BS EN 16907-4:2018

BSI Standards Publication

Earthworks

Part 4: Soil treatment with lime and/or hydraulic binders

National foreword

This British Standard is the UK implementation of EN 16907-4:2018.

The UK participation in its preparation was entrusted to Technical Committee B/526/-/1, Earthworks.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Published by BSI Standards Limited 2018

ISBN 978 0 580 91185 9

ICS 93.020

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 December 2018.

Amendments/corrigenda issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 16907-4

December 2018

ICS 93.020

English Version

Earthworks - Part 4: Soil treatment with lime and/or hydraulic binders

Terrassements - Partie 4: Traitement des sols à la chaux et/ou aux liants hydrauliques

Erdarbeiten - Teil 4: Bodenbehandlung mit Kalk und/oder hydraulischen Bindemitteln

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

Ref. No. EN 16907-4:2018 E

Contents

Page

European foreword ... 6
Introduction ... 7
1 Scope ... 9
2 Normative references ... 9
3 Terms and definitions ... 11
4 Symbols and abbreviations ... 14
5 Constituents ... 15
5.1 Materials ... 15
5.1.1 General ... 15
5.1.2 Natural soils and processed aggregates ... 15
5.1.3 Low strength, intermediate strength and high strength rocks, and chalk ... 15
5.1.4 Recycled materials ... 15
5.1.5 Artificial materials ... 15
5.2 Binders ... 15
5.2.1 Cement ... 15
5.2.2 Fly ash ... 16
5.2.3 Slag ... 16
5.2.4 Hydraulic road binder ... 16
5.2.5 Lime ... 16
5.2.6 Blends ... 16
5.3 Water ... 16
5.4 Other constituents ... 16
6 Mixtures ... 16
6.1 General ... 16
6.2 Proportioning ... 16
7 Laboratory testing methodology ... 17
7.1 General ... 17
7.2 Identification tests ... 17
7.2.1 Identification of the materials to be treated ... 17
7.2.2 Identification of the binders ... 17
7.3 Feasibility of treatment ... 17
7.4 Workability period ... 18
7.5 Characteristics for execution ... 18
7.5.1 Improvement ... 18
7.5.2 Stabilization ... 18
7.6 Mechanical performance ... 19
7.6.1 Curing conditions ... 19
7.6.2 Resistance to water ... 19
7.6.3 Strength for direct construction trafficking ... 19
7.6.4 Resistance to frost ... 19
7.6.5 Performance classification testing ... 19
7.6.6 Other performance tests ... 20
7.7 Preparation of the specimens ... 20
7.7.1 Particle size of the material ... 20

7.7.2 Production of the mixtures 20
7.7.3 Dimensions of the specimens 20
7.7.4 Compaction procedures 20
7.7.5 Curing 21
7.8 Content of the laboratory studies 21
7.8.1 General 21
7.8.2 Identification of the constituents 21
7.8.3 Improvement 21
7.8.4 Stabilization 21
7.9 Laboratory testing report 22

8 Performance classification of the mixtures 23
8.1 General 23
8.2 Improvement 23
8.2.1 General 23
8.2.2 Immediate bearing index 24
8.2.3 Moisture condition value 24
8.2.4 Degree of compaction 24
8.2.5 Swelling 25
8.3 Stabilization 25
8.3.1 Requirements for the fresh mixture 25
8.3.2 Laboratory mechanical performance classification 28
8.3.3 Resistance to water 32
8.3.4 Strength for direct construction trafficking 34
8.3.5 Resistance to frost 34
8.3.6 Other performance 34

9 Execution and control 34
9.1 Introduction 34
9.1.1 General 34
9.1.2 Prerequisites 34
9.2 Preliminary engineering check 35
9.2.1 General 35
9.2.2 Site investigation 35
9.2.3 Sulfide, sulfate, organic matter and other deleterious materials 35
9.2.4 Influential parameters 36
9.2.5 Prior laboratory testing 36
9.3 Binders 36
9.4 Soil treatment plant types 36
9.5 Soil improvement 37
9.5.1 General 37
9.5.2 Materials suitable for improvement 37
9.5.3 Improvement during excavation 37
9.5.4 Improvement in fill area 37
9.5.5 Binder spreading 37
9.5.6 *In situ* mixing 38
9.5.7 Compaction 38
9.5.8 Protection of the works 38
9.5.9 Climatic considerations 38
9.6 Soil stabilization 38
9.6.1 General 38
9.6.2 Material suitable for stabilization 39
9.6.3 Soil preparation 39
9.6.4 Stabilization processes for capping and embankment 40

9.6.5 Other applications ... **42**
9.6.6 Layer Interface and organization of the work ... **42**
9.7 Testing and Compliance ... **43**
9.7.1 Specification ... **43**
9.7.2 Compliance tests and records ... **43**
9.7.3 Completion reports ... **45**
9.8 Climatic and practical considerations ... **46**
Annex A (informative) Production of test specimens for treated materials ... **47**
A.1 Introduction ... **47**
A.2 Sampling ... **47**
A.3 Water content ... **47**
A.4 Maximum size of the particles ... **47**
A.5 Treatment ... **48**
A.6 Mellowing and compaction of the treated material in the specimen mould ... **49**
A.7 Curing and storage ... **49**
A.8 Removing sample from the mould ... **50**
A.9 Reporting ... **51**
Annex B (informative) Loading speed for the strength and modulus tests ... **52**
Annex C (informative) Non destructive seismic test method for mechanical performance ... **54**
C.1 Introduction ... **54**
C.2 Scope ... **54**
C.3 Test apparatus ... **54**
C.4 Definitions and theoretical approach ... **55**
C.5 Principle of test method ... **56**
C.6 Significance and use ... **56**
C.7 Measurement ... **57**
C.8 References ... **59**
Annex D (informative) Example of evaluation of performance variability of treated soil as a result of variation during implementation Binder percentage adjustment and method for compensating it ... **60**
Annex E (informative) Examples of age of classification and curing regimes for mechanical performance of treated materials for earthworks ... **62**
Annex F (informative) Other performance characteristics for treated materials ... **63**
Annex G (informative) Field and laboratory identifications of common sulfide and sulfate minerals ... **64**
G.1 Field Identification ... **64**
G.2 Laboratory Identification ... **64**
G.3 References ... **65**
Annex H (informative) Soil Treatment Plant Types ... **66**

H.1 General **66**
H.2 Binder storage units **66**
H.3 Binder spreading units **66**
H.4 Soil preparation plant **67**
H.5 *In situ* mixing plant **67**
H.6 Fixed or semi mobile mixing plants **69**
H.7 Water bowsers **71**
H.8 Compaction plant **71**
Annex I (informative) Treatment sequence and processes **72**
Annex J (informative) Other applications for stabilized materials **78**
J.1 General **78**
J.2 Filling in narrow places **78**
J.3 Construction of lower layers in high embankments built with water sensitive soils or evolutive rocks which may be subject to occasional flooding. **79**
J.4 Steepened slopes of embankment **79**
J.5 Slope repairs **80**
J.6 Reinforced slopes **80**
J.7 Foundations **80**
J.8 Load transfer platforms **80**
J.9 Water retaining structures **81**
J.10 Contaminated soils **81**
Annex K (informative) Site Stabilization checklist **82**
Annex L (informative) Safety considerations **85**
L.1 General **85**
L.2 Specific protective equipment **85**
Annex M (informative) Climatic and practical considerations **86**
M.1 General **86**
M.2 Weather **86**
M.3 Binder dust emission **87**
M.4 Run off and leachate **88**
Annex N (informative) Method and charts to determine the quantity of lime needed to reach a targeted IPI value **89**

European foreword

This document (EN 16907-4:2018) 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*, as follows:

— *Part 1: Principles and general rules;*

— *Part 2: Classification of materials;*

— *Part 3: Construction procedures;*

— *Part 4: Soil treatment with lime and/or hydraulic binders* (this document)*;*

— *Part 5: Quality control;*

— *Part 6: Land reclamation earthworks using dredged hydraulic fill;*

— *Part 7: Hydraulic placement of extractive waste.*

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

In the context of the present standard, the treatment of a material designates the operation which consists of mixing, to an agreed specification, the material with a binder, for example lime, or hydraulic binder, or both of them, and optionally with additional water. The objective is to enhance the properties of materials with poor characteristics for use in earth structures. It can also be to enhance properties of materials to enable their use in specific applications (like capping layers, abutment fills, foundations, etc.).

Although the technique has been used for a long time, its application at a large scale, for the construction of earth structures, started in the 1960s. Since then, the technique has seen a substantial increase thanks to its many benefits, among which are:

— enhancement of the mechanical properties of material;

— elimination of lorry movements for disposal of site material;

— reduced lorry movements for importation of construction material;

— reduced noise and nuisance to local residents;

— less wear and tear on the local road network;

— no tipping charges or landfill tax;

— maintained landfill capacity;

— no waste of valuable non-renewable aggregate resources;

— generally reduced construction time and cost.

Once treated properly, the material can be used in embankment, capping layer or any part of the structure, provided it meets the specification of the project.

The treatment products considered in this standard are limited to the following standardized products: cement, fly ash, granulated blast furnace slag, hydraulic road binder and lime.

For the purpose of this standard, these treatment products will be designated as binders.

For the purpose of this standard, cement, granulated blast furnace slag and hydraulic road binder will be designated as hydraulic binders.

Fly ash includes siliceous fly ash and calcareous fly ash. Siliceous fly ash is a material which requires a source of calcium oxide, e.g. lime or cement, to produce a hydraulic reaction. Calcareous fly ash contains calcium oxide and is comparable to a hydraulic binder. For the purpose of this standard, both types of fly ash will be designated as hydraulic binders.

Lime is air lime and has no hydraulic property. For the purpose of this standard, it will be designated as a binder.

Typical uses of the binders are as follows:

— lime is generally used to dry up wet materials, and/or to enhance the performance of cohesive materials;

— hydraulic binders are mainly used to quickly and significantly increase the mechanical performance of non-cohesive materials;

— in presence of cohesive material and depending on the application, lime and hydraulic binder may be used together, in two steps on site, or through a pre-blended form like a hydraulic road binder.

The materials considered in this standard are: soils, weak rocks, intermediate rocks, chalk, recycled materials, artificial materials. They can also be mixes of these different types.

The success of a treatment operation relies upon the respect of specifications as well as of good practices that closely depend on local geological and climatic conditions. Thus, in addition to the requirements of this standard, reference may be made to the guidelines of good practices valid in the place of use. Some of them are included as notes in the standard or in the annexes at the end of this document.