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Zemeljska dela - 1. del: Načela in splošna pravila

Earthworks - Part 1: Principles and general rules

Erdarbeiten - Teil 1: Grundsätze und allgemeine Regeln

Terrassement - Partie 1 : Principes et règles générales

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Earthworks - Part 1: Principles and general rules

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Erdarbeiten - Teil 1: Grundsätze und allgemeine Regeln

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

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Contents	Page
European foreword.....	5
Introduction	6
1 Scope.....	7
2 Normative references.....	7
3 Terms and definitions	7
4 Principles of earthworks design and execution.....	8
4.1 General.....	8
4.2 Stages of earthworks projects.....	8
4.3 Instructions for the execution of works.....	9
4.4 Design of earthworks and design of earth-structures.....	10
4.5 Earthworks, sustainable development and the environment	12
4.6 Risk management.....	13
4.7 Types of earthworks	13
5 Specific site and material investigations.....	13
5.1 Information needed for earthworks design.....	13
5.2 Coordination of geotechnical investigations for earth-structure and earthworks.....	14
5.2.1 General.....	14
5.2.2 Site investigations for geotechnical design	14
5.2.3 Specific geotechnical investigations for earthworks	15
5.2.4 <i>Geotechnical reporting</i>	16
5.3 Use of classification systems	16
6 Design of earthworks for embankments.....	17
6.1 Introduction.....	17
6.2 Design procedure.....	18
6.2.1 General.....	18
6.2.2 Embankment zones	18
6.3 Selection of the fill material properties and compaction process.....	23
6.3.1 General.....	23
6.3.2 Characterization of materials	24
6.3.3 Criteria for assessing the compacted fill material	24
6.3.4 Compaction behaviour of fill materials.....	25
6.3.5 Relationship testing to assess fill performance	28
6.3.6 Link between construction method and earthworks fill design.....	28
6.3.7 Validation of the compaction process for a given fill material.....	28
6.3.8 Design of embankment cross-section.....	29
6.4 Design of specific parts of embankments.....	29
6.4.1 Introduction.....	29
6.4.2 Capping layers.....	29
6.4.3 Transition zones.....	30
6.4.4 Embankments on slopes.....	32
6.4.5 Specific materials	32
6.4.6 High embankments	34
6.4.7 Embankments on soft soils.....	34
6.4.8 Embankments built above cavities.....	35

6.4.9	Surplus materials.....	35
7	Design of earthworks for cuttings	35
7.1	General	35
7.2	Materials involved.....	36
7.3	Geometry	36
7.4	Drainage.....	36
7.5	Overall stability.....	37
7.6	Relevant properties of the cutting base (subgrade)	37
8	Design of earthworks formed by dredging and hydraulic placement of fills	37
9	Design of earthworks for hydraulic placement of mineral wastes.....	38
10	Drainage.....	39
10.1	Drainage for collecting water.....	39
10.2	Protection of slopes against erosion.....	41
11	Optimization of earthworks project design	42
12	Specifications for earthworks	43
12.1	General	43
12.2	End product Specification.....	44
12.3	Method Specification	45
12.4	Performance Specification	45
12.5	Additional requirements for deep fill areas/buildings and structures.....	46
13	Execution of earthworks	46
14	Monitoring earthworks and checking earth-structures performance.....	47
14.1	Introduction.....	47
14.2	Needs and techniques for monitoring and checking earthworks	47
14.3	Checking earth-structure performance.....	48
15	Use of national experience and non-conflicting rules.....	48
15.1	General	48
15.2	Informative examples of experience-based national practices.....	49
Annex A (informative)	Example of procedure for the validation of the compaction process for a given fill material. Organization and execution of trial sections	50
Annex B (informative)	Geometry definitions for earthworks and earth-structures	52
Annex C (informative)	Summary of national practice - France.....	55
C.1	Introduction.....	55
C.2	Classification of materials	55
C.3	Design of Earthworks	59
C.4	Control of earthworks.....	70
C.5	References.....	74
Annex D (informative)	Summary of national practice - Germany.....	75
D.1	Introduction.....	75
D.2	Classification of materials	76
D.3	Execution of earthworks	83
D.4	Control of Earthworks.....	87

D.5	References	89
Annex E (informative) Summary of national practice - Norway		91
E.1	Introduction	91
E.2	Classification of materials.....	91
E.3	Design of earthworks.....	92
E.4	Quality control of earthworks	104
E.5	References	106
Annex F (informative) Summary of national practice - Spain.....		107
F.1	Introduction	107
F.2	Classification of materials.....	107
F.3	Possible use of marginal materials.....	110
F.4	Preliminary design of earth-structure cross section	112
F.5	Types of earthstructures to be built.....	113
F.6	Basic construction rules	113
F.7	Control of earthworks	116
F.8	Reference	118
Annex G (informative) Summary of national practice – Sweden		119
G.1	Introduction	119
G.2	Classification of materials.....	119
G.3	Design of earthworks.....	121
G.4	Control of earthworks	121
Annex H (informative) Summary of national practice - United Kingdom.....		123
H.1	Introduction	123
H.2	Classification of materials.....	123
H.3	Design of earthworks.....	126
H.4	Control of earthworks during construction	133
H.5	References	134

European foreword

This document (prEN 16907-1:2016) has been prepared by Technical Committee CEN/TC 396 “Earthworks”, the secretariat of which is held by AFNOR.

This document is currently submitted to the CEN Enquiry.

This document is one of the European Standards within the framework series of EN 16907 on *Earthworks*, as follows:

- *Part 1: Principles and general rules* (this document);
- *Part 2: Classification of materials*;
- *Part 3: Construction procedures*;
- *Part 4: Soil treatment with lime and/or hydraulic binders*;
- *Part 5: Quality control*;
- *Part 6: Land reclamation with dredged hydraulic fill*;
- *Part 7: Hydraulic placement of mineral waste*.

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Introduction

Earthworks are a civil engineering process aimed at creating earth-structures by changing the geometry of the earth surface for construction or other activities. Application fields of earthworks are associated with:

- transport infrastructures (road and motorways, railways, waterways, airports);
- platforms for industrial, commercial and residential buildings;
- water engineering, flood defence and coastal protection works;
- harbours and airport areas, including the construction of embankments in water;
- river dykes and marine embankments for land reclamation;
- earth and rock fill dams;
- onshore embankments made of hydraulically placed fill;
- landscaping embankments;
- backfilling of open mines;
- tailing dams;
- etc.

They are characterized by the need to use available natural or recycled materials and to handle them in a way appropriate to yield prescribes properties.

The set of standards prepared by CEN/TC 396 is divided into several parts, which correspond to different steps of the planning, execution and control of earthworks and should be considered for executing earthworks:

- Part 1: Principles and general rules (this document);
- Part 2: Classification of materials;
- Part 3: Construction procedures;
- Part 4: Soil treatment with lime and/or hydraulic binders;
- Part 5: Quality control;
- Part 6: Land reclamation with dredged hydraulic fill;
- Part 7: Hydraulic placement of mineral waste.

These “Earthworks standards” do not apply to the environmental planning and geotechnical design that determines the required form and properties of the earth-structure that is to be constructed (these aspects are covered in other European Standards). They apply to the design of the earthworks materials, execution, monitoring and checking of earthworks construction processes to ensure that the completed earth-structure satisfies the geotechnical design.

1 Scope

This European Standard (Part 1) gives definitions, principles and general rules for the planning, design and specification of earthworks. It introduces the other parts of the standard, which need to be used together with Part 1.

It is applicable to all types of earth-structures, whatever their intended use is (roads, railways, airfields, waterways, buildings, landfills, tailing dams, etc.), except where listed below:

- some specific types of works such as the execution of trenches and small earthworks may be organized using simplified or specific rules;
- some structures, such as dykes and dams, need earthworks which have specific design and construction requirements: these may extend beyond the rules of this standard.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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

3 Terms and definitions

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

3.1

earthworks

civil engineering process that modifies the geometry of ground surface, by creating stable and durable earth-structures

3.2

earth-structure

civil engineering structure, made of soils, rocks, by-products or recycled materials, resulting from earthworks (cutting, embankment)

3.3

design of earthworks

defining of the construction process to produce a specified earth-structure

3.4

materials

all soils, rocks, by-products and recycled materials handled during earthworks

Note 1 to entry: Materials do not include binders, geosynthetics and other materials, which are designated by their own name.

3.5

fill material

material used for the construction of an embankment

prEN 16907-1:2016 (E)**3.6****embankment**

any earth-structure formed by the placement of fill material in a controlled manner (including the infilling of large excavations, and earth-structures formed by dredging)

3.7**embankment zone**

subdivision of an embankment, such as the base, the core, the shoulders and the upper zone

3.8**superstructure**

any type of civil engineering construction placed on top of an embankment

Note 1 to entry: Examples of superstructure are road, rail track, building, etc.

3.9**capping layer**

specific transition layer, part of the upper zone, placed below the superstructure

3.10**cutting**

structure produced by excavating ground

Note 1 to entry: The geometry of earth-structures and parts of them (layers, surfaces, etc.) are not always described in the same way in different languages and countries. Drawings explaining the meaning of these geometric terms are given in informative Annex B.

4 Principles of earthworks design and execution**4.1 General**

Earthworks include to extract, load, transport, transform/improve, place, stabilize and compact natural materials (soils, rocks), by-products or recycled materials in order to obtain stable and durable cuttings, embankments or engineered fills, with prescribed properties. These works may be executed underwater. Earthworks require planning, design, construction and maintenance. They depend on the properties on the materials, the required properties of the structure and the environment.

This document gives rules relative to the organization of earthworks projects and their design and planning.

4.2 Stages of earthworks projects

Each earthworks project consists of two main stages:

- pre-construction studies, including:
 - the analysis of the earth-structure to be built;
 - site investigations and classification of materials (prEN 16907-1:2016, Clause 5 and prEN 16907-2:2015, Clause 5);
 - assessment of the compatibility of these materials with the required properties of the earth-structure (prEN 16907-1:2016, Clauses 6, 7, 8 and 9);
 - selection of a construction procedure (prEN 16907-1, -3, -6 and -7);

- optimization of earthworks at the scale of the whole project (prEN 16907-1:2016, Clause 11);
- specifications for executing the works (construction procedure, monitoring, quality control) (prEN 16907-1, -3, -5, -6 and -7);
- execution of works (construction):
 - installation on site;
 - checking the design assumptions (that may be revised, if necessary);
 - execution of works as specified;
 - monitoring;
 - quality assessment;
 - checking the characteristics of the completed earth-structure vs. the requirements, leading to the acceptance of the results of the earthworks.

4.3 Instructions for the execution of works

The design of earthworks shall produce detailed instructions to be imposed on the execution of works (Parts 3 to 7). These instructions include such items as:

- for building sites:
 - type and consistency of the area to be worked with;
 - foundation level, type of foundation and construction of buildings nearby;
 - type and consistency of existing enclosure or retaining structures;
 - type, position, dimension and owner of natural or artificial cavities and obstacles (anchors, geosynthetics, stone columns, sealing bodies, grouted material, etc.);
- for embankments and cuttings:
 - quantity (volume), type, position, dimensions and structure of the earth-structures;
 - quantity, type, position, dimensions, formations and purpose of construction pits and trenches, including minimum dimensions of the working space;
 - inclination of slopes and development of berms;
 - deviations from the specified dimensions for ablation or removal profiles; especially for planum and coating thickness;
 - protection for construction pits and trenches, embankments and slopes;
 - efforts related to the laying and reconstruction of the protection for construction pits and trenches, embankments and slopes;
 - keeping a protective layer above foundation level, thickness of the protective layer and moment of removal;

prEN 16907-1:2016 (E)

- description and classification of soils, rocks and other materials, en accordance with Part 2;
- main differences to do with properties and conditions of soils, rocks and other materials before and after excavation;
- constraints concerning the use of specific materials, especially by-products and recycled materials;
- usage, treatment and processing of soils, rocks and other materials as well as type of laying or other uses;
- type, position, length, conditions and potential restrictions on the usage of transportation routes;
- type and possibilities of storage place;
- usage of soils for planting purposes;
- type and scope of verifications of suitability and certificates of quality requested by the Contractor for materials to be delivered;
- requirements and proofs of compaction;
- guidelines resulting from expert's reports — specially for geotechnical reports and hydrogeology — and to what extent those guidelines should be followed concerning the execution;
- guidelines resulting from water law permits;
- collection and derivation of surface water from neighbouring areas as well as groundwater, stratum water, spring water and leachate;
- development of access from the earthworks to the other constructions;
- installation of geosynthetic material;
- quantity, type, position, dimensions and masses of installation, i.e. level of settlement, shaft rings, pipes;
- guidelines resulting from geotechnical calculations and analyses;
- cleaning of construction elements that were laid open;
- protection and security measures for construction at risk.

4.4 Design of earthworks and design of earth-structures

The design of earthworks differs from the design of earth-structures.

The design of earth-structures in terms of stability and deformations is ruled by EN 1997 (Eurocode 7) and other relevant standards. Geotechnical and structural design produces the requirements put on the properties and functions of the completed structure (geometry, stiffness, bearing capacity, permeability...). The standards on earthworks all assume that the earth-structure to be built has been properly designed.

For earthworks, “designing” means “defining the process” enabling to transform natural *in situ* ground (soil or rock) and/or by-products or recycled materials into a well compacted and durable embankment with the required properties or a stable cut. This decision process includes the characterization of natural ground, the choice of suitable equipment and rules to plan extraction, transport, compaction and control of the materials. The products of this design include risk assessment reports, execution plans, time-tables, work-flow schemes, etc. These conditions may be met by experience-based prescriptions or by performance-based design.

Design of earthworks shall account for:

- the type of structure (cutting, embankment, etc.);
- the required properties of the completed structure;
- the nature and state of materials to be handled (prEN 16907-2);
- the hydrogeological and meteorological contexts;
- the importance of the earth-structure to be built;
- the type of available equipment to perform the works (prEN 16907-3);
- the possibilities offered by material treatment for fill construction (prEN 16907-4);

Design prepares specifications for executing the works (prEN 16907-3, -4, -6, -7);

The specifications resulting from the design phase describe the details of the construction process. They shall be used to prepare the monitoring and quality control procedures. Specifications include:

- the assumed nature (classes) of materials, which shall be checked during the execution of works,
- the mechanical process used for extraction, transport, layering, eventual treatment with binders or aeration/humidification and compaction;
- the destination of every volume of excavated material;
- the location of temporary or permanent disposals;
- the schedule of operations;
- the climatic restrictions, for example how to proceed at temperatures close to freezing;
- the procedures and planning of monitoring and control activities during the execution of the works;
- requirements for the protection of the earthworks to avoid deterioration of the fill material or subgrade.

Earth-structure design strongly depends on the available materials and the possibility to reach the expected result through earthworks. Designers are therefore expected to at least globally account for earthworks design when they design earth-structures. Consideration shall be given to available materials, site conditions, land requirements, including all temporary works and the limitation of environmental impact during the construction phase, in use and for future maintenance operations.

Site conditions include:

- constraints due to nature: physical adaptation to the site (topography, geology, geomorphology, hydrogeology, climate, and climate change, use of land), floods, landslides, old mines, etc.;

prEN 16907-1:2016 (E)

- constraints due to: archaeology/historical heritage, the environment, the owners and inhabitants, unexploded ordnance (bombs), etc.;
- constraints due to existing service lines (e.g. high tension electric lines, water, oil and gas pipelines).

These constraints are normally considered in the civil engineering project and are outside the scope of this standard.

4.5 Earthworks, sustainable development and the environment

Earthworks should be designed with sustainability in mind. For the purpose of this European Standard, sustainable development is taken to mean: “an enduring, balanced approach to economic activity, environmental responsibility and social progress”. Some aspects of sustainable development are covered at the level of the project and not directly linked to the execution of earthworks.

Examples of contributions of earthworks to sustainable development are:

- the preservation of natural resources by optimising the re-use of site materials;
- the limitation of heavy vehicles traffic to bring materials to the construction site;
- the reduction of the externalisation of stockpiles and borrow pits;
- the use of techniques with low environmental impact, such as aeration or the use of industrial by-products;
- the diminution of energy consumption for transport and compaction of fills and the reduction of emitted gases (carbon dioxide);
- the decrease of water consumption (ploughing sprinkler, dust fixing products);
- the optimization of costs and duration of works.

Environmental considerations concern either the completed earth-structure or the execution of earthworks. This European Standard deals with effects of earthworks only (Part 3). Consideration shall be given to:

- noise and vibrations;
- road traffic;
- waste and contaminated ground management;
- dust production, including binders in case of fill material treatment;
- pollution of air and water;
- onsite and offsite disposal of excess or unsuitable materials.

All these environmental questions shall be answered with respect to existing laws, standards and other good practice rules.

The presence of polluted soils and possible use of manufactured or recycled materials of industrial or mining processes should be considered from the beginning of a project to maximize chances of re-use.

4.6 Risk management

The management of risk should be a key aspect of complex projects involving earthworks as in all construction activity. The areas of risk to be managed include:

- programme, quality and financial risks to ensure the successful delivery of the project;
- health and safety, along with environmental risks to satisfy statutory requirements.

On large or complex earthworks projects, it can be advantageous if each design team develops and maintains a risk register for the element of the works that they are responsible for.

Special risks for earthworks projects are related to geotechnics like:

- unknown site conditions due to inadequate soil investigation;
- the impact on adjacent structures/infrastructure;
- the sensitivity of the soils together with the weather during execution (and more generally, the climate);
- the failure of drainages and dewatering systems;
- the safety of dams and slopes; and
- the environment (e.g. building in protected areas, use of dangerous substances).

In the case of earthworks, the risks are likely to be captured within a geotechnical risk register, which can be used to enable the design team to manage out or minimize some of the risks associated with the earthworks element of the project. All residual risks should be managed at the global project level.

4.7 Types of earthworks

Earthworks encompass a large range of activities, which cannot be covered by a unique set of rules. Experience and existing rules apply to one of the following four types of works, which serve as a guide for the parts and clauses of this standard:

- construction of embankments (prEN 16907-1, -3, -4, -5 and -6:2015, Clause 6);
- execution of cuts and excavations (prEN 16907-1, -3:2015, Clause 7);
- hydraulic placement of dredged material (prEN 16907-1 and -6:2015, Clause 8);
- hydraulic placement of soils and mineral waste (prEN 16907-1 and -7:2015, Clause 9).

5 Specific site and material investigations

5.1 Information needed for earthworks design

The description, identification, classification and characterization of soils, rocks and other fill materials are an essential part of the design of earthworks. They yield the necessary information to determine the nature of each material, the best way to take that material from excavations or cuttings, the final state it may reach after compaction and the best way to achieve this final state.

The description of natural and man-made materials for earthworks should cover:

- the type of material (soils, rocks, other materials);