

Geregistreeerde Belgische norm

NBN EN 1993-5

2e uitg., augustus 2007

Normklasse: B 51

Eurocode 3 - Ontwerp en berekening van staalconstructies - Deel 5: Palen en damwanden (+ AC:2009)

Eurocode 3 - Calcul des structures en acier - Partie 5: Pieux et palplanches (+ AC:2009)

Eurocode 3 - Design of steel structures - Part 5: Piling (+ AC:2009)

Toelating tot publicatie: 30 mei 2007

Vervangt NBN ENV 1993-5 (1998).

Deze Europese norm EN 1993-5:2007 heeft de status van een Belgische norm.

Deze Europese norm bestaat in drie officiële versies (Duits, Engels, Frans).

Er is bij het NBN ook een Nederlandstalige versie beschikbaar, die dezelfde status heeft als de officiële versies.

Deze norm mag in België slechts samen met zijn nationale bijlage (ANB) worden toegepast. Deze laatste legt hoofdzakelijk de waarden van de parameters vast die op nationaal vlak worden bepaald.

*norme belge
enregistrée*

NBN EN 1993-5

2e éd., août 2007

Indice de classement: B 51

Eurocode 3 - Calcul des structures en acier - Partie 5: Pieux et palplanches (+ AC:2009)

Eurocode 3 - Ontwerp en berekening van staalconstructies - Deel 5: Palen en damwanden (+ AC:2009)

Eurocode 3 - Design of steel structures - Part 5: Piling (+ AC:2009)

Autorisation de publication: 30 mai 2007

Remplace NBN ENV 1993-5 (1998).

La présente norme européenne EN 1993-5:2007 a le statut d'une norme belge.

La présente norme européenne existe en trois versions officielles (allemand, anglais, français).

Une version en néerlandais, ayant le même statut que les versions officielles, est également disponible au NBN.

Cette norme ne peut être utilisée en Belgique qu'en combinaison avec son annexe nationale (ANB) qui fixe principalement la valeur des paramètres à déterminer au niveau national.

NATIONAAL VOORWOORD VAN NBN EN 1993-5:2007

1. De norm NBN EN 1993-5:2007 «Eurocode 3 – Ontwerp en berekening van staalconstructies – Deel 5: Palen en damwanden» omvat de nationale bijlage NBN EN 1993-5 ANB:2011 met een normatief karakter in België. Hij vervangt vanaf de datum van de publicatie in het Belgische Staatsblad van de bekrachtiging van de norm NBN EN 1993-5 ANB:2011 de volgende norm:

NBN ENV 1993-5:1998 Eurocode 3 – Ontwerp van stalen draagsystemen - Deel 5: Palen en damplanken

Het corrigendum EN 1993-5:2007/AC:2009, zoals door CEN gepubliceerd, is na deze norm toegevoegd.

2. De Europese normen (EN) waarnaar de tekst van deze norm met hun Engelse titel verwijst, dragen in België de volgende Nederlandstalige titels:

Vermelde norm	Nederlandstalige titel (NBN)
EN 1990 Eurocode: Basis of structural design	NBN EN 1990 Eurocode - Grondslagen van het constructief ontwerp
EN 1991 Eurocode 1: Actions on structures	NBN EN 1991 Eurocode 1: Belastingen op constructies
EN 1992 Eurocode 2: Design of concrete structures	NBN EN 1992 Eurocode 2: Ontwerp en berekening van betonconstructies
EN 1993 Eurocode 3: Design of steel structures	NBN EN 1993 Eurocode 3: Ontwerp en berekening van staalconstructies
Part 1.1: General rules: General rules and rules for buildings	Deel 1.1: Algemene regels en regels voor gebouwen
EN 1993 Eurocode 3: Design of steel structures	NBN EN 1993 Eurocode 3: Ontwerp en berekening van staalconstructies
Part 1.2: General rules: Structural fire design	Deel 1-2: Algemene regels - Ontwerp en berekening van constructies bij brand

EN 1993 Eurocode 3: Design of steel structures Part 1.3: General rules: Supplementary rules for cold formed thin gauge members and sheeting	NBN EN 1993 Eurocode 3: Ontwerp en berekening van staalconstructies Deel 1-3: Algemene regels - Aanvullende regels voor koudgevormde profielen en platen
EN 1993 Eurocode 3: Design of steel structures Part 1.5: General rules: Plated structural elements	NBN EN 1993 Eurocode 3: Ontwerp en berekening van staalconstructies Deel 1-5: Algemene regels - Constructieve plaatvelden
EN 1993 Eurocode 3: Design of steel structures Part 1.6: General rules: Strength and stability of shell structures	NBN EN 1993 Eurocode 3: Ontwerp en berekening van staalconstructies Deel 1-6: Algemene regels - Sterkte en stabiliteit van schaalconstructies
EN 1993 Eurocode 3: Design of steel structures Part 1.8: General rules: Design of joints	NBN EN 1993 Eurocode 3: Ontwerp en berekening van staalconstructies Deel 1-8: Algemene regels - Ontwerp en berekening van verbindingen
EN 1993 Eurocode 3: Design of steel structures Part 1.9: General rules: Fatigue	NBN EN 1993 Eurocode 3: Ontwerp en berekening van staalconstructies Deel 1-9: Algemene regels - Vermoeiing
EN 1993 Eurocode 3: Design of steel structures Part 1.10: General rules: Material toughness and through-thickness properties	NBN EN 1993 Eurocode 3: Ontwerp en berekening van staalconstructies Deel 1-10: Algemene regels - Materiaaltaaiheid en eigenschappen in de dikterichting
EN 1993 Eurocode 3: Design of steel structures Part 1.11: General rules: Design of structures with tension components made of steel	NBN EN 1993 Eurocode 3: Ontwerp en berekening van staalconstructies Deel 1-11: Algemene regels - Ontwerp en berekening van aan trek onderworpen componenten
EN 1994 Eurocode 4: Design of composite steel and concrete structures	NBN EN 1994 Eurocode 4: Ontwerp en berekening van staal-betonconstructies
EN 1997 Eurocode 7: Geotechnical design	NBN EN 1997 Eurocode 7: Geotechnisch ontwerp

EN 1998 Eurocode 8: Earthquake resistant design of structures	NBN EN 1998 Eurocode 8 - Ontwerp en berekening van aardbevingsbestendige constructies
EN 10002 Metallic materials; tensile testing	NBN EN 10002 Metalen - Trekproef
EN 10027 Designation systems for steel	NBN EN 10027 Systemen voor het aanduiden van staalsoorten
EN 10210 Hot finished structural hollow sections of non-alloy fine grain structural steels	NBN EN 10210 Warmvervaardigde buisprofielen voor constructiedoeleinden van ongelegeerd en fijnkorrelig constructiestaal
EN 10219 Cold formed structural hollow sections of non-alloy fine grain structural steels	NBN EN 10219 Koudvervaardigde gelaste buisprofielen voor constructiedoeleinden van ongelegeerd en fijnkorrelig staal
EN 10248 Hot rolled sheet piling of non-alloy steels	NBN EN 10248 Warmgewalste damwandprofielen van ongelegeerde staalsoorten
EN 10249 Cold formed sheet piling of non-alloy steels	NBN EN 10249 Koudgevormde damwandprofielen van ongelegeerde staalsoorten
EN 1536 Execution of special geotechnical work – Bored piles	NBN EN 1536 Uitvoering van bijzonder grondwerk - Boorpalen
EN 1537 Execution of special geotechnical work – Ground anchors	NBN EN 1537 Uitvoering van bijzonder grondwerk - Grondankers
EN 12063 Execution of special geotechnical work – Sheet-pile walls	NBN EN 12063 Uitvoering van bijzonder grondwerk - Damwanden
EN 12699 Execution of special geotechnical work – Displacement piles	NBN EN 12699 Uitvoering van bijzonder grondwerk - Verdringingspalen
EN 14199 Execution of special geotechnical work – Micro piles	NBN EN 14199 Uitvoering van bijzonder grondwerk - Micropalen
EN 10045 Metallic materials; Charpy impact test	NBN EN 10045 Metalen - Kerfslagproef volgens Charpy
EN 1090-2 Execution of steel structures and aluminium structures	NBN EN 1090-2 Het vervaardigen van staal- en aluminiumconstructies
Part 2: Technical requirements for steel structures	Deel 2: Technische eisen voor staalconstructies

- 3.** Aanvullende opmerking van het NBN: de hieronder opgenomen verbeteringen behoren te worden aangebracht in de Nederlandstalige versie van de NBN EN 1993-5:2007. Zie EN 1993-5:2007/AC:2009.

AVANT-PROPOS NATIONAL À LA NBN EN 1993-5:2007

1. La norme NBN EN 1993-5:2007 "Eurocode 3 – Calcul des structures en acier – Partie 5 : Pieux et palplanches" comprend l'annexe nationale NBN EN 1993-5 ANB:2011 qui a un caractère normatif en Belgique. Elle remplace à partir de la date de publication au Moniteur Belge de l'homologation de la norme NBN EN 1993-5 ANB:2011 la norme suivante:

NBN ENV 1993-5:1998 Eurocode 3 : Calcul des structures en acier –
Partie 5 : Pieux et palplanches

Le corrigendum NBN EN 1993-5:2007/AC:2009, tel que publié par le CEN, est joint à cette norme.

2. La version en langue française de l'EN 1993-5:2007 a été rédigée en France par l'AFNOR.
En conséquence, on y rencontre certaines expressions d'usage moins courant en Belgique.

Une liste de termes équivalents est donnée ci-après :

Terme de l'EN 1993-5	Terme équivalent en Belgique
client	le maître de l'ouvrage assisté de ses bureaux d'architectes, d'ingénierie et de consultance
poteau	colonne

English Version

Eurocode 3 - Design of steel structures - Part 5: Piling

Eurocode 3 - Calcul des structures en acier - Partie 5:
Pieux et palplanches

Eurocode 3 - Bemessung und Konstruktion von
Stahlbauten - Teil 5: Pfähle und Spundwände

This European Standard was approved by CEN on 12 June 2006.

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 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 Management Centre has the same status as the official versions.

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



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

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

Content	Page
Foreword	4
1 General	7
1.1 Scope	7
1.2 Normative references	8
1.3 Assumptions	8
1.4 Distinction between principles and application rules	9
1.5 Definitions	9
1.6 Symbols	9
1.7 Units	10
1.8 Terminology	11
1.9 Convention for sheet pile axes.....	19
2 Basis of design	20
2.1 General	20
2.2 Ultimate limit state criteria	20
2.3 Serviceability limit state criteria	21
2.4 Site investigation and soil parameters	21
2.5 Analysis	22
2.6 Design assisted by testing.....	23
2.7 Driveability	24
3 Material properties	25
3.1 General	25
3.2 Bearing piles	25
3.3 Hot rolled steel sheet piles.....	25
3.4 Cold formed steel sheet piles.....	25
3.5 Sections used for waling and bracing	26
3.6 Connecting devices.....	26
3.7 Steel members used for anchors	26
3.8 Steel members used for combined walls	26
3.9 Fracture toughness.....	27
4 Durability	28
4.1 General	28
4.2 Durability requirements for bearing piles.....	29
4.3 Durability requirements for sheet piling.....	30
4.4 Corrosion rates for design.....	30
5 Ultimate limit states	32
5.1 Basis	32
5.2 Sheet piling	32
5.3 Bearing piles	46
5.4 High modulus walls.....	48
5.5 Combined walls	49
6 Serviceability limit states	52
6.1 Basis	52
6.2 Displacements of retaining walls.....	52
6.3 Displacements of bearing piles.....	52
6.4 Structural aspects of steel sheet piling.....	52
7 Anchors, walings, bracing and connections	54
7.1 General	54

7.2	Anchorage	54
7.3	Walings and bracing	56
7.4	Connections	56
8	Execution	64
8.1	General	64
8.2	Steel sheet piling.....	64
8.3	Bearing piles	64
8.4	Anchorage	64
8.5	Walings, bracings and connections	64
A	[normative] - Thin walled steel sheet piling	65
A.1	General	65
A.2	Basis of design.....	66
A.3	Properties of materials and cross-sections	66
A.4	Local buckling	70
A.5	Resistance of cross-sections	72
A.6	Design by calculation	76
A.7	Design assisted by testing.....	77
B	[informative] - Testing of thin walled steel sheet piles	79
B.1	General	79
B.2	Single span beam test	79
B.3	Intermediate support test	80
B.4	Double span beam test.....	81
B.5	Evaluation of test results.....	82
C	[informative] - Guidance for the design of steel sheet piling	84
C.1	Design of sheet pile cross section at ultimate limit state	84
C.2	Serviceability limit state	87
D	[informative] - Primary elements of combined walls	89
D.1	I-sections used as primary elements	89
D.2	Tubular piles used as primary elements.....	91

EN 1993-5: 2007 (E)

Foreword

This European Standard EN 1993-5, “Eurocode 3: Design of steel structures: Part 5 Piling”, has been prepared by Technical Committee CEN/TC250 « Structural Eurocodes », the Secretariat of which is held by BSI. CEN/TC250 is responsible for all Structural Eurocodes.

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 August 2007, and conflicting National Standards shall be withdrawn at latest by March 2010.

This Eurocode supersedes ENV 1993-5:1998.

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

Background to the Eurocode programme

In 1975, the Commission of the European Community decided on an action programme in the field of construction, based on article 95 of the Treaty. The objective of the programme was the elimination of technical obstacles to trade and the harmonisation of technical specifications.

Within this action programme, the Commission took the initiative to establish a set of harmonised technical rules for the design of construction works which, in a first stage, would serve as an alternative to the national rules in force in the Member States and, ultimately, would replace them.

For fifteen years, the Commission, with the help of a Steering Committee with Representatives of Member States, conducted the development of the Eurocodes programme, which led to the first generation of European codes in the 1980’s.

In 1989, the Commission and the Member States of the EU and EFTA decided, on the basis of an agreement¹ between the Commission and CEN, to transfer the preparation and the publication of the Eurocodes to the CEN through a series of Mandates, in order to provide them with a future status of European Standard (EN). This links de facto the Eurocodes with the provisions of all the Council’s Directives and/or Commission’s Decisions dealing with European standards (e.g. the Council Directive 89/106/EEC on construction products - CPD - and Council Directives 93/37/EEC, 92/50/EEC and 89/440/EEC on public works and services and equivalent EFTA Directives initiated in pursuit of setting up the internal market).

The Structural Eurocode programme comprises the following standards generally consisting of a number of Parts:

EN 1990	Eurocode: Basis of structural 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

¹ Agreement between the Commission of the European Communities and the European Committee for Standardisation (CEN) concerning the work on EUROCODES for the design of building and civil engineering works (BC/CEN/03/89).

Eurocode standards recognise the responsibility of regulatory authorities in each Member State and have safeguarded their right to determine values related to regulatory safety matters at national level where these continue to vary from State to State.

Status and field of application of Eurocodes

The Member States of the EU and EFTA recognise that Eurocodes serve as reference documents for the following purposes:

- as a means to prove compliance of building and civil engineering works with the essential requirements of Council Directive 89/106/EEC, particularly Essential Requirement N°1 – Mechanical resistance and stability - and Essential Requirement N°2 - Safety in case of fire;
- as a basis for specifying contracts for construction works and related engineering services;
- as a framework for drawing up harmonised technical specifications for construction products (ENs and ETAs)

The Eurocodes, as far as they concern the construction works themselves, have a direct relationship with the Interpretative Documents² referred to in Article 12 of the CPD, although they are of a different nature from harmonised product standard³. Therefore, technical aspects arising from the Eurocodes work need to be adequately considered by CEN Technical Committees and/or EOTA Working Groups working on product standards with a view to achieving a full compatibility of these technical specifications with the Eurocodes. The Eurocode standards provide common structural design rules for everyday use for the design of whole structures and component products of both a traditional and an innovative nature. Unusual forms of construction or design conditions are not specifically covered and additional expert consideration will be required by the designer in such cases.

National Standards implementing Eurocodes

The National Standards implementing Eurocodes will comprise the full text of the Eurocode (including any annexes), as published by CEN, which may be preceded by a National title page and National foreword, and may be followed by a National Annex (informative).

The National Annex (informative) may only contain information on those parameters which are left open in the Eurocode for national choice, known as Nationally Determined Parameters, to be used for the design of buildings and civil engineering works to be constructed in the country concerned, i.e.:

- values for partial factors and/or classes where alternatives are given in the Eurocode,
- values to be used where a symbol only is given in the Eurocode,
- geographical and climatic data specific to the Member State, e.g. snow map,
- the procedure to be used where alternative procedures are given in the Eurocode,
- references to non-contradictory complementary information to assist the user to apply the Eurocode.

2 According to Art. 3.3 of the CPD, the essential requirements (ERs) shall be given concrete form in interpretative documents for the creation of the necessary links between the essential requirements and the mandates for hENs and ETAGs/ETAs.

3 According to Art. 12 of the CPD the interpretative documents shall:

- (a) give concrete form to the essential requirements by harmonising the terminology and the technical bases and indicating classes or levels for each requirement where necessary;
- (b) indicate methods of correlating these classes or levels of requirement with the technical specifications, e.g. methods of calculation and of proof, technical rules for project design, etc.;
- (c) serve as a reference for the establishment of harmonised standards and guidelines for European technical approvals.

The Eurocodes, de facto, play a similar role in the field of the ER 1 and a part of ER 2.

EN 1993-5: 2007 (E)**Links between Eurocodes and product harmonised technical specifications (ENs and ETAs)**

There is a need for consistency between the harmonised technical specifications for construction products and the technical rules for works⁴. Furthermore, all the information accompanying the CE Marking of the construction products which refer to Eurocodes should clearly mention which Nationally Determined Parameters have been taken into account.

Additional information specific to EN 1993-5

EN 1993-5 gives design rules for steel sheet piling and bearing piles to supplement the generic rules in EN 1993-1.

EN 1993-5 is intended to be used with Eurocodes EN 1990 - Basis of design, EN 1991 - Actions on structures and Part 1 of EN 1997 Geotechnical Design.

Matters that are already covered in those documents are not repeated.

EN 1993-5 is intended for use by

- committees drafting design related product, testing and execution standards,
- clients (e.g. for the formulation of their specific requirements)
- designers and constructors
- relevant authorities.

Numerical values for partial factors and other parameters are recommended as basic values that provide an acceptable level of safety. They have been selected assuming that an appropriate level of workmanship and quality management applies.

Annex A and Annex B have been prepared to complement the provisions of EN 1993-1-3 for class 4 steel sheet piles.

Annex C gives guidance on the plastic design of steel sheet pile retaining structures.

Annex D gives one possible set of design rules for primary elements of combined walls.

Reference should be made to EN 1997 for geotechnical design which is not covered in this document.

National Annex for EN 1993-5

This standard gives alternative procedures, values and recommendations for classes with notes indicating where national choices may have to be made. Therefore the National Standard implementing EN 1993-5 should have a National Annex containing all Nationally Determined Parameters to be used for the design of buildings and civil engineering works to be constructed in the relevant country.

National choice is allowed in EN 1993-5 through clauses:

3.7 (1)	5.2.2 (13)	7.2.3 (2)
3.9 (1)P	5.2.5 (7)	7.4.2 (4)
4.4 (1)	5.5.4 (2)	A.3.1 (3)
5.1.1 (4)	6.4 (3)	B.5.4 (1)
5.2.2 (2)	7.1 (4)	D.2.2 (5)

⁴ See Art. 3.3 and Art. 12 of the CPD, as well as clauses 4.2, 4.3.1, 4.3.2 and 5.2 of ID 1.

1 General

1.1 Scope

- (1) Part 5 of EN 1993 provides principles and application rules for the structural design of bearing piles and sheet piles made of steel.
- (2) It also provides examples of detailing for foundation and retaining wall structures.
- (3) The field of application includes:
 - steel piled foundations for civil engineering works on land and over water;
 - temporary or permanent structures needed to carry out steel piling work;
 - temporary or permanent retaining structures composed of steel sheet piles, including all kinds of combined walls.
- (4) The field of application excludes:
 - offshore platforms;
 - dolphins.
- (5) Part 5 of EN 1993 also includes application rules for steel piles filled with concrete.
- (6) Special requirements for seismic design are not covered. Where the effects of ground movements caused by earthquakes are relevant see EN 1998.
- (7) Design provisions are also given for walings, bracing and anchorages, see section 7.
- (8) The design of steel sheet piling using class 1, 2 and 3 cross-sections is covered in sections 5 and 6, whereas the design of class 4 cross-sections is covered in annex A.

NOTE: The testing of class 4 sheet piles is covered in annex B.

- (9) The design procedures for crimped U-piles and straight web steel sheet piles utilise design resistances obtained by testing. Reference should be made to EN 10248 for testing procedures.
- (10) Geotechnical aspects are not covered in this document. Reference is made to EN 1997.
- (11) Provisions for taking into account the effects of corrosion in the design of piling are given in section 4.
- (12) Allowance for plastic global analysis in accordance with 5.4.3 of EN 1993-1-1 is given in 5.2.

NOTE: Guidance for the design of steel sheet pile walls allowing for plastic global analysis is given in Annex C.

- (13) The design of combined walls at ultimate limit states is covered in section 5 including general provisions for the design of primary elements.

NOTE: Guidance for the design of both tubular piles and I-sections used as primary elements is given in Annex D.