive and tensile);

c) permeability.

5.2.3.3 Environmental, chemical and biological characteristics:

a) groundwater quality (e.g. contamination, aggressiveness, chemistry, pH- value, type and concentration of ions and metals (reference measurements);

b) contamination test data;

c) leaching tests.

5.2.4 The ground level and location at any point of investigation or testing should be established relative to the recognised national datum or to a fixed reference point.

6 Materials and products

6.1 General

6.1.1 Construction of deep mixing involves the addition of a binder and, if needed, one or more of the following components to the soil:

a) admixture;

b) water;

c) filler;

d) structural reinforcement.

6.1.2 All materials and products for incorporation in deep mixing shall be in accordance with the relevant European Standards. Where the respective European Standards are not available, the use of materials and products shall be in accordance with the national standards and/or guidance.

6.1.3 All materials and products used shall comply with local environmental regulations.

6.1.4 All materials and products used shall comply with the design specifications.

6.1.5 Appropriate tests shall be provided in order to ensure compliance with the design specifications for materials not covered by existing standards.

6.1.6 The sources of supply materials shall be documented and shall not be changed without prior notification.

6.2 Special considerations

6.2.1 Water from other sources than recognised potable water shall be tested to determine whether or not it is suitable for the intended use.

6.2.2 Environmentally significant traces of chemical substances in materials and products may be present as normally occurring impurity, and their environmental impact may need to be assessed.

7 Considerations related to design

7.1 General

7.1.1 The *in-situ* strength of columns is influenced by several factors, such as properties of the soil to be treated, mixing condition, mixing tool and mixing process, curing condition, type and amount of binder, ground conditions, etc. Therefore it can be difficult to estimate the field strength accurately at the design stage. It is important to estimate and verify the field strength in several stages by laboratory mixing tests, accumulated experience, field trials and verification tests. The design should be modified if the requirements cannot be fulfilled.

7.1.2 The execution of deep mixing projects involves geotechnical design in several phases and can be an iterative process. The objective of the design is to produce technical documents, which enable works to be constructed with regard to safety, serviceability, economy and durability, taking into account the expected service life. It is recommended that the parties responsible for the design should be involved also during the construction.

7.1.3 The geotechnical design of deep mixing projects shall be based on ENV 1991, EN 1997-1 and prEN 1997-2. The informative Annex B summarises important parameters, which affect overall stability and settlement of the treated ground.

7.1.4 Reference to relevant experience is permitted if appropriate verification has been undertaken (e.g. by penetration tests, pressuremeter tests or other tests).

7.1.5 A method statement shall be prepared, which details the deep mixing works. As a minimum requirement, the method statement shall detail the location and the purpose of the works, the required design life, possible restrictions during the construction phase and any hazards associated with the execution of the works.

7.1.6 When there is some latitude in the selection of materials, the method statement shall emphasise the particular requirements, which can influence the final selection.

7.1.7 Preliminary design can be based on tests of laboratory mixed samples and comparable experience, taking into account the difference in characteristics between laboratory mixed samples and treated soil *in-situ*.

NOTE For guidance, reference is made to Annex B.

7.1.8 Testing may not be sufficient to verify the adequacy of the treatment. Appropriate supervision, monitoring and records are required. An observational approach is often appropriate and design is not normally complete until site experience is gained.

7.2 Additional design considerations

7.2.1 Loading conditions, climatic effects, hydraulic conditions, and acceptable limits of settlement, heave, distortion of structures and services, which may be affected by the deep mixing works, shall be taken into account.

7.2.2 The design should identify and take into account environmental restrictions on construction, such as noise, vibration, pollution of air and water and impact on adjacent structures.

7.2.3 Where end-bearing capacity of the column is required, the use of a suitable mixing tool and mixing process shall be prescribed to avoid forming a remoulded zone at the base of the column.

7.2.4 The specified column or wall layout and tolerances should take into account the limitations of the mixing equipment.

7.2.5 For grid type or block type or overlap columns; the specified spacing between the columns shall take into account the angular deviation and the positional tolerances.

7.2.6 Amendments necessitated by unforeseen circumstances, such as essential changes in ground or hydraulic conditions, shall be reported immediately.

7.2.7 Suitable protection and testing should be specified when treated soils are likely to be exposed to freeze/thaw cycles.

7.2.8 Consequences due to exposure of the columns to chemical and physical effects shall be considered in the design. Particular consideration regarding long-term durability is needed in marine environments or contaminated ground conditions.

7.3 Selection of the binder and the additives

7.3.1 The site and ground conditions and the nature and properties of the soil to be treated shall be considered in the selection of binder.

7.3.2 The efficiency of the binder and the admixture shall be studied by laboratory and/or *in-situ* tests of the treated soil, taking into account the prescriptions given in 7.4.

7.4 Laboratory and in-situ mixing and treatment tests

7.4.1 As the properties of the treated soil are influenced by numerous factors, including the execution process, preliminary trials and tests of the treated soil shall be carried out to confirm that the design requirements can be achieved.

7.4.2 When studying treated soil one should consider that laboratory test results might overestimate the achievable field results (owing to e.g. the use of more thorough mixing in the laboratory and to varying cure conditions).

7.4.3 When studying the process and the behaviour of treated soil, the improvement of soil with time should be considered. The rate of improvement depends on the type and quantity of binder utilised and the curing

condition. When studying the effect of time on trial mix specimens, considerations should be given to the effect of curing conditions (temperature, curing under water, preloading etc.).

7.4.4 Sequence and rate of execution, setting and hardening time, and diameter of the columns shall be considered in order to avoid local soil failure or unacceptable settlement or heave.

7.4.5 Where deep mixing is used to immobilise contaminants or to stabilise waste deposits, or for similar purposes where there may be unpredictable interaction between binder and *in-situ* material, site-specific test programmes shall be executed.

7.5 Design statement

7.5.1 The design output should state the performance objectives and geometry of the treatment, the specification of materials or products assumed in the design, any further details such as phasing of the works and, where relevant, provide the following information:

a) specifications for the deep mixing work;

b) column requirements (strength and deformation characteristics and permeability);

c) the width of the overlapping portion between adjacent columns;

d) tolerances for columns in respect of length, diameter, inclination and plan position;

e) boundaries and geometry of installation, setting out drawings;

f) construction programme, including time schedule for loading and possible preloading, and notice of any restrictions such as construction phasing required in the design;

g) a schedule of any testing and acceptance procedures for materials incorporated in the works and of any required testing and monitoring procedures during execution;

h) requirements concerning possible structural reinforcement (class of material and installation procedure) and time schedule for its installation;

i) toe penetration into bearing or impermeable stratum;

j) reporting procedure for unforeseen circumstances, or conditions revealed that appear to be different from those assumed in the design, or if an observational procedure is adopted.

7.5.2 Whenever acceptance is defined on the basis of tests of core samples, the design shall specify location, age at test, coring equipment and procedure.

7.5.3 For mechanical tests on treated soil, the conditions of testing the samples and the criteria for acceptance shall be specified. Tolerances in respect of specified performance parameters shall consider the adequacy of the proposed test method, especially when these methods are indirect, as described in Annex B.

7.5.4 Limiting values of critical geotechnical design parameters shall be stated, as well as steps to be taken if values are likely to be exceeded.

7.5.5 Any additional or deviating requirements, falling within the permission clauses given in the standard, shall be established and agreed upon before the commencement of the work.