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Eurokod 3: Dimensionering av stålkonstruktioner – Del 2: Broar

Eurocode3: Design of steel structures – Part 2: Steel bridges

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EUROPEAN STANDARD

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English Version

Eurocode 3 - Design of steel structures - Part 2: Steel Bridges

Eurocode 3 - Calcul des structures en acier - Partie 2: Ponts métalliques

Eurocode 3 - Bemessung und konstruktion von Stahlbauten - Teil 2: Stahlbrücken

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COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Foreword

This European Standard EN 1993-2, Eurocode 3: Design of steel structures Part 2: Steel bridges, 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of an identical text or by endorsement, at the latest by April 2007 and conflicting National Standards shall be withdrawn at latest by March 2010.

This Eurocode supersedes ENV 1993-2.

According to the CEN-CENELEC Internal Regulations, the National Standard Organizations of the following countries are bound to implement this European Standard: Austria, Belgium, 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 of 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 agreement[1] 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 0: 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

[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).

EN 1998 Eurocode 8: Design of structures for earthquake resistance

EN 1999 Eurocode 9: Design of aluminium structures

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 Documents[2] referred to in Article 12 of the CPD, although they are of a different nature from a harmonised product standard[3]. 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.

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[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.

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 works[4]. 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 1993-2

EN 1993-2 is the second part of six parts of EN 1993 – Design of Steel Structures – and describes the principles and application rules for the safety and serviceability and durability of steel structures for bridges.

EN 1993-2 gives design rules which are supplementary to the generic rules in EN 1993-1-1.

EN 1993-2 is intended to be used with Eurocodes EN 1990 – Basis of design, EN 1991 – Actions on structures and the parts 2 of EN 1992 to EN 1998 when steel structures or steel components for bridges are referred to.

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

EN 1993-2 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 reliability parameters are recommended as basic values that provide an acceptable level of reliability. They have been selected assuming that an appropriate level of workmanship and quality management applies.

National annex for EN 1993-2

This standard gives alternative procedures, values and recommendations with notes indicating where national choices may have to be made. The National Standard implementing EN 1993-2 should have a National Annex containing all Nationally Determined Parameters to be used for the design of steel structures to be constructed in the relevant country.

National choice is allowed in EN 1993-2 through:

- 2.1.3.2(1)
- 2.1.3.3(5)
- 2.1.3.4(1)
- 2.1.3.4(2)
- 2.3.1(1)
- 3.2.3(2)
- 3.2.3(3)
- 3.2.4(1)
- 3.4(1)
- 3.5(1)
- 3.6(1)

[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.

- 3.6(2)
- 4(1)
- 4(4)
- 5.2.1(4)
- 5.4.1(1)
- 6.1(1)P
- 6.2.2.3(1)
- 6.2.2.4(1)
- 6.3.2.3(1)
- 6.3.4.2(1)
- 6.3.4.2(7)
- 7.1(3)
- 7.3(1)
- 7.4(1)
- 8.1.3.2.1(1)
- 8.1.6.3(1)
- 8.2.1.4(1)
- 8.2.1.5(1)
- 8.2.1.6(1)
- 8.2.10(1)
- 8.2.13(1)
- 8.2.14(1)
- 9.1.2(1)
- 9.1.3(1)
- 9.3(1)P
- 9.3(2)P
- 9.4.1(6)
- 9.5.2(2)
- 9.5.2(3)
- 9.5.2(5)
- 9.5.2(6)
- 9.5.2(7)
- 9.5.3(2) (two places)
- 9.6(1) (two places)
- 9.7(1)
- A.3.3(1)P
- A.3.6(2)
- A.4.2.1(2)
- A.4.2.1(3)
- A.4.2.1(4)
- A.4.2.4(2)
- C.1.1(2)

- C.1.2.2(1)
- C.1.2.2(2)
- E.2(1)

1 General

1.1 Scope

1.1.1 Scope of Eurocode 3

(1) See 1.1.1(1), (2), (3), (4), (5) and (6) of EN 1993-1-1.

1.1.2 Scope of Part 2 of Eurocode 3

(1) EN 1993-2 provides a general basis for the structural design of steel bridges and steel parts of composite bridges. It gives provisions that supplement, modify or supersede the equivalent provisions given in the various parts of EN 1993-1.

(2) The design criteria for composite bridges are covered in EN 1994-2.

(3) The design of high strength cables and related parts are included in EN 1993-1-11.

(4) This European Standard is concerned only with the resistance, serviceability and durability of bridge structures. Other aspects of design are not considered.

(5) For the execution of steel bridge structures, EN 1090 should be taken into account.

NOTE: As long as EN 1090 is not yet available a provisional guidance is given in Annex C.

(6) Execution is covered to the extent that is necessary to indicate the quality of the construction materials and products that should be used and the standard of workmanship needed to comply with the assumptions of the design rules.

(7) Special requirements of seismic design are not covered. Reference should be made to the requirements given in EN 1998, which complements and modifies the rules of EN 1993-2 specifically for this purpose.

1.2 Normative references

(1) This European Standard incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication applies (including amendments).

(2) In addition to the normative references given in EN 1990 and EN 1993-1 the following references should apply:

EN 1090	Execution of steel structures and aluminium structures
EN 1337	Structural bearings
EN 10029:1991	Specification for tolerances on dimensions, shape and mass for hot rolled steel plates 3 mm thick or above.
EN 10164	Steel products with improved deformation properties perpendicular to the surface of the product - Technical delivery conditions.
EN ISO 5817	Arc-welded joints in steel - Guidance on quality levels for imperfections.
EN ISO 12944-3	Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Design considerations.
EN ISO 9013:2002	Thermal cutting - Classification of thermal cuts - Geometrical product specification and quality tolerances.

EN ISO 15613	Specification and qualification of welding procedures for metallic materials - Qualification based on pre-production welding test
EN ISO 15614-1	Specification and qualification of welding procedures for metallic materials - Welding procedure test - Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys

1.3 Assumptions

(1) See 1.3(1) of EN 1993-1-1.

1.4 Distinction between principles and application rules

(1) See 1.4(1) of EN 1993-1-1.

1.5 Terms and definitions

(1) The terms and definitions given in EN 1990, EN 1993-1 and the following apply:

1.5.1
bridges
civil engineering construction works mainly intended to carry traffic or pedestrian loads over a natural obstacle or a communication line

> **NOTE:** Railway bridges and bridges which carry canals, service pipes or other vehicles such as an aircraft are also covered.

1.5.2
abutment
any end support of a bridge

> **NOTE:** A distinction is made between rigid abutments and flexible abutments where relevant.

1.5.3
integral abutment
abutment that is connected to the deck without any movement joint

1.5.4
pier
intermediate support of a bridge, situated under the deck

1.5.5
bearing
structural support located between the superstructure and an abutment or pier of the bridge that transfers loads from the deck to the abutment or pier

1.5.6
cable stay
tensioned element which connects the deck of a bridge to the pylon or pylons above the deck

1.5.7
prestress
permanent effect due to controlled forces and /or controlled deformations imposed within a structure

> **NOTE:** Various types of prestress are distinguished from each other as relevant (such as prestress by tendons or prestress by imposed deformation of supports).

1.5.8
headroom
clear height available for traffic

1.5.9
breathing (of plates)
out-of-plane deformation of a plate caused by repeated application of in-plane loading

1.5.10
secondary structural elements
structural elements that do not form part of the main structure of the bridge

NOTE: The secondary structural elements are provided for other reasons, such as guard rails, parapets, ladders and access covers.

1.6 Symbols

(1) The symbols in EN 1990 und EN 1993-1 apply. Further symbols are given as follows:

$\sigma_{Ed,ser}$, $\tau_{Ed,ser}$	nominal stresses from the characteristic load combination
λ, λ_1, λ_2, λ_3, λ_4, λ_{max}, λ_{loc}, λ_{glo}	damage equivalent factors
Φ_2, Φ_{loc}, Φ_{glo}	damage equivalent impact factors
$\Delta\sigma_p$, $\Delta\sigma_{loc}$, $\Delta\sigma_{glo}$	stress ranges from load p
μ_k	characteristic value of friction coefficient
γ_μ	partial factor for friction
α	factor depending on type of bearing and number of bearings with adverse or relieving forces
T_{0max}, T_{0min}, T_0	temperatures
ΔT_0, ΔT_K, ΔT_γ	temperature differences
γ_T	partial factor for temperature
K, $K_{foundation}$, K_{pier}, $K_{bearing}$	spring stiffness
S_d, S_T	slide path

(2) Additional symbols are defined in the text where they first occur.

1.7 Conventions for member axes

(1) See 1.7(1), (2), (3) and (4) of EN 1993-1-1.

2 Basis of design

2.1 Requirements

2.1.1 Basic requirements

(1) See 2.1.1(1), (2) and (3) of EN 1993-1-1.

2.1.2 Reliability management

(1) See 2.1.2(1) of EN 1993-1-1.

2.1.3 Design working life, durability and robustness

2.1.3.1 General

(1) See 2.1.3.1(1) of EN 1993-1-1.

(2)P Bridges shall be designed for fatigue for the duration of their design working life.

2.1.3.2 Design working life

(1) The design working life should be taken as the period for which a bridge is required to be used for its intended purpose, taking into account anticipated maintenance but not major repair.

NOTE 1: The National Annex may specify the design working life. A design working life of a permanent bridge of 100 years is recommended.

NOTE 2: For temporary bridges the design working life may be stated in the project specifications.

(2) For structural elements that cannot be designed for the total design life of the bridge, see 2.1.3.3.

2.1.3.3 Durability

(1) To ensure durability, bridges and their components may be designed to minimise damage or be protected from excessive deformation, deterioration, fatigue and accidental actions that are expected during the design working life.

(2) Structural parts of a bridge to which guardrails or parapets are connected, should be designed to ensure that plastic deformations of the guardrails or parapets can occur without damaging the structure.

(3) Where a bridge includes components that need to be replaceable, see 4(6), the possibility of their safe replacement should be verified as a transient design situation.

(4) Permanent connections of structural parts of the bridge should be made with preloaded bolts in a Category B or C connection. Alternatively closely fitted bolts, rivets or welding may be used to prevent slipping.

(5) Joints where the transmission of forces is purely by contact may be used where justified by fatigue assessments.

NOTE: The National Annex may give additional recommendations for durable details.

2.1.3.4 Robustness and structural integrity

(1) The design of the bridge should ensure that when the damage of a component due to accidental actions occurs, the remaining structure can sustain at least the accidental load combination with reasonable means.

NOTE: The National Annex may define components that are subject to accidental design situations and also details for assessments. Examples of such components are hangers, cables, bearings.

(2) The effects of corrosion or fatigue of components and material should be taken into account by appropriate detailing, see also EN 1993-1-9 and EN 1993-1-10.

NOTE 1: EN 1993-1-9, section 3 provides assessment methods using the principles of damage tolerance or safe life.

NOTE 2: The National Annex may give a choice of the design method to be used for fatigue assessment.

NOTE 3: For guidance on access, maintenance and inspection, see section 4.

2.2 Principles of limit state design

(1) See 2.2(1) and (2) of EN 1993-1-1.

(3) For damage limitation at the ultimate limit state global analysis models should be elastic for transient and persistent design situations, see 5.4.

(4) The required fatigue life should be achieved through design for fatigue and/or appropriate detailing, see Annex C, and by serviceability checks.

2.3 Basic variables

2.3.1 Actions and environmental influences

(1) Actions for the design of bridges should be taken from EN 1991. For the combination of actions and partial factors for actions see Annex A.2 of EN 1990.

NOTE 1: For actions on steel bridge decks of road bridges, see Annex E.

NOTE 2: For actions not specified in EN 1991, see the National Annex.

(2) See 2.3(2), (3), (4) and (5) of EN 1993-1-1.

NOTE: For actions on bearings, see Annex A.

2.3.2 Material and product properties

(1) See 2.3.2(1) of EN 1993-1-1.

2.4 Verification by the partial factor method

(1) See 2.4.1(1), 2.4.2(1) and (2), 2.4.3(1) and 2.4.4(1) of EN 1993-1-1.

2.5 Design assisted by testing

(1) See 2.5(1), (2) and (3) of EN 1993-1-1.

3 Materials

3.1 General

(1) See 3.1(1) and (2) of EN 1993-1-1.

3.2 Structural steel

3.2.1 Material properties

(1) See 3.2.1(1) of EN 1993-1-1.

3.2.2 Ductility requirements

(1) See 3.2.2(1) and (2) of EN 1993-1-1.

3.2.3 Fracture toughness

(1) The material should have the required material toughness to prevent brittle fracture within the intended design working life of the structure.

(2) No further checks against brittle fracture need to be made if the conditions given in EN 1993-1-10 are met for the lowest service temperature.

NOTE 1: The lowest service temperature to be adopted in design may be taken from EN 1991-1-5.

NOTE 2: The National Annex may specify additional requirements depending on the plate thickness. An example is given in Table 3.1.

Table 3.1: Example for additional requirement for toughness of base material

Example	Nominal thickness	Additional requirement
1	$t \le 30$ mm	T_{27J} = -20 °C in accordance with EN 10025
	$30 < t \le 80$ mm	Fine grain steel in accordance with EN 10025, e.g. S355N/M
	$t > 80$ mm	Fine grain steel in accordance with EN 10025, e.g. S355NL/ML

(3) For bridge components under compression a suitable minimum toughness property should be selected.

NOTE: The National Annex may give guidance on the selection of toughness properties for members in compression. The use of Table 2.1 of EN 1993-1-10 for $\sigma_{Ed} = 0{,}25\, f_y(t)$ is recommended.

3.2.4 Through thickness properties

(1) Steel with improved through thickness properties forming to EN 10164 should be used where required, see EN 1993-1-10.

NOTE: Where Z_{Ed} values have been determined in accordance with EN 1993-1-10, the required quality class according to EN 10164 may be chosen in the National Annex. The choice in Table 3.2 is recommended.

Table 3.2: Quality class conforming to EN 10164

Target value Z_{Ed}	Quality class
$Z_{Ed} \le 10$	–
$10 < Z_{Ed} \le 20$	Z15
$20 < Z_{Ed} \le 30$	Z25
$Z_{Ed} > 30$	Z35

3.2.5 Tolerances

(1) The dimensional and mass tolerances of rolled steel sections, structural hollow sections and plates should conform with the relevant product standard, ETAG or ETA unless more severe tolerances are specified.

(2) For welded components the tolerances in EN 1090 should be applied.

(3) See 3.2.5(3) of EN 1993-1-1.

3.2.6 Design values of material coefficients

(1) See 3.2.6(1) of EN 1993-1-1.

3.3 Connecting devices

3.3.1 Fasteners

3.3.1.1 Bolts, nuts and washers

(1) Bolts, nuts and washers should conform to the Reference Standards given in EN 1993-1-8, 2.8: Group 4.

(2) The rules in this part are applicable to bolts of grades given in Table 3.3.

(3) The nominal values of the yield strength f_{yb} and the ultimate tensile strength f_{ub} are given in Table 3.3 and they should be adopted as characteristic values in calculations.

Table 3.3: Nominal values of the yield strength f_{yb} and the ultimate tensile strength f_{ub} for bolts

Bolt grade	4.6	5.6	6.8	8.8	10.9
f_{yb} (N/mm^2)	240	300	480	640	900
f_{ub} (N/mm^2)	400	500	600	800	1000

3.3.1.2 Preloaded bolts

(1) High strength structural bolts of bolt grades 8.8 and 10.9 which conform to the Reference standards given in EN 1993-1-8, 2.8: Group 4 may be used as preloaded bolts when controlled tightening is carried out in accordance with the Reference Standards given in EN 1993-1-8, 2.8: Group 7.

3.3.1.3 Rivets

(1) The material properties, dimensions and tolerances of steel rivets should conform to the Reference Standards given in EN 1993-1-8, 2.8: Group 6.

3.3.1.4 Anchor bolts

(1) The following steel grades may be used for anchor bolts:

- Steel grades in accordance with the appropriate Reference Standards given in EN 1993-1-8, 2.8: Group 1;
- Steel grades in accordance with the appropriate Reference Standards given in EN 1993-1-8, 2.8: Group 4;
- Reinforcing bars conforming to EN 10080.

The nominal yield strength for anchor bolts should not exceed 640 N/mm^2.

3.3.2 Welding consumables

(1) All welding consumables should conform to the Reference Standards given in EN 1993-1-8, 2.8: Group 5.

(2) The performance of the weld metal should not be less than the corresponding values specified for steel grade being welded. This should take into account:

- specified yield strength;
- ultimate tensile strength;
- elongation at failure;
- minimum Charpy V-notch energy value of the filler metal.