



BSI Standards Publication

Eurocode 7 — Geotechnical design

Part 1: General rules

National foreword

This British Standard is the UK implementation of EN 1997-1:2024. Together with BS EN 1990:2023 and BS EN 1997-3:—¹, it supersedes BS EN 1997-1:2004+A1:2013, which will be withdrawn on 30 March 2028.

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

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

National choice is allowed in this standard where explicitly stated within notes. The National Annex to this standard contains the national choices to be used for buildings and civil engineering works constructed in the UK.

The first generation of EN Eurocodes was published between 2002 and 2007, with conflicting British Standards withdrawn in 2010. This document forms part of the second generation of EN Eurocodes.

The second generation of EN Eurocodes is expected to be published between 2023 and 2026. These documents are being published as soon as they are available. This is being done to enable users to prepare for the transition from the first generation to second generation of EN Eurocodes.

UK adoptions of the first generation of EN Eurocodes will be withdrawn by BSI on 30 March 2028. Until that date, the first generation documents should be considered as the applicable standards for buildings and civil engineering works constructed in the UK unless otherwise specified by the relevant authority or in the specification for a particular project.

This standard is intended to be used with its National Annex and other referenced documents, including other second generation Eurocodes, as an interdependent suite of documents.

While the use of provisions in this standard in conjunction with first generation Eurocodes is not precluded, it should be undertaken with care and should only be done when users are satisfied that it will not result in a lower level of reliability than the minimum level set in the first generation Eurocodes and associated UK National Annexes.

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¹ Under preparation. Stage at time of publication: FprEN 1997-3:2024.

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© The British Standards Institution 2024
Published by BSI Standards Limited 2024

ISBN 978 0 539 06276 2

ICS 91.010.30; 93.020

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 September 2024.

Amendments/corrigenda issued since publication

Date	Text affected
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English Version

Eurocode 7 - Geotechnical design - Part 1: General rules

Eurocode 7 - Calcul géotechnique - Partie 1 : Règles
générales

Eurocode 7 - Entwurf, Berechnung und Bemessung in
der Geotechnik - Teil 1: Allgemeine Regeln

This European Standard was approved by CEN on 7 July 2024.

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Contents

Page

European foreword.....	5
Introduction	7
1 Scope	9
1.1 Scope of EN 1997-1	9
1.2 Assumptions.....	9
2 Normative references	9
3 Terms, definitions and symbols.....	11
3.1 Terms and definitions	11
3.1.1 Terms relating to the ground.....	11
3.1.2 Terms relating to geotechnical reliability	12
3.1.3 Terms relating to ground properties.....	13
3.1.4 Terms relating to actions and resistance	13
3.1.5 Terms relating to verification methods	14
3.1.6 Terms relating to analysis and models	14
3.1.7 Terms relating to structural deformation and ground movement	16
3.1.8 Terms relating to groundwater	16
3.1.9 Terms relating to implementation of design	17
3.1.10 Terms relating to testing.....	18
3.1.11 Terms relating to reporting	18
3.2 Symbols and abbreviations	18
3.2.1 Symbols.....	18
3.2.2 Abbreviations	22
4 Basis of design	23
4.1 General rules.....	23
4.1.1 Basic requirements	23
4.1.2 Geotechnical reliability.....	23
4.1.3 Consequences of failure.....	26
4.1.4 Robustness.....	27
4.1.5 Design service life	28
4.1.6 Durability	29
4.1.7 Sustainability	29
4.1.8 Quality management.....	30
4.2 Principles of limit state design.....	30
4.2.1 General.....	30
4.2.2 Design situations	30
4.2.3 Geotechnical Design Model.....	31
4.2.4 Validation of information from the Ground Investigation Report	32
4.2.5 Impacts within the zone of influence	34
4.3 Basic variables	35
4.3.1 Actions and environmental influences.....	35
4.3.2 Material and product properties.....	37
4.3.3 Geometrical properties.....	40
4.4 Verification by the partial factor method.....	40
4.4.1 Verification of ultimate limit states.....	40
4.4.2 Verification of serviceability limit states	44

4.5	Verification by prescriptive rules.....	44
4.6	Verification by testing.....	45
4.7	Verification by the Observational Method	45
5	Materials	45
5.1	Ground.....	45
5.2	Engineered fill.....	45
5.3	Geosynthetics	46
5.4	Grout.....	46
5.5	Plain and reinforced concrete.....	46
5.6	Steel	47
5.7	Timber	47
5.8	Masonry.....	47
6	Groundwater	47
6.1	General	47
6.2	Properties of groundwater.....	48
6.3	Measurements	49
6.4	Representative values of groundwater pressures.....	49
6.5	Design values of groundwater pressures	51
6.5.1	Design values of groundwater pressures for ultimate limit state design	51
6.5.2	Design values of groundwater pressures for serviceability limit state design	52
7	Geotechnical analysis.....	52
7.1	Calculation models.....	52
7.1.1	General	52
7.1.2	Empirical models.....	53
7.1.3	Analytical models	53
7.1.4	Numerical models.....	53
7.1.5	Calculation models for cyclic and dynamic actions.....	54
7.2	Model factors.....	54
8	Ultimate limit states	55
8.1	Type of ultimate limit states.....	55
8.1.1	Failure by rupture	55
8.1.2	Failure due to excessive deformation of the ground	55
8.1.3	Failure by loss of static equilibrium of the structure or ground	55
8.1.4	Hydraulic failure.....	58
8.1.5	Failure caused by time-dependent effects.....	61
8.1.6	Failure caused by the effect of cyclic actions.....	61
8.2	Procedure for numerical models.....	61
9	Serviceability limit states	65
9.1	General	65
9.2	Serviceability criteria.....	65
9.3	Calculation of ground movements.....	66
9.4	Structural aspects.....	67
9.5	Hydraulic aspects	67
10	Implementation of design.....	68
10.1	General	68
10.2	Supervision	69
10.3	Inspection.....	69
10.4	Monitoring.....	70
10.5	Maintenance	71
10.6	Application of the Observational Method.....	72

11	Testing.....	72
11.1	General.....	72
11.1.1	Use of testing.....	72
11.1.2	Test planning.....	72
11.1.3	Test evaluation.....	73
11.2	Testing to determine ground properties.....	73
11.3	Testing to determine parameters for use in design	73
11.4	Testing to verify resistance	74
11.5	Testing to control quality	74
11.6	Testing to determine geotechnical behaviour.....	74
12	Reporting	74
12.1	General.....	74
12.2	Ground Investigation Report	75
12.3	Geotechnical Design Report	76
12.3.1	General.....	76
12.3.2	Ground properties and Geotechnical Design Model.....	76
12.3.3	Properties	76
12.3.4	Verification of limit states.....	76
12.3.5	Implementation of design	77
12.4	Geotechnical Construction Record	77
12.5	Geotechnical test reports	77
	Annex A (informative) Characteristic value determination procedure	78
	Annex B (informative) Contents of reports.....	85
	Annex C (informative) Guideline on selection of Geotechnical Complexity Class	95
	Bibliography.....	98

European foreword

This document (EN 1997-1:2024) has been prepared by Technical Committee CEN/TC 250 “Structural Eurocodes”, the secretariat of which is held by BSI. CEN/TC 250 is responsible for all Structural Eurocodes and has been assigned responsibility for structural and geotechnical design matters by CEN.

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 September 2027, and conflicting national standards shall be withdrawn at the latest by March 2028.

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.

Together with EN 1990:2023 and EN 1997-3:—¹, this document supersedes EN 1997-1:2004.

EN 1997-1:2024 includes the following significant technical changes with respect to EN 1997-1:2004:

- the scope of EN 1997-1 has been extended to include rock (the word “ground” is now used extensively to denote soil, rock, and fill);
- the Geotechnical Category has been redefined as a combination of the Consequence Class of the structure and the complexity of the ground (Geotechnical Complexity Class) (Clause 4 and Annex C);
- robustness, durability and sustainability have been introduced as new topics (Clause 4);
- the representative value of a ground property has been defined as either a nominal value (cautious estimate) or a characteristic value (based on statistical evaluation) (Clause 4 and Annex A);
- a new clause on the determination of groundwater levels and groundwater pressures has been added (Clause 6);
- a new procedure for verifying ultimate limit states using numerical models has been added (Clause 8);
- greater emphasis has been given to serviceability limit states, including ground movements and structural and hydraulic aspects (Clause 9);
- a new clause on the implementation of design (covering supervision, inspection, monitoring, and maintenance) has been added (Clause 10);
- a new clause on testing has been added, covering tests for determining ground properties, tests for measuring the resistance of geotechnical structures, product quality tests, and tests to determine geotechnical behaviour (Clause 11); and
- the clause on reporting has been revised to cover updated specification of the Ground Investigation and Geotechnical Design Reports and new requirements for Geotechnical Construction Records and geotechnical test reports (Clause 12 and Annex C).

¹ Under preparation. Stage at the time of publication: prEN 1997-3:2022.

This document has been prepared under a standardization request addressed to CEN by the European Commission. The Standing Committee of the EFTA States subsequently approves these requests for its Member States.

The first generation of EN Eurocodes was published between 2002 and 2007. This document forms part of the second generation of the Eurocodes, which have been prepared under Mandate M/515 issued to CEN by the European Commission and the European Free Trade Association.

The Eurocodes have been drafted to be used in conjunction with relevant execution, material, product and test standards, and to identify requirements for execution, materials, products and testing that are relied upon by the Eurocodes.

The Eurocodes recognize the responsibility of each Member State and have safeguarded their right to determine values related to regulatory safety matters at national level through the use of National Annexes.

Any feedback and questions on this document should be directed to the users' national standards body. A complete listing of these bodies can be found on the CEN website.

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, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and the United Kingdom.

Introduction

0.1 Introduction to the Eurocodes

The Structural Eurocodes comprise the following standards generally consisting of a number of Parts:

- EN 1990, *Eurocode — Basis of structural and geotechnical design*
- EN 1991, *Eurocode 1 — Actions on structures*
- EN 1992, *Eurocode 2 — Design of concrete structures*
- EN 1993, *Eurocode 3 — Design of steel structures*
- EN 1994, *Eurocode 4 — Design of composite steel and concrete structures*
- EN 1995, *Eurocode 5 — Design of timber structures*
- EN 1996, *Eurocode 6 — Design of masonry structures*
- EN 1997, *Eurocode 7 — Geotechnical design*
- EN 1998, *Eurocode 8 — Design of structures for earthquake resistance*
- EN 1999, *Eurocode 9 — Design of aluminium structures*
- New parts are under development, e.g. Eurocode for design of structural glass

The Eurocodes are intended for use by designers, clients, manufacturers, constructors, relevant authorities (in exercising their duties in accordance with national or international regulations), educators, software developers, and committees drafting standards for related product, testing and execution standards.

NOTE Some aspects of design are most appropriately specified by relevant authorities or, where not specified, can be agreed on a project-specific basis between relevant parties such as designers and clients. The Eurocodes identify such aspects making explicit reference to relevant authorities and relevant parties.

0.2 Introduction to EN 1997 (all parts)

EN 1997 consists of a number of parts:

- EN 1997-1, *Eurocode 7 — Geotechnical design – Part 1: General rules*
- EN 1997-2, *Eurocode 7 — Geotechnical design – Part 2: Ground properties*
- EN 1997-3, *Eurocode 7 — Geotechnical design – Part 3: Geotechnical structures*

EN 1997 (all parts) establishes additional principles and requirements to those given in EN 1990 (all parts) for the safety, serviceability, robustness, and durability of geotechnical structures.

EN 1997 (all parts) is intended to be used in conjunction with the other Eurocodes for the design of geotechnical structures, including temporary geotechnical structures.

Design and verification in EN 1997 (all parts) are based on the partial factor method or other reliability-based methods, prescriptive rules, testing, or the Observational Method.

0.3 Introduction to EN 1997-1

EN 1997-1 establishes additional principles and requirements to those given in EN 1990 (all parts) for the safety, serviceability, robustness, and durability of geotechnical structures.

Design and verification in EN 1997-1 are based on the partial factor method or other reliability-based methods, prescriptive rules, testing, or the Observational Method.

0.4 Verbal forms used in the Eurocodes

The verb “shall” expresses a requirement strictly to be followed and from which no deviation is permitted in order to comply with the Eurocodes.

The verb “should” expresses a highly recommended choice or course of action. Subject to national regulation and/or any relevant contractual provisions, alternative approaches could be used/adopted where technically justified.

The verb “may” expresses a course of action permissible within the limits of the Eurocodes.

The verb “can” expresses possibility and capability; it is used for statements of fact and clarification of concepts.

0.5 National annex for EN 1997-1

National choice is allowed in this document where explicitly stated within notes. National choice includes the selection of values for Nationally Determined Parameters (NDPs).

The national standard implementing EN 1997-1 can have a National Annex containing all national choices to be used for the design of buildings and engineering works to be constructed in the relevant country.

When no national choice is given, the default choice given in this standard is to be used.

When no national choice is made and no default is given in this standard, the choice can be specified by a relevant authority or, where not specified, agreed for a specific project by appropriate parties.

National choice is allowed in EN 1997-1 through notes to the following clauses:

4.1.2.2(1)	4.1.2.3(3)	4.1.3(1)	4.1.4(2)
4.1.5(1)	4.1.8(3)	4.2.3.2(2)	4.2.4(3)
4.3.2.3(2)	4.4.1.3(1) – 3 choices	4.4.1.3(9) – 2 choices	4.4.1.5(1) – 2 choices
4.5(1)	4.5(4)	5.4(2)	5.5(2)
5.5(3)	7.1.1(7)	7.2(2)	8.1.4.2(3)
8.2(1) – 2 choices	10.2(3)	12.1(4)	A.4(3)
A.4(8) – 2 choices	A.4(11)	C.3(3)	C.3(4)

National choice is allowed in EN 1997-1 on the application of the following informative annexes:

Annex A	Annex B	Annex C
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The National Annex can contain, directly or by reference, non-contradictory complementary information for ease of implementation, provided it does not alter any provisions of the Eurocodes.

1 Scope

1.1 Scope of EN 1997-1

- (1) This document provides general rules for the design and verification of geotechnical structures.
- (2) This document is applicable for the design and verification of geotechnical structures outside the scope of EN 1997-3.

NOTE In this case, additional or amended provisions can be necessary.

1.2 Assumptions

- (1) In addition to the assumptions given in EN 1990, the provisions of EN 1997 (all parts) assume that:
- ground investigations are planned by individuals or organisations with knowledge of potential ground and groundwater conditions;
 - ground investigations are executed by individuals with appropriate skills and experience;
 - the evaluation of test results and derivation of ground properties from the ground investigation are carried out by individuals with appropriate geotechnical experience and qualifications;
 - the data required for design are collected, recorded, and interpreted by appropriately qualified and experienced individuals;
 - geotechnical structures are designed and verified by individuals with appropriate qualifications and experience in geotechnical design;
 - adequate continuity and communication exist between the individuals involved in data collection, design, verification and execution.

- (2) This document is intended to be used in conjunction with EN 1990, which establishes principles and requirements for the safety, serviceability, robustness, and durability of structures, including geotechnical structures, and other construction works.

NOTE Additional or amended provisions can be necessary for assessment of existing structures, see EN 1990-2.

- (3) This document is intended to be used in conjunction with EN 1997-2, which gives provisions for determining ground properties from ground investigations.
- (4) This document is intended to be used in conjunction with EN 1997-3, which gives specific rules for the design and verification of certain types of geotechnical structures.
- (5) This document is intended to be used in conjunction with other Eurocodes for the design of geotechnical structures, including temporary geotechnical structures.

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.

NOTE See the Bibliography for a list of other documents cited that are not normative references, including those referenced as recommendations (i.e. in 'should' clauses), permissions (i.e. in 'may' clauses), possibilities (i.e. in 'can' clauses), and in notes.

EN 206, *Concrete - Specification, performance, production and conformity*

EN 1537, *Execution of special geotechnical works - Ground anchors*

EN 1990:2023,² *Eurocode — Basis of structural and geotechnical design*

EN 1991-2:2023, *Eurocode 1 — Actions on structures — Part 2: Traffic loads on bridges and other civil engineering works*

EN 1991-1-1:—,³ *Eurocode 1 — Actions on structures — Part 1-1: Specific weight of materials, self-weight of construction works and imposed loads on buildings*

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

EN 1993-1-10, *Eurocode 3: Design of steel structures — Part 1-10: Material toughness and through-thickness properties*

EN 1993-5, *Eurocode 3 - Design of steel structures — Part 5: Piling*

EN 1995-1-1, *Eurocode 5 — Design of timber structures — Part 1-1: General - Common rules and rules for buildings*

EN 1996 (all parts), *Eurocode 6 — Design of masonry structures*

EN 1997-2:2024, *Eurocode 7 — Geotechnical design — Part 2: Ground properties*

EN 1997-3:—,⁴ *Eurocode 7 — Geotechnical design — Part 3: Geotechnical structures*

EN 1998-1-1, *Eurocode 8 — Design of structures for earthquake resistance — Part 1-1: General rules and seismic action*

EN 12715, *Execution of special geotechnical work — Grouting*

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

EN 13670, *Execution of concrete structures*

EN 14199, *Execution of special geotechnical works — Micropiles*

EN 14475, *Execution of special geotechnical works — Reinforced fill*

EN 14487 (all parts), *Sprayed concrete*

EN 14490, *Execution of special geotechnical works - Soil nailing*

EN ISO 14688 (all parts), *Geotechnical investigation and testing — Identification and classification of soil*

EN 15237, *Execution of special geotechnical works — Vertical drainage*

² As impacted by EN 1990:2023/prA1:2024

³ Under preparation. Stage at the time of publication: FprEN 1991-1-1:2024.

⁴ Under preparation. Stage at the time of publication: prEN 1997-3:2022.

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 1990 and the following apply.

3.1.1 Terms relating to the ground

3.1.1.1

ground

soil, rock, and fill existing in place prior to execution of the construction works

Note 1 to entry: In this definition rock refers to the rock mass

[SOURCE: EN 1990:2023, 3.1.1.5]

3.1.1.2

soil

aggregate of minerals and/or organic materials including fills which can be disaggregated by hand in water

[SOURCE: EN ISO 14688-1:2018, 3.17]

3.1.1.3

rock

naturally occurring assemblage or aggregate of mineral grains, crystals or mineral based particles compacted, cemented, or otherwise bound together and which cannot be disaggregated by hand in water

[SOURCE: EN ISO 14689:2018, 3.5]

3.1.1.4

rock mass

rock comprising the intact material together with the discontinuities and weathered zones

[SOURCE: EN ISO 14689:2018, 3.6]

3.1.1.5

rock material

intact rock between the discontinuities

[SOURCE: EN ISO 14689:2018, 3.7]

3.1.1.6

weathered zone

distinctive layer of ground, differing physically, chemically, and/or mineralogically from the layers above and/or below due to the process of weathering

3.1.1.7

discontinuities

bedding planes, joints, fissures, faults and shear planes

[SOURCE: EN ISO 14688-1:2018, 3.4]

3.1.1.8

foliation

planar arrangements of constituents in any type of rock, especially the parallel structure that results from flattening, segregation and other processes undergone by the grains in a metamorphic rock

3.1.1.9

interface

surface between two geotechnical units that interact or surface where ground and structure interact

3.1.1.10

fill

made ground

ground that has been formed by using material to fill in a depression or to raise the level of a site

[SOURCE: ISO 6707-1:2020 3.4.4.9]

3.1.1.11

engineered fill

material placed in a controlled manner to ensure that its geotechnical properties conform to a predetermined specification

3.1.1.12

non-engineered fill

material placed with no compaction control and likely to have heterogeneous and anisotropic geotechnical properties within its mass

3.1.2 Terms relating to geotechnical reliability

3.1.2.1

desk study

analysis and presentation of information about the construction site from existing documentation

Note 1 to entry: A desk study includes, for example, the history of the site, observations of neighbouring structures, previous construction activities, information from aerial photographs, satellite observations, local experience in the area, and seismicity.

Note 2 to entry: See also EN 1997-2:2024, Annex C.

3.1.2.2

Geotechnical Complexity Class

classification of a geotechnical structure based on the complexity of the ground, groundwater and ground-structure interaction, taking account of prior knowledge

3.1.2.3

Geotechnical Category

classification system that combines the uncertainty and complexity of the ground, including groundwater and ground-structure interaction, with the consequence of failure of the structure

3.1.2.4

comparable experience

documented previous information about ground and structural behaviour that is considered relevant for design, as established by geological, geotechnical and structural similitude with the design situation

3.1.3 Terms relating to ground properties

3.1.3.1

ground property

physical, mechanical, geometrical, or chemical attribute of a ground material

3.1.3.2

derived value of a ground property

value of a ground property obtained by theory, correlation, or empiricism from test results or field measurements

3.1.3.3

nominal value of a ground property

cautious estimate of the value of a ground property that affects the occurrence of a limit state

Note 1 to entry: Further explanation of 'cautious estimate' is given in 4.3.2.

3.1.3.4

characteristic value of a ground property

statistical determination of the value of a ground property that affects the occurrence of a limit state having a prescribed probability of not being attained

Note 1 to entry: This value corresponds to a specified fractile (mean, superior or inferior) of the assumed statistical distribution of the particular property of the ground.

3.1.3.5

representative value of a ground property

nominal or characteristic value including the conversion factor

Note 1 to entry: Further explanation about the representative value is given in 4.3.2.

3.1.3.6

best estimate value of a ground property

estimate of the most probable value of a ground property

Note 1 to entry: Further explanation about the best estimate value is given in 4.3.2.

3.1.3.7

indicative value of a ground property

value of a ground property determined from ground description or classification

3.1.4 Terms relating to actions and resistance

3.1.4.1

ground resistance

capacity of the ground, or part of it, to withstand actions without failure

3.1.4.2

ground strength

mechanical property of the ground indicating its ability to resist actions

3.1.4.3

overall stability

failure mechanism in the ground that encompasses the entire geotechnical structure

3.1.4.4

local stability

failure mechanism that encompasses only a part of the entire geotechnical structure without failure of the entire geotechnical structure

3.1.4.5

cyclic action

variable load that can induce significant stiffness and strength degradation, generation of excess pore pressure, liquefaction, or permanent settlements

3.1.4.6

creep

increase in strain at constant effective stress

3.1.5 Terms relating to verification methods

3.1.5.1

Observational Method

continuous, managed, integrated process of design, construction control, monitoring and review that enables previously defined modifications to be incorporated during or after construction as appropriate

[SOURCE: CIRIA Report 185, 1999]

3.1.5.2

prescriptive rules

pre-determined, experienced-based, and suitably conservative rules for design

3.1.5.3

verification assisted by testing

testing of a structural element to verify design ground properties or resistance

Note 1 to entry: Verification assisted by testing includes the determination of shaft friction and end bearing of piles, pull-out strength of anchors, and shear strength of lime-cement columns, for example.

3.1.5.4

verification by testing

testing performed to verify that the performance of the geotechnical structure (or part of the structure) is within the limiting values

Note 1 to entry: Verification by testing includes full-scale or reduced-scale tests.

3.1.5.5

design variant

describes the anticipated behaviour of the geotechnical structure, given that the relevant ground properties lie in a predefined range

3.1.6 Terms relating to analysis and models

3.1.6.1

zone of influence

zone where construction works or the geotechnical structure can adversely affect the safety, serviceability, robustness, durability, or sustainability of the geotechnical structure, other structures, utilities, ground, or groundwater

3.1.6.2**geotechnical analysis**

procedure or algorithm for determining effects of actions in and resistance of the ground

3.1.6.3**geotechnical system**

term describing the ground, groundwater and the structure interacting with it

3.1.6.4**Geotechnical Design Model**

conceptual representation of the site derived from the ground model for the verification of each appropriate design situation and limit state

Note 1 to entry: Guidance on the contents of a Geotechnical Design Model is given in Clause 12 and Annex B

3.1.6.5**geotechnical unit**

volume of ground that is defined as a single material

3.1.6.6**Ground Model**

site specific outline of the disposition and character of the ground and groundwater based on the results of ground investigations and other available data

3.1.6.7**numerical models**

calculation models involving numerical approximation to obtain solutions

Note 1 to entry: Numerical methods include, but are not limited to, finite-element, finite-difference, boundary-element, discrete-element and subgrade reaction methods.

3.1.6.8**validation**

process of determining the degree to which a model and its input parameters represent a real design situation

3.1.6.9**robustness**

ability of a structure to withstand unforeseen adverse events without being damaged to an extent disproportionate to the original cause

[SOURCE: EN 1990:2023, 3.1.2.30]

Note 1 to entry: The aim of designing for robustness is either to prevent disproportionate consequences resulting from an adverse or unforeseen event or to provide some additional resistance to reduce the likelihood and extent of such an event.

Note 2 to entry: There is a distinction between design for identified accidental actions and design for robustness. In design for accidental actions, a target level of reliability is expected to be achieved whereas design for robustness aims to increase the safety margin without aiming for a specified target reliability.

3.1.6.10**toppling**

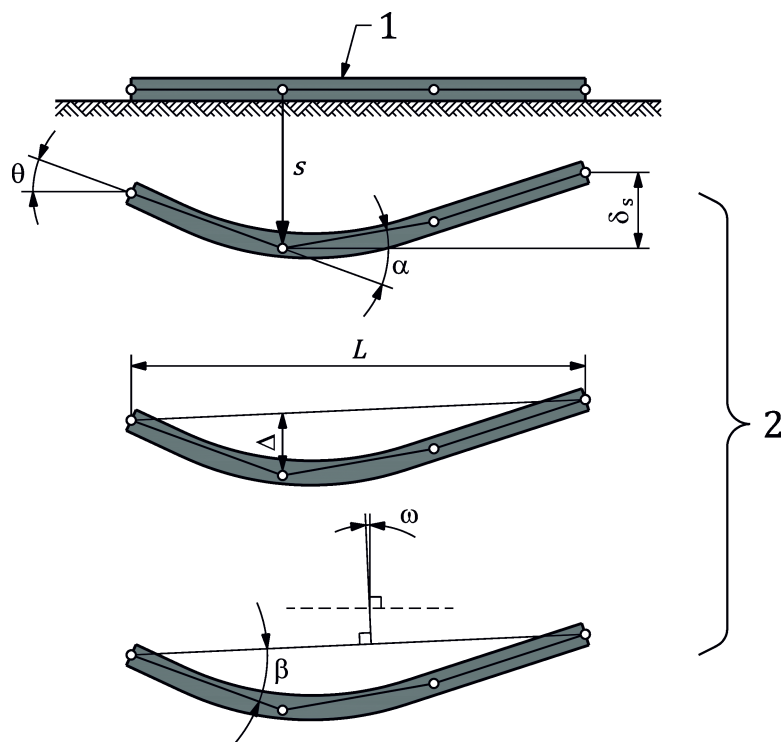
loss of static equilibrium due to rotation of the structure

3.1.6.11
overturning

rotation of the structure involving failure of the ground

3.1.7 Terms relating to structural deformation and ground movement

Definitions of some terms for foundation movement and deformation are given in Figure 3.1.



Key			
s	settlement	Δ/L	deflection ratio
δ_s	differential settlement	ω	tilt
θ	rotation	β	angular distortion
α	angular strain	1	original position and shape
Δ	relative deflection	2	deformed position and shape

Figure 3.1 — Definitions of foundation movement

3.1.8 Terms relating to groundwater

3.1.8.1
groundwater

water held underground in the soil or in pores and discontinuities in rock

3.1.8.2
groundwater level

level of the water surface in the ground

3.1.8.3**piezometric level**

level to which water would rise in a standpipe designed to detect the pressure of water at a point beneath the ground surface

3.1.8.4**surface water level**

level of water above the ground surface

3.1.9 Terms relating to implementation of design**3.1.9.1****limiting values**

value of the serviceability criteria

Note 1 to entry: Expressed, for example, as deformation, stress, strain, or vibration.

3.1.9.2**threshold value**

value that, with an appropriate safety margin, defines the point at which contingency measures are applied to avoid exceeding the limiting value

3.1.9.3**acceptance criteria**

acceptable variations of material, ground and geometrical properties expressed as tolerances to avoid exceeding the serviceability criteria or the ultimate limit state

3.1.9.4**supervision**

measures or activities during execution to check that the construction work follows the process, including execution methods and construction stages, set by the execution specification

3.1.9.5**inspection**

measures or activities during or after execution to check the compliance of the execution with the execution specification and the validity of the design assumptions in relation to encountered ground conditions at the site

3.1.9.6**monitoring**

measurement or observation of the behaviour of the ground or structure to check compliance with the serviceability criteria and to check that the execution complies with the design assumptions and execution specifications

3.1.9.7**execution specification**

set of documents comprising drawings, a description of the works, product choices, execution classes, tolerance classes, and other technical data and requirements necessary for the execution of the works

Note 1 to entry: An execution specification can include method statements, inspection plan, monitoring plan, maintenance plan, contingency plan, material specification, technical description etc. The information can be presented in text, drawings, models or databases, for example.

3.1.10 Terms relating to testing

3.1.10.1 investigation test

load test to establish the geotechnical ultimate load resistance of an anchor, soil nail, or rock bolt at the interface between the supporting element and the ground and to determine the behaviour of the element in the working load range

3.1.10.2 suitability test

load test to confirm that an particular anchor, soil nail, or rock bolt design will be adequate in particular ground conditions

3.1.10.3 acceptance test

load test to confirm that a individual anchor, soil nail, or rock bolt conforms with its acceptance criteria

3.1.10.4 control test

test used to check that a product meets its specifications and that its properties are consistent throughout the product

3.1.11 Terms relating to reporting

3.1.11.1 Ground Investigation Report

report (or reports) that compiles the results of ground investigation

Note 1 to entry: Details are given in EN 1997-2

3.1.11.2 Geotechnical Design Report

report (or reports) that compiles verification and design process of all construction phases and final design of the geotechnical structure

3.1.11.3 Geotechnical Construction Record

collection of documents of construction, supervision, monitoring and inspection of the final structure and each phase of execution

3.2 Symbols and abbreviations

For the purposes of this document, the following symbols and abbreviations apply.

NOTE 1 The symbols commonly used in all Eurocodes are defined in EN 1990.

NOTE 2 The notation used for the symbols used is based on ISO 3898.

3.2.1 Symbols

Latin upper-case letters

A_{wd} accidental component of groundwater pressure

E modulus of elasticity (Young's modulus)

E_d	design value of action
$F_{w,rep}$	representative groundwater pressure
G	shear modulus
G_{rep}	representative value of any unfavourable permanent force (acting upwards) that is not caused by groundwater pressures
$G_{rep,fav}$	representative value of the favourable permanent force (acting downwards)
$G_{vd,dst}$	design value of any permanent destabilising force (upwards) not caused by groundwater pressure
$G_{vd,stab}$	design value of any stabilizing (downward) force
G_w	permanent component of groundwater pressure
G_{wk}	characteristic value of G_w
$G_{wk,inf}$	lower (inferior) value of G_{wk}
$G_{wk,sup}$	upper (superior) value of G_{wk}
$G_{w,rep}$	representative value of groundwater pressure
K	hydraulic conductivity
N_{95}	parameter of the normal distribution, evaluated for a 95 % confidence level and infinite degrees of freedom
N_{SPT}	blow count measured in Standard Penetration Test
Q_{rep}	representative value of any unfavourable variable force (acting upwards) that are not caused by groundwater pressures
$Q_{vd,dst}$	design value of any variable destabilising force (acting upwards) not caused by groundwater pressure
Q_w	variable component of the groundwater pressure
$Q_{w,comb}$	combination value of Q_w
$Q_{w,freq}$	frequent value of Q_w
Q_{wk}	characteristic value of Q_w
$Q_{w,qper}$	quasi-permanent value of Q_w
$Q_{w,rep}$	representative value of Q_w
R_d	design value of resistance
T_{lf}	design service life
$U_{d,dst}$	design value of destabilising (uplift) force due to groundwater pressures
$U_{G,rep}$	representative value of the (unfavourable) uplift force due to permanent groundwater pressures
$U_{Q,rep}$	representative value of the (unfavourable) uplift forces due to variable groundwater pressures

V_X	coefficient of variation of the ground material property X
$V_{X,inh}$	coefficient of variation of a ground material property X due to inherent ground variability
$V_{X,quality}$	coefficient of variation of the measurement error
$V_{X,trans}$	coefficient of variation of the transformation error
X_d	design value of a ground property X
X_k	characteristic value of a ground property X
X_{mean}	mean value of a ground property X from test results
X_{nom}	nominal value of a ground property X
X_{rep}	representative value of X
Y_{mean}	mean value of the logarithmic values of a ground property Y from test results.

Latin lower-case letters

c'_p	peak effective cohesion
c'_r	residual effective cohesion
c_u	undrained shear strength of soil
c_h	coefficient of horizontal consolidation
c_v	coefficient of vertical consolidation
f_s	sleeve friction measured in a Cone Penetration Test
h_{wz}	piezometric level at elevation z
i_{cd}	design value of critical hydraulic gradient (when soil particles begin to move)
i_d	design value of the hydraulic gradient
k_n	coefficient that depends on the number of sample derived values (n) used to calculate X_{mean}
k_F	consequence factor applied to actions
k_M	consequence factor applied to material properties
k_R	consequence factor applied to resistance
k_{tr}	reduction factor for a transient design situation
n	number of sample test results, site-specific data, or derived values
p_l	pressuremeter limit pressure
$p'_{v,rep}$	representative value of any effective vertical overburden at the ground surface
q_c	cone resistance measured in a Cone Penetration Test
q_u	unconfined compressive strength of soil or rock
s_x	standard deviation of the sample derived values

$t_{95,n-1}$	Student's t -factor, evaluated for a 95 % confidence level and $(n-1)$ degrees of freedom
u	groundwater pressure at a point in the ground
u_0	groundwater pressure in the absence of flow (hydrostatic)
u_d	design value of groundwater pressure at a point in the ground
$u_{d,dst}$	design value of destabilising (uplift) groundwater pressures
$u_{G,rep}$	representative value of the (unfavourable) uplift permanent groundwater pressures
$u_{Q,rep}$	representative value of the (unfavourable) uplift variable groundwater pressures
z	vertical distance or the elevation where u is measured (positive upwards) vertical distance of the point in the ground below the ground surface

Greek upper-case letters

Δ	relative deflection
Δ/L	deflection ratio
Δu_d	design excess groundwater pressure

Greek lower-case letters

β	angular distortion
γ'	buoyant weight density (effective density) of the ground
$\gamma_{c,x}$	partial factor on effective cohesion (where 'x' is replaced by 'p' for peak friction, 'cs' for critical state, 'r' for residual, or 'dis' for along a discontinuity)
γ_{cu}	partial factor on shear strength in total stress analysis
γ_E	partial factor applied to the effect of actions
γ_F	partial factor on action
γ_G	partial factor on an unfavourable permanent action
γ_{Gw}	partial factor on a permanent water action
$\gamma_{G,fav}$	partial factor on a favourable permanent action
γ_{HYD}	partial factor for hydraulic heave
γ_M	partial factor on a material property
γ_{pv}	partial factor for effective vertical overburden pressure
γ_{qu}	partial factor on unconfined compressive strength
γ_Q	partial factor on a variable action
γ_{Qw}	partial factor on a variable water action
γ_R	partial factor on resistance
γ_{rep}	representative value of the weight density of the ground
$\gamma_{\tan\delta}$	partial factor on the coefficient of ground/structure interface friction

$\gamma_{\tan\varphi_x}$	partial factor on $\tan \varphi_x$ (where 'x' is replaced by 'p' for peak friction, 'cs' for critical state, 'r' for residual, or 'dis' for along a discontinuity)
γ_w	weight density of groundwater or porewater
$\gamma_{w,rep}$	representative weight density of groundwater
$\gamma_{\tau f}$	partial factor on the shear strength of soil in effective stress analysis
$\gamma_{\tau r}$	partial factor on the shear strength of rock and rock mass
$\gamma_{\tau dis}$	partial factor on the shear strength of rock discontinuities
δ	ground/structure interface angle of friction
δ_s	differential settlement
δ_X	vertical scale of fluctuation of the property X
η	conversion factor accounting for the effect of scale, moisture, temperature, ageing of materials, anisotropy, stress path or strain level.
τ_f	shear strength in effective stress analysis
φ'	effective angle of friction of the ground
$\sigma_{v,d}$	design value of the (stabilizing) vertical total stress at the base of the layer that is subject to uplift.
$\sigma_{v,rep}$	representative value of the (favourable) vertical total stress at the base of the layer that is subject to uplift
$\tan\delta$	coefficient of the ground/structure interface friction
$\tan\varphi'$	coefficient of effective friction
ω	tilt

3.2.2 Abbreviations

CC	Consequence Class
DCL	Design Check Level
DQL	Design Qualification (and experience) Level
GC	Geotechnical Category
GCC	Geotechnical Complexity Class
GCR	Geotechnical Construction Record
GDM	Geotechnical Design Model
GDR	Geotechnical Design Report
GIR	Ground Investigation Report
GM	Ground Model
IL	Inspection Level
MFA	Material Factor Approach
NDP	National Determined Parameter

OM	Observational Method
RFA	Resistance Factor Approach
VC	Verification Case

4 Basis of design

4.1 General rules

4.1.1 Basic requirements

- (1) The assumptions given in 1.2 shall be verified.
- (2) The design of geotechnical structures shall comply with EN 1990 and EN 1997 (all parts).
- (3) The following models shall be used to verify the requirements for safety, serviceability, robustness, and durability of geotechnical structures:
 - Ground Model, as specified in EN 1997-2:2024, Clause 4;
 - Geotechnical Design Model, as specified in 4.2.3.

NOTE Further guidance on reporting, including the Geotechnical Design Model, is given in Annex B.

4.1.2 Geotechnical reliability

4.1.2.1 Zone of influence

- (1) The extent of the zone of influence shall be defined.
- (2) When defining the extent of the zone of influence, consideration where relevant should be given, but not limited, to:
 - the structure and its elements;
 - any transient or persistent changes in ground conditions;
 - all relevant ultimate limit states of the surrounding ground;
 - all relevant serviceability limit states;
 - all relevant hydraulic or hydrogeological effects;
 - topography and geomorphology;
 - relevant redistribution of the in situ stress state; and
 - the influence of work undertaken during execution.
- (3) The extents of the zone of influence should also take account of:
 - environmental impact;
 - pollution;
 - vibrations; and

— noise.

(4) The extents of the zone of influence shall be estimated prior to the ground investigation.

(5) The extents of the zone of influence should be updated based on the results of the ground investigation and during the design process.

(6) The extent of potential failure surfaces and the potential occurrence of significant ground displacements shall be determined.

(7) In addition to (3), the zone of influence should include the extent of potential transient or persistent changes in the representative groundwater or piezometric levels.

4.1.2.2 Geotechnical Complexity Class

(1) The Geotechnical Complexity Class (GCC) shall be selected using engineering judgement, taking into account complexity and uncertainty in the ground, groundwater conditions and ground-structure interaction.

NOTE 1 General features to consider when selecting the GCC are given in Table 4.1 (NDP) unless the National Annex gives different features.

NOTE 2 Specific features to consider when selecting the GCC are given in Annex C.

Table 4.1 (NDP) — Selection of Geotechnical Complexity Class

Geotechnical Complexity Class	Complexity	General features
GCC 3	Higher	Any of the following apply: — considerable uncertainty regarding ground conditions — highly variable or difficult ground conditions — significant sensitivity to groundwater and surface water conditions — significant complexity of the ground structure interaction
GCC 2	Normal	GCC2 applies if GCC 1 and GCC3 are not applicable
GCC 1	Lower	All the following conditions apply: — negligible uncertainty regarding the ground conditions — uniform ground conditions — low sensitivity to groundwater and surface water conditions, — low complexity of the ground structure interaction
NOTE The terms 'considerable', 'significant', 'highly', etc. are relative to any comparable experience that exists for the particular geotechnical structure, design situation, and ground conditions.		

(2) A preliminary GCC should be selected as part of the desk study (see EN 1997-2:2024, 5.2.1).

(3) As an alternative to (2), a preliminary GCC may be selected based on a site inspection.

(4) The GCC shall be reviewed and, if appropriate, changed at each stage of design and execution.

(5) The GCC shall be assumed to be GCC3 unless a different class has been determined by the ground investigation.

4.1.2.3 Geotechnical Category

(1) Geotechnical structures shall be classified into a Geotechnical Category that combines the uncertainty and complexity of the ground and ground-structure interaction with the consequence of failure of the structure.

(2) Different parts of a geotechnical structure may be classified in different Geotechnical Categories if the geotechnical complexity or the consequence of failure differs between the parts.

(3) The Geotechnical Category should be determined from a combination of the Consequence Class of the structure and Geotechnical Complexity Class.

NOTE 1 The relationship between Geotechnical Category, Consequences Class, and Geotechnical Complexity Class is given in Table 4.2 (NDP) unless the National Annex gives a different relationship or specifies a direct determination of the Geotechnical Category.

NOTE 2 Guidance on classification of geotechnical structures in Consequence Classes is given in 4.1.3.

NOTE 3 The Consequence Class of the structure is defined by EN 1990:2023, Table 4.1.

Table 4.2 (NDP) — Relationship between Geotechnical Category, Consequences Class, and Geotechnical Complexity Class

Consequence Class (CC)	Geotechnical Complexity Class (GCC)		
	Lower (GCC1)	Normal (GCC2)	Higher (GCC3)
High (CC3)	GC2	GC3	GC3
Normal (CC2)	GC2	GC2	GC3
Low (CC1)	GC1	GC2	GC2

(4) To ensure the appropriate level of reliability required by EN 1990:2023, 4.2 is obtained, the Geotechnical Category shall be used to specify the extent and amount of the following measures:

- measures to achieve appropriate representation of parameters for design, including:
 - appropriate extent of ground investigation (EN 1997-2);
 - validation of available information from Ground investigations (4.2.4);
 - validation of the Geotechnical Design Model (4.2.3);
- measures to achieve accuracy of the calculation models used and the interpretation of their results, including:
 - validation of calculation models (7.1);
- measures to prevent errors in design and execution, and the occurrence of gross human errors, including:
 - designer qualifications and experience (4.1.8);
 - quality management measures (4.1.8);

- amount and type of reporting (12);
- measures to ensure appropriate implementation of design according to procedures specified in the project documentation, including:
 - supervision (10.2);
 - inspection (10.3);
 - monitoring (10.4);
 - maintenance (10.5).

NOTE 1 Guidance on measures related to designer qualification and experience is given in EN 1990:2023, Annex B.

NOTE 2 Guidance on the amount and type of reporting is given in Annex B.

(5) If the measures in (4) are insufficient to obtain the appropriate level of reliability required by EN 1990, additional measures should be taken.

4.1.3 Consequences of failure

(1) In addition to EN 1990:2023, 4.3, the classification of the consequences of failure of a geotechnical structure should account for the potential effects on structures, utilities, and ground within the zone of influence.

NOTE 1 Table 4.3 (NDP) gives examples of geotechnical structures in Consequence Classes CC0 to CC4 unless the National Annex gives other examples.

NOTE 2 The provisions in EN 1997 (all parts) do not entirely cover design rules needed for geotechnical structures classified as CC4. For these structures, additional or amended provisions to those given in EN 1997 (all parts) can be needed.

Table 4.3 (NDP) — Examples of geotechnical structures in different Consequence Classes

Consequence class	Description of consequence	Examples
CC4	Highest	— Geotechnical structures whose integrity is of vital importance for civil protection^a; — Geotechnical structures in areas with significant landslide hazards.
CC3	Higher	— Retaining walls and foundations supporting public buildings, with high exposure; — Man-made slopes and cuttings and retaining structures with high exposure; — Major road/railway embankments, bridge foundations that can cause severe interruption of service in emergency situations;

Consequence class	Description of consequence	Examples
		— Geotechnical structures with a primary navigational function^b; — Flood barrier protecting a large number of people; — Underground constructions with large occupancy.
CC2	Normal	All geotechnical structures not classified as CC0, CC1, CC3, or CC4
CC1	Lower	— Retaining walls and foundations supporting buildings with low occupancy; — Man-made slopes and cuttings, in areas where a failure will have low impact on society; — Minor road/railway embankments not vital for society; — Underground structures with occasional occupancy^c.
CC0	Lowest	Not applicable for geotechnical structures
^a Examples of geotechnical structures whose integrity is of vital importance for civil protection are road/railway embankments with a fundamental role in the event of natural disasters, earth dams connected to aqueducts and energy plants, earth dams and tailing dams with extreme consequences upon failure, foundation of nuclear structures, and major harbour structures. ^b Examples of geotechnical structures with primary navigational function are marking or protecting entrances of ports. ^c Examples of underground structures with occasional occupancy are culverts not supporting main railway lines or major roads.		

4.1.4 Robustness

(1) EN 1990:2023, 4.4 shall apply.

NOTE 1 For most geotechnical structures, design in accordance with the Eurocodes provides an adequate level of robustness without the need for any additional design measures to enhance robustness.

NOTE 2 Appropriate prognosis of climate change affecting the geotechnical structure during its design service life is considered in 4.3.1.4.

(2) Measures to enhance robustness of a geotechnical structure should, as relevant, take into account:

- interaction between different structures or parts of structures;
- interaction between different failure modes affecting the geotechnical structure;
- potential progressive failures in the ground;
- ground conditions with specific issues that are not fully covered by normal design;
- impact on the geotechnical structure due to potential adverse events in the surroundings of the structure; and

- erosive influence of running water.

NOTE 1 Ground conditions with specific issues refer to local ground conditions known, by comparable experience, to be problematic (e.g. quick clay, swelling ground, liquefiable soils).

NOTE 2 Design measures to enhance robustness of geotechnical structure can be given in the National Annex.

(3) Potential strategies for designing geotechnical structures for robustness should provide:

- enough ductility and deformation capacity;
- redistribution of load within the geotechnical structure to avoid sudden collapse;
- increased resistance of critical elements identified within the geotechnical structure;
- addition of a margin to the execution tolerances;
- extra drainage capacity by appropriate design of drainage systems;
- measures to prevent scour leading to erosion of soil under and around a geotechnical structure; and
- restriction on future loads on the ground surface or the structure.

4.1.5 Design service life

(1) In addition to EN 1990:2023, 4.5, the design service life T_{lf} of a geotechnical structure should be specified.

NOTE 1 The value of T_{lf} is given in Table 4.4 (NDP) for different categories of geotechnical structures, unless the National Annex gives different values or categories.

NOTE 2 The design service life of the supported structure is given in EN 1990:2023, Annex A.

Table 4.4 (NDP) — Design service life categories of geotechnical structures

Category of geotechnical structures	Design service life T_{lf} years
Geotechnical structures that support other structures	At least that of the supported structure ^a
Geotechnical structures ^b supporting (or incorporated into) road or railway infrastructure Embankment dams for water defence	100
Geotechnical structures not covered by another category	50
Replaceable parts of geotechnical structure ^c	25
Temporary geotechnical structures	10
Temporary anchors ^d	2
^a See EN 1990:2023, Annex A ^b For example slopes, cuttings, embankments, retaining structures, reinforced fill or soil nailed structures, or ground improvement ^c For example anchors ^d Durability requirements related to EN 1993-5	