

This document is a preview generated by EVS

Earthworks - Part 6: Land reclamation earthworks using dredged hydraulic fill

EESTI STANDARDI EESSÕNA

NATIONAL FOREWORD

See Eesti standard EVS-EN 16907-6:2018 sisaldab Euroopa standardi EN 16907-6:2018 ingliskeelset teksti.	This Estonian standard EVS-EN 16907-6:2018 consists of the English text of the European standard EN 16907-6:2018.
Standard on jõustunud sellekohase teate avaldamisega EVS Teatajas.	This standard has been endorsed with a notification published in the official bulletin of the Estonian Centre for Standardisation.
Euroopa standardimisorganisatsioonid on teinud Euroopa standardi rahvuslikele liikmetele kättesaadavaks 05.12.2018.	Date of Availability of the European standard is 05.12.2018.
Standard on kättesaadav Eesti Standardikeskusest.	The standard is available from the Estonian Centre for Standardisation.

Tagasisidet standardi sisu kohta on võimalik edastada, kasutades EVS-i veebilehel asuvat tagasiside vormi või saates e-kirja meiliaadressile [standardiosakond@evs.ee](mailto:standardiosakond@evs.ee).

ICS 93.020

Standardite reproduutseerimise ja levitamise õigus kuulub Eesti Standardikeskusele

Andmete paljundamine, taastekitamine, kopeerimine, salvestamine elektroonsesse süsteemi või edastamine ükskõik millises vormis või millisel teel ilma Eesti Standardikeskuse kirjaliku loata on keelatud.

Kui Teil on küsimusi standardite autorikaitse kohta, võtke palun ühendust Eesti Standardikeskusega:  
Koduleht [www.evs.ee](http://www.evs.ee); telefon 605 5050; e-post [info@evs.ee](mailto:info@evs.ee)

The right to reproduce and distribute standards belongs to the Estonian Centre for Standardisation

No part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying, without a written permission from the Estonian Centre for Standardisation.

If you have any questions about copyright, please contact Estonian Centre for Standardisation:

Homepage [www.evs.ee](http://www.evs.ee); phone +372 605 5050; e-mail [info@evs.ee](mailto:info@evs.ee)

EUROPEAN STANDARD  
NORME EUROPÉENNE  
EUROPÄISCHE NORM

EN 16907-6

December 2018

ICS 93.020

English Version

Earthworks - Part 6: Land reclamation earthworks using  
dredged hydraulic fill

Terrassements - Partie 6 : Terre-plein en remblai  
hydraulique dragué

Erdarbeiten - Teil 6: Landgewinnung mit  
nassgebaggertem Einbaumaterial

This European Standard was approved by CEN on 14 May 2018.

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 CEN-CENELEC Management Centre 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 CEN-CENELEC Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.



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

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

## Contents

	Page
<b>European foreword .....</b>	<b>5</b>
<b>Introduction.....</b>	<b>6</b>
<b>1 Scope .....</b>	<b>7</b>
<b>2 Normative references .....</b>	<b>7</b>
<b>3 Terms and definitions.....</b>	<b>9</b>
<b>4 Symbols and abbreviations.....</b>	<b>13</b>
<b>5 Stages of land reclamation projects.....</b>	<b>13</b>
<b>6 Design aspects for earthworks with dredged hydraulic fill .....</b>	<b>14</b>
<b>6.1 Introduction.....</b>	<b>14</b>
<b>6.2 Basis of Design .....</b>	<b>14</b>
<b>6.2.1 General .....</b>	<b>14</b>
<b>6.2.2 Scope of Work .....</b>	<b>15</b>
<b>6.2.3 The project site.....</b>	<b>15</b>
<b>6.2.4 Standards and Codes of Practice .....</b>	<b>15</b>
<b>6.2.5 Functional requirements .....</b>	<b>15</b>
<b>6.2.6 Boundary conditions and constraints.....</b>	<b>15</b>
<b>6.2.7 Performance requirements .....</b>	<b>16</b>
<b>6.2.8 Site data.....</b>	<b>16</b>
<b>6.2.9 Borrow area.....</b>	<b>16</b>
<b>6.2.10 Environmental constraints .....</b>	<b>17</b>
<b>6.2.11 Regulations, permits and licenses .....</b>	<b>17</b>
<b>6.3 General design aspects .....</b>	<b>17</b>
<b>6.3.1 Earth-structure design aspects.....</b>	<b>17</b>
<b>6.3.2 Morphological and environmental aspects.....</b>	<b>17</b>
<b>6.4 Boundary conditions affecting the execution.....</b>	<b>18</b>
<b>6.4.1 General .....</b>	<b>18</b>
<b>6.4.2 Locations of land reclamation area, borrow area and disposal site .....</b>	<b>18</b>
<b>6.4.3 Soil conditions at the land reclamation area.....</b>	<b>18</b>
<b>6.4.4 Soil conditions at the borrow area .....</b>	<b>18</b>
<b>6.4.5 Suitable fill material properties.....</b>	<b>19</b>
<b>6.4.6 Dredging close to existing structures.....</b>	<b>19</b>
<b>6.4.7 Construction tolerances .....</b>	<b>19</b>
<b>6.4.8 Return of process water .....</b>	<b>19</b>
<b>6.4.9 Ground improvement of the fill mass and the subsoil .....</b>	<b>19</b>
<b>6.4.10 Project execution time and milestones .....</b>	<b>19</b>
<b>6.5 Earthworks design considerations .....</b>	<b>20</b>
<b>6.5.1 Introduction.....</b>	<b>20</b>
<b>6.5.2 Land reclamation area.....</b>	<b>20</b>
<b>6.5.3 Borrow area.....</b>	<b>20</b>
<b>6.5.4 Available quantity of suitable fill material.....</b>	<b>21</b>
<b>6.6 Design considerations in relation to dredging equipment.....</b>	<b>22</b>
<b>7 Technical specifications for earthworks with dredged hydraulic fill .....</b>	<b>22</b>
<b>7.1 Introduction.....</b>	<b>22</b>

7.2	Technical specifications for the subsoil .....	22
7.3	Technical specifications for the fill mass .....	22
7.4	Technical specifications for the fill material .....	23
8	Data collection .....	23
8.1	General .....	23
8.2	Bathymetrical and topographical data .....	24
8.3	Geotechnical and geophysical data .....	24
8.3.1	General .....	24
8.3.2	Geotechnical and geophysical data in the borrow area .....	24
8.3.3	Geotechnical and geophysical data in the land reclamation area .....	26
8.4	Hydrological and meteorological data .....	26
8.5	Seismic data .....	27
8.6	Morphological and environmental data .....	27
8.6.1	General .....	27
8.6.2	Sediment transport .....	27
8.6.3	Total Suspended Solids (TSS) and turbidity .....	28
8.6.4	Organic matter and gas .....	28
8.6.5	Contaminants .....	28
8.6.6	Underwater sound .....	28
8.7	Seabed features .....	28
8.8	Site constraints .....	29
9	Equipment .....	30
9.1	Selection of the dredging equipment .....	30
9.1.1	General .....	30
9.1.2	Selection of the dredging equipment based on the capabilities of the equipment .....	30
9.1.3	Selection of the dredging equipment based on hydraulic and meteorological conditions .....	30
9.1.4	Selection of the dredging equipment based on the presence of shipping .....	31
9.1.5	Selection of the dredging equipment based on environmental restrictions .....	31
9.2	Typical dredging equipment .....	31
9.3	Accuracy and tolerances .....	32
9.4	Minimal vessel requirements for monitoring and data logging .....	32
10	Design of the execution of earthworks with dredged hydraulic fill .....	33
10.1	Construction .....	33
10.1.1	General .....	33
10.1.2	Preparation phase .....	33
10.1.3	Construction phase .....	34
10.1.4	Post-construction phase .....	35
10.2	Selection of placement method .....	35
10.3	Preparation of the seabed for dredging and for the land reclamation works .....	37
10.4	Containment bunds .....	38
10.5	Process water management .....	39
10.6	Water table in the land reclamation area .....	39
10.7	Use of cohesive or fine grained materials .....	39
10.8	Ground improvement .....	39
11	Quality control .....	40
11.1	General .....	40
11.2	Quality Control Plan .....	40
11.3	Monitoring and testing .....	41
11.4	Dimensions and boundary conditions .....	41

<b>11.4.1 Borrow area.....</b>	<b>41</b>
<b>11.4.2 Land reclamation area.....</b>	<b>42</b>
<b>11.5 Quality of the fill material.....</b>	<b>42</b>
<b>11.5.1 Source material in borrow area .....</b>	<b>42</b>
<b>11.5.2 Fill material in land reclamation area .....</b>	<b>42</b>
<b>11.6 Fill mass .....</b>	<b>42</b>
<b>11.6.1 Bearing capacity.....</b>	<b>42</b>
<b>11.6.2 Slope stability.....</b>	<b>43</b>
<b>11.6.3 Consolidation and deformations.....</b>	<b>43</b>
<b>11.6.4 <i>In situ</i> density and density index .....</b>	<b>43</b>
<b>11.6.5 Permeability.....</b>	<b>45</b>
<b>11.6.6 Frequency of testing .....</b>	<b>45</b>
<b>11.6.7 Environmental monitoring .....</b>	<b>46</b>
<b>11.7 Handover documentation.....</b>	<b>47</b>
<b>Annex A (informative) Non EN and non ISO test and monitoring methods .....</b>	<b>48</b>
<b>A.1 General .....</b>	<b>48</b>
<b>A.2 Electrical piezometer .....</b>	<b>49</b>
<b>A.3 Inclinometer .....</b>	<b>49</b>
<b>A.4 Rod and plate settlement gauges .....</b>	<b>49</b>
<b>A.5 Settlement profiling tube.....</b>	<b>50</b>
<b>A.6 Trial embankment.....</b>	<b>50</b>
<b>A.7 Zone Loading Test .....</b>	<b>51</b>
<b>Annex B (informative) Determination of minimum and maximum dry densities and density index .....</b>	<b>52</b>
<b>B.1 General .....</b>	<b>52</b>
<b>B.2 British Standard procedures .....</b>	<b>52</b>
<b>B.2.1 General .....</b>	<b>52</b>
<b>B.2.2 Minimum dry density of sands.....</b>	<b>52</b>
<b>B.2.3 Minimum dry density of gravelly soils.....</b>	<b>53</b>
<b>B.2.4 Maximum dry density of sands .....</b>	<b>53</b>
<b>B.2.5 Maximum dry density of gravelly soils .....</b>	<b>53</b>
<b>B.3 ASTM procedures.....</b>	<b>53</b>
<b>B.3.1 General .....</b>	<b>53</b>
<b>B.3.2 Minimum index dry density .....</b>	<b>53</b>
<b>B.3.3 Maximum index dry density .....</b>	<b>54</b>
<b>B.4 Density index.....</b>	<b>54</b>
<b>Bibliography .....</b>	<b>55</b>

## European foreword

This document (EN 16907-6:2018) has been prepared by Technical Committee CEN/TC 396 "Earthworks", 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 June 2019, and conflicting national standards shall be withdrawn at the latest by June 2019.

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

This document is one of the European Standards within the framework series of EN 16907 on *Earthworks*. 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 collectively as a group of standards for executing earthworks. The full set of Parts is as follows:

- EN 16907-1 *Earthworks — Part 1: Principles and general rules*;
- EN 16907-2 *Earthworks — Part 2: Classification of materials*;
- EN 16907-3 *Earthworks — Part 3: Construction procedures*;
- EN 16907-4 *Earthworks — Part 4: Soil treatment with lime and/or hydraulic binders*;
- EN 16907-5 *Earthworks — Part 5: Quality control*;
- EN 16907-6 *Earthworks — Part 6: Land reclamation earthworks using dredged hydraulic fill* (this document);
- EN 16907-7 *Earthworks — Part 7: Hydraulic placement of extractive waste*.

Within this standard references to specific parts of the standard are written by the full reference (e.g. "EN 16907-2").

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. 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.

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

## Introduction

Dredging and land reclamation projects generally have three main stages: Pre-construction (Initiative, Initiation, Earth-structure Design and Procurement), Construction (including the earthworks design of a dredged hydraulic fill project) and Post-construction (Use and End of life).

This standard covers the execution stage of land reclamation with dredged hydraulic fill and the associated design of the works. The design of a land reclamation itself is not covered in detail in this standard. For the geotechnical design aspects of land reclamation works, reference is made to EN 1997-1, *Eurocode 7: Geotechnical design - Part 1: General rules* and the relevant parts of the EN 1998 series *Eurocode 8: Design of structures for earthquake resistance*.

The principles of dredging and hydraulic fill equipment are discussed in outline. For more detail reference is made to textbooks such as the *Hydraulic Fill Manual* [1].

## 1 Scope

This European Standard deals with underwater excavation and hydraulic placement of fill material for land reclamation projects.

The scope is limited to soils that exhibit free-draining behaviour during and after placement.

The main purpose of this European Standard is to ensure that functional requirements and specifications for such projects are in harmony with site boundary conditions and construction methods.

This European Standard specifies minimum requirements for site related data to be acquired before the procurement and execution stage of a dredging and land reclamation project.

This European Standard gives guidance on how the selection of the dredging equipment shall be undertaken. It also gives guidance on the selection of a borrow area and on the judgement regarding the suitability of the fill material for the project.

This European Standard offers the general principles on how to design the actual execution of a dredged hydraulic fill project and offers guidelines for monitoring and quality control of that execution in order to guarantee that the fill mass exhibits the behaviour as intended by the designer of the land reclamation.

This European Standard does not cover dredging and/or placement of rock, mine tailings, mineral wastes and contaminated soils.

## 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 933-7, *Tests for geometrical properties of aggregates — Part 7: Determination of shell content — Percentage of shells in coarse aggregates*

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

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

EN 1998 (all parts), *Eurocode 8 — Design of structures for earthquake resistance*

EN 13137, *Characterization of waste — Determination of total organic carbon (TOC) in waste, sludges and sediments*

EN 13286-47, *Unbound and hydraulically bound mixtures — Part 47: Test method for the determination of California bearing ratio, immediate bearing index and linear swelling*

EN ISO 10693, *Soil quality — Determination of carbonate content — Volumetric method (ISO 10693)*

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

EN ISO 17892-1, *Geotechnical investigation and testing — Laboratory testing of soil — Part 1: Determination of water content (ISO 17892-1)*

EN ISO 17892-3, *Geotechnical investigation and testing — Laboratory testing of soil — Part 3: Determination of particle density (ISO 17892-3)*

EN ISO 17892-4, *Geotechnical investigation and testing — Laboratory testing of soil — Part 4: Determination of particle size distribution (ISO 17892-4)*

EN ISO 17892-7, *Geotechnical investigation and testing — Laboratory testing of soil — Part 7: Unconfined compression test (ISO 17892-7)*

CEN ISO/TS 17892-8, *Geotechnical investigation and testing — Laboratory testing of soil — Part 8: Unconsolidated undrained triaxial test (ISO/TS 17892-8)*

CEN ISO/TS 17892-9, *Geotechnical investigation and testing — Laboratory testing of soil — Part 9: Consolidated triaxial compression tests on water saturated soil (ISO/TS 17892-9)*

CEN ISO/TS 17892-10, *Geotechnical investigation and testing — Laboratory testing of soil — Part 10: Direct shear tests (ISO/TS 17892-10)*

CEN ISO/TS 17892-11, *Geotechnical investigation and testing — Laboratory testing of soil — Part 11: Determination of permeability by constant and falling head (ISO/TS 17892-11)*

CEN ISO/TS 17892-12, *Geotechnical investigation and testing — Laboratory testing of soil — Part 12: Determination of Atterberg limits (ISO/TS 17892-12)*

EN ISO 18674-2, *Geotechnical investigation and testing — Geotechnical monitoring by field instrumentation — Part 2: Measurement of displacements along a line: Extensometers (ISO 18674-2)*

EN ISO 22282-2, *Geotechnical investigation and testing — Geohydraulic testing — Part 2: Water permeability tests in a borehole using open systems (ISO 22282-2)*

EN ISO 22476-1, *Geotechnical investigation and testing — Field testing — Part 1: Electrical cone and piezocone penetration test (ISO 22476-1)*

EN ISO 22476-2, *Geotechnical investigation and testing — Field testing — Part 2: Dynamic probing (ISO 22476-2)*

EN ISO 22476-3, *Geotechnical investigation and testing — Field testing — Part 3: Standard penetration test (ISO 22476-3)*

EN ISO 22476-4, *Geotechnical investigation and testing — Field testing — Part 4: Ménard pressuremeter test (ISO 22476-4)*

EN ISO 5814, *Water quality — Determination of dissolved oxygen — Electrochemical probe method (ISO 5814)*

EN ISO 7027-1, *Water quality — Determination of turbidity — Part 1: Quantitative methods (ISO 7027-1)*

ISO 11923, *Water quality — Determination of suspended solids by filtration through glass-fibre filters*

ISO 11048, *Soil quality — Determination of water-soluble and acid-soluble sulfate*