STANDARDISERINGEN I SVERIGE
SWEDISH INSTITUTE FOR STANDARDS

SVENSK STANDARD SS-ENV 1993-2

Handläggande organ	Fastställd	Utgåva	Sida
Byggstandardiseringen, BST	1999-02-26	1	1 (1+182)

Stålkonstruktioner – Dimensionering – Eurocode 3 – Del 2: Stålbroar

Eurocode 3: Design of steel structures – Part 2: Steel bridges

Den europeiska förstandarden ENV 1993-2:1997 gäller som svensk standard och publiceras i form av försöksstandard. Detta dokument innehåller den officiella engelska språkversionen av ENV 1993-2:1997.

Nationellt förord

Denna standarddel utgör en del av för närvarande sammanlagt 11 delar för beräkning och dimensionering av stålkonstruktioner av olika typer och material.

Standarden förutsätts användas i kombination med anvisningar, principer och ändringar givna i ett nationellt anpassningsdokument, NAD(S)/SS-ENV 1993-2, är under utarbetande av Banverket, Boverket och Vägverket i samarbete.

Det finns för närvarande inga planer på att översätta standarden till svenska.

ICS 91.010.30; 91.080.10; 93.040.00

Standarder kan beställas hos SIS som även lämnar allmänna upplysningar om svensk och utländsk standard.
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Prisgrupp V

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EUROPEAN PRESTANDARD
PRÉNORME EUROPÉENNE
EUROPÄISCHE VORNORM

ENV 1993-2

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ICS 91.010.30; 91.080.10; 93.040
Descriptors: steel construction, structural steels, structures, bridges, computation

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

This European Prestandard (ENV) was approved by CEN on 30 May 1997 as a prospective standard for provisional application.

The period of validity of this ENV is limited initiallly to three years. After two years the members of CEN will be requested to submit their comments, particularly of the question whether the ENV can be converted into a European Standard.

CEN members are required to announce the existence of this ENV in the same way as for an EN and to make the ENV available promptly at national level in an appropriate form. It is permissible to keep conflicting national standards in force (in parallel to the ENV) until the final decision about the possible conversion of the ENV into an EN is reached.

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

Central Secretariat: rue de Stassart 36, B-1050 BRUSSELS

Ref. No. ENV 1993-2:1997 E

Contents

Foreword

Objectives of the Eurocodes

(1) The "Structural Eurocodes" comprise a group of standards for the structural and geotechnical design of buildings and civil engineering works.

(2) They cover execution and control only to the extent that is necessary to indicate the quality of the construction products, and the standard of the workmanship, needed to comply with the assumptions of the design rules.

(3) Until the necessary set of harmonized technical specifications for products and for methods of testing their performance is available, some of the Structural Eurocodes cover some of these aspects in informative annexes.

Background to the Eurocode programme

(4) The Commission of the European Communities (CEC) initiated the work of establishing a set of harmonized technical rules for the design of building and civil engineering works which would initially serve as an alternative to the different rules in force in the various member states and would ultimately replace them. These technical rules became known as the "Structural Eurocodes".

(5) In 1990, after consulting their respective member states, the CEC transferred the work of further development, issue and updating of the Structural Eurocodes to CEN, and the EFTA Secretariat agreed to support the CEN work.

(6) CEN Technical Committee CEN/TC 250 is responsible for all Structural Eurocodes.

Eurocode programme

(7) Work is in hand on the following Structural Eurocodes, each generally consisting of a number of parts:

EN 1991 Eurocode 1 Basis of design and 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 provisions for earthquake resistance of structures;

EN 1999 Eurocode 9 Design of aluminium alloy structures.

(8) Separate sub-committees have been formed by CEN/TC 250 for the various Eurocodes listed above.

(9) This Part 2 of Eurocode 3 is published by CEN as a European Prestandard (ENV) with an initial life of three years.

(10) This Prestandard is intended for experimental application.

(11) After approximately two years CEN members will be invited to submit formal comments to be taken into account in determining future actions.

(12) Meanwhile feedback and comments on this Prestandard should be sent to the secretariat of CEN/TC250/SC3 at the following address:

BSI Standards
British Standards House
389 Chiswick High Road
London W4 4AL
England

or to your national standards organization.

National Application Documents (NADs)

(13) In view of the responsibilities of the authorities in member countries for safety, health and other matters covered by the essential requirements of the Construction Products Directive (CPD), certain safety elements in this ENV have been assigned indicative values which are identified by ☐ ("boxed values"). The authorities in each member country are expected to review the "boxed values" and may substitute alternative definitive values for these safety elements for use in national application.

(14) Bridges are essentially public works, for which:

- the European Directive on contracts for public works is relevant;
- public authorities have responsibilities as owners.

(15) Within this context, this Prestandard has been established with two objectives:

- sufficient precision and comprehensiveness for contractual use;
- sufficient flexibility to allow the relevant authorities to exert their technical responsibilities.

(16) Because of the responsibilities of public authorities for bridge design, it is expected that, for application, this ENV 1993-2 will be supplemented by:

- the general complementary rules and options in the National Application Document (NAD), see (19);
- complementary specifications and modifications for particular projects.

(17) Wherever this Prestandard uses such phrases as "unless specified otherwise by the competent authority", the intention is that the relevant authorities (to be identified, if necessary, in the NAD) can intervene at either of these two levels.

(18) Where this Prestandard makes reference to the "project specification", the intention is that the documentation defining a particular project can add complementary specifications and select options, which can include requirements of the competent authority as well as those of the owner, if these are separate.

(19) Some of the supporting European or International Standards might not be available by the time this Prestandard is issued. It is therefore anticipated that a National Application Document (NAD) giving any substitute definitive values for safety elements, referencing compatible supporting standards and providing guidance on the national application of this Prestandard, will be issued by each member country or its Standards Organization.

(20) It is intended that this Prestandard is used in conjunction with the NAD valid in the country where the bridge is located.

Matters specific to this Prestandard

(21) The Parts of ENV 1993 that are currently envisaged are:

ENV 1993-1-1 General rules: General rules and rules for buildings;
ENV 1993-1-2 General rules: Structural fire design;
ENV 1993-1-3 General rules: Supplementary rules for cold formed thin gauge members and sheeting;
ENV 1993-1-4 General rules: Supplementary rules for stainless steels;
ENV 1993-1-5 General rules: Supplementary rules for the strength and stability of planar plated structures without transverse loading;
ENV 1993-2 Steel bridges;
ENV 1993-3 Towers, masts and chimneys;
ENV 1993-4 Silos, tanks and pipelines;
ENV 1993-5 Piling;
ENV 1993-6 Crane supporting structures;
ENV 1993-7 Marine and maritime structures;
ENV 1993-8 Agricultural structures.

(22) This Part 2 of Eurocode 3 has been produced to complement Part 1.1 for the design of bridges.

(23) Steel bridge design requires additional rules for plated structures, but these rules are not specific to bridges, so they have been provided separately as ENV 1993-1-5.

(24) Reference is made to both Part 1.1 and Part 1.5 and matters that are already covered in those documents are not repeated. Similarly reference is also made to Eurocode 1: Part 1 for matters concerning the basis of design instead of repeating them in this document.

(25) For the application of this Part 2 of Eurocode 3 it is assumed that the competent authority or the owner, if these are separate, will define the load model and the characteristic values of the traffic loads according to Part 3 of Eurocode 1.

(26) In each Section of the main portion of the text, the extent to which it supplements, modifies, replaces or supersedes the corresponding elements of Part 1.1 of Eurocode 3 is specifically indicated.

1 General

1.1 Scope

(1)P This Part 2 of ENV 1993 gives a general basis for the structural design of steel bridges, steel parts of composite bridges and also steel temporary works in bridges. It gives provisions that supplement, modify or supersede the equivalent provisions given in ENV 1993-1-1, to which reference shall also be made.

(2) This Part 2 also gives detailed application rules that are mainly applicable to commonly used types of bridge. Where the applicability of these rules is limited, for practical reason or due to simplifications, their use and any limits of applicability are explained in the text.

(3) Provisions for composite bridges are covered in ENV 1994-2.

(4) The design of steel bearing piles and steel sheet pile walls is covered in ENV 1993-5.

(5)P The provisions of this Prestandard are also applicable to the steel parts of bridges that are mainly of other construction materials.

(6)P This Prestandard is concerned only with provisions for resistance, serviceability and durability of bridge structures. Other aspects of design are not considered.

(7)P 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 on site needed to comply with the assumptions of the design rules.

(8) Provisions for the design of high strength cables and related parts are included in annex A. Pending the availability of European Standards for these items, annex A temporarily includes some aspects related to the materials used for them.

(9) For the execution of steel bridge structures, reference should be made to ENV 1090-5.

(10)P ENV 1993 does not cover the special requirements of seismic design. Reference shall be made to the requirements given in ENV 1998, which complements and modifies the rules of ENV 1993 specifically for this purpose.

1.2 Distinction between principles and application rules

(1)P Depending on the contents of the individual paragraphs, a distinction is made in this Part between principles and application rules.

(2)P The principles comprise:

- general or definitive statements for which there is no alternative;
- requirements and analytical models for which no alternative is permitted unless specifically stated.

(3) The principles are identified by the letter P following the paragraph number.

(4)P The application rules are generally recognized rules that follow the principles and satisfy their requirements. Alternative design rules different from the application rules given in the Eurocode may be used, provided that it is shown that the alternative rule accords with the relevant principles and has at least the same reliability.

(5) In this Part the application rules are identified by a number in brackets, as in this paragraph.

1.3 Normative references

This European Prestandard 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 or revisions of any of these publications apply to this European Prestandard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies. When for some European Prestandards the numbers were not available at the date of draft, only a reference is given to EN ... .

EN 1337 *Structural bearings*:

Part 1: *General design rules*;

EN 10025 *Hot rolled products of non-alloy structural steels - Technical delivery conditions*;

EN 10164 *Steel products with improved deformation properties perpendicular to the surface of the product - Technical delivery conditions*;

ENV 1090 *Execution of steel structures*:

Part 1: *General rules and rules for buildings*;

Part 5: *Supplementary rules for bridges*;

ENV 1991 *Eurocode 1: Basis of design and actions on structures*:

Part 1: *Basis of design*;

Part 2.4: *Wind actions*;

Part 2.6: *Loads and deformations imposed during execution*;

Part 2.7: *Accidental actions*;

Part 3: *Traffic loads on bridges*;

ENV 1992 *Eurocode 3 : Design of concrete structures*:

Part 2: *Concrete bridges*;

ENV 1993 *Eurocode 3: Design of steel structures*:

Part 1: *General rules*;

Part 1.1: *General rules: General rules and rules for buildings*;

Part 1.5: *General rules: Supplementary rules for the strength and stability of planar plated structures without transverse loading*;

Part 3: *Towers masts and chimneys*;

Part 5: *Piling*;

ENV 1994 *Eurocode 4: Design of composite steel and concrete structures*:

Part 2: *Composite bridges*;

ENV 1997 *Eurocode 7: Geotechnical design*;

ENV 1998 *Eurocode 8: Earthquake resistant design of structures*;

ISO 286 *ISO system of limits and fits*:

Part 2: *Tables of standard tolerance grades and limit deviations for hole and shafts*;

ISO 2408 *Steel wire ropes for general purposes; Characteristics;*

ISO 8930 *General principles on reliability for structures - List of equivalent terms*;

ISO 8369	*Large diameter steel wire ropes;*
ISO 12944	*Paints and varnishes - Corrosion protection of steel structures by protective paint systems:*
Part 3:	*Design considerations.*
EURONORM 18	*Taking and preparation of samples and sample sections of steel and steel products;*
EURONORM 58	*Hot-rolled flat steel for general use;*
EURONORM 91	*Hot-rolled wide flats - Tolerances on dimensions, shape and mass;*
EN 10113	*Hot-rolled products with weldable fine grain structural steels;*
EN 10137	*Plates and wide flats made of high yield strength structural steels in the quenched and tempered or precipitation hardened conditions;*
EN 10155	*Structural steels with improved atmospheric corrosion resistance; technical delivery conditions;*
EN 10210	*Hot finished structural hollow sections of non-alloy and fine grain structural steels;*
EN 10219	*Cold formed hollow sections of structural steel;*
EN 10204	*Metallic products - Types of inspection documents;*
EN 10029	*Hot-rolled steel plates 3mm thick or above - Tolerances on dimensions, shape and mass;*
EN 10051	*Continuously hot-rolled uncoated plate, sheet and strip of non-alloy and alloy steels - Tolerances on dimensions and shape;*

1.4 Definitions

For the purposes of this Part 2 of ENV 1993, in addition to the definitions given in ISO 8930, ENV 1991, and ENV 1993-1, the following definitions apply:

1.4.1 bridge: Civil engineering construction works mainly intended to carry traffic or pedestrian loads over a natural obstacle or a communication line. They cover all types of bridges including railway bridges and bridges which carry canals, service pipes or other vehicles such as an aircraft.

1.4.2 abutment: Any end support of a bridge without rigid continuity with the deck. A distinction is made between rigid abutments and flexible abutments where relevant.

1.4.3 integral abutment: An abutment that is connected to the deck without any movement joint.

1.4.4 pier: Intermediate support of a bridge, situated under the deck.

1.4.5 bearing: Structural device located between the deck and an abutment or pier of the bridge and transferring loads from the deck to the abutment or pier.

1.4.6 cable stay: A tensioned element which connects the deck of a bridge to the pylon or pylons above the deck.

1.4.7 prestress: Permanent effect due to controlled forces and /or controlled deformations imposed within a structure. Various types of prestress are distinguished from each other as relevant (such as prestress by tendons or prestress by imposed deformation of supports).

1.4.8 headroom: The free height available for traffic.

1.4.9 breathing (of plates): Out-of-plane deformation of a slender plate caused by repeated application of in-plane loading.

1.4.10 secondary structural elements: Structural elements that do not form part of the main structure of the bridge, but are provided for other reasons, such as guard rails, parapets, ladders and access covers.

1.5 Symbols

(1) · In addition to those given in ENV 1993-1-1 the following symbols are used in this Part 2 of ENV 1993.

1.5.1 Latin upper case letters

C Stiffness
D Diameter
K Factor
N Number of ...
P Parallel component of an applied force
T Perpendicular
T Tension force
U Temperature of member
Z Percentage reduction of area

1.5.2 Greek upper case letters

Θ Torsional moment of inertia

1.5.3 Latin lower case letters

f Distance
k Number of ...
m Factor
m Mass
n Proportion of traffic that crosses whilst on the bridge
t Time
w Width
y Lateral deflection

1.5.4 Greek lower case letters

η Coefficient
λ Damage equivalence factor
ν Strain rate
ϕ Factor

1.5.5 Subscripts

amp Amplitude
c Compression
crit Critical
f Solidity
fs Full slip
g General
gen Generalized
glo Global
H Hanger
Ld Design life
loc Local
m Average
ns No slip
Obs Observed
p Primary
QT Crossbeam
r Ring
r Radiation
s Secondary
St Post
w Weight

2 Basis of design

2.1 General

(1)P The design of steel bridges shall be in accordance with the general principles for the structural design of civil engineering works given in ENV 1991 and in Section 2 of ENV 1993-1-1.

(2)P The supplementary rules for bridges given in this Section 2 shall also be applied.

(3)P The assumptions given in ENV 1991 are also applicable for the design of steel bridges.

2.2 Requirements

2.2.1 Fundamental requirements

(1)P The design of bridges shall include fatigue assessments, where repeatative loading occurs.

2.2.2 Reliability

(1)P The reliability required for bridges shall be obtained by carrying out the execution according to ENV 1090-5 as well as by design according to ENV 1991 and ENV 1993.

(2)P A different level of reliability shall be adopted for fatigue depending on the failure consequences.

(3) For durability, see 2.2.5.

2.2.3 Design situations

(1)P The design situations for erection conditions specified in ENV 1991-2-6 and the accidental design situations specified in ENV 1991-2-7 shall also be taken into account.

2.2.4 Design working life

(1)P The design working life shall be taken as the period for which a bridge is required to be used for its intended purpose, with anticipated maintenance but without major repair being necessary.

(2)P The intended design working life of a permanent bridge shall be taken as 100 years unless otherwise specified.

(3)P For temporary bridges the design working life shall be defined by the competent authority.

(4) For structural elements that cannot be designed for the total design life of the bridge, see 2.2.5.

2.2.5 Durability

(1)P To ensure durability, bridges and their components shall either be designed for the deterioration, fatigue and accidental actions that are expected during the design working life, or else protected from them.

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

(3) Components that cannot be designed with sufficient reliability to achieve the total design working life of the bridge should be replaceable. Such parts may include:

- the corrosion protection;

- stays, cables, hangers;
- bearings;
- expansion joints;
- drainage devices;
- guardrails, parapets;
- asphalt layer and other surface protection;
- wind shields;
- noise barriers.

(4) Where a bridge includes components that need to be replaceable, the possibility of their safe replacement should be verified as a transient design situation, taking into account (as far as possible) the need to minimise interruption to the use of the bridge and reduction of the traffic on it.

2.2.6 Quality assurance

(1)P The quality assurance measures shall be as specified by the competent authority, see ENV 1991-1.

2.2.7 Robustness and structural integrity

(1) Bridges should be designed to tolerate damage.

(2) The design should ensure that when damage due to accidental actions occurs, the remaining structure can sustain at least the accidental load combination, see annex A 2.5(1).

(3) The effects of deterioration of material, corrosion or fatigue should be taken into account by appropriate choice of material or structural redundancy and corrosion protection system.

(4) To ensure sufficient integrity, provision should be made for inspection and maintenance at appropriate intervals as specified by the competent authority.

(5) To secure accessibility for maintenance and inspection, the requirements given in Section 4 should be satisfied.

2.3 Limit states

2.3.1 Static equilibrium

(1)P Where the results of a verification are likely to be very sensitive to variations of the magnitude of a permanent action from place to place in the structure, the unfavourable and the favourable parts of this action shall be considered as individual actions. In the design of bridges, this shall be applied in particular to the verification of static equilibrium and to the verification of anchors to prevent uplift.

NOTE: Information on uplift verification is given in annex B.

2.3.2 Partial factors for actions

(1) The partial factors for ultimate limit states in the persistent, transient and accidental design situations should be obtained from ENV 1991-3 and ENV 1991-2-6.

(2) Prestress that is imposed by deformations (e.g. prestress of cables of cable stayed bridges or precambering) may be represented by its nominal value. It should be included with the permanent action G_k and need not be

treated separately, except that a partial factor of γ_p = [1,0] should be applied to prestress during erection of the bridge.

2.3.3 Combination factors

(1) The values of the combination factors ψ for bridges should be obtained from ENV 1991-3.

2.3.4 Serviceability limit states

(1)P The frequent load combination may be used for reversible serviceability limit states, but for irreversible serviceability limit states, the characteristic (rare) load combination shall be used.

2.4 Actions

2.4.1 Characteristic values of actions

(1)P Characteristic values of actions F_k for the design of bridges that are not specified in the relevant part of ENV 1991, shall be specified by the competent authority.

(2) The effects of predicted absolute and differential settlements should be considered as best estimates of imposed deformations.

(3)P The actions to be considered in the erection stages shall be obtained from ENV 1991-2-6.

2.4.2 Other representative values

(1)P In addition to the representative values of variable actions listed in ENV 1991-1, the infrequent value $\psi_i' Q_k$ shall be considered where specified.

3 Materials

3.1 General

(1)P Unless specified otherwise the provisions of this Section 3 shall be followed, superseding Section 3 of ENV 1993-1-1.

(2)P The material properties given in this Section 3 shall be treated as nominal values and adopted as characteristic values in design calculations.

(3) Unless specified by the competent authority inspection documents in accordance with 3.1.6 of EN 10209 should contain material test certificates.

3.2 Structural steel

3.2.1 Scope

(1)P This Part 2 of ENV 1993 covers the design of bridges fabricated from steel material conforming to the steel grades listed in table 3.1.

(2)P Other steel materials shall not be used unless approved by the competent authority.

3.2.2 Material properties

(1)P The nominal values of the yield strength f_y and the ultimate strength f_u for structural steel shall be obtained from table 3.1.

(2) As an alternative to (1)P the values specified in EN 10025, EN 10113, EN 10137, EN 10210, EN 10219 and EN 10155 for a larger range of thicknesses may be used.

3.2.3 Global plastic analysis (accidental design situations only)

(1) Global plastic analysis may be used for accidental design situations if the steel complies with the following additional requirements:

- unless otherwise specified the ratio of the specified minimum ultimate tensile strength f_u to the specified minimum yield strength f_y should satisfy:

$$f_u/f_y \geq \boxed{1{,}10}$$

- the elongation at failure on a gauge length of $5{,}65\sqrt{A_0}$ (where A_0 is the original cross-section area) is not less than 15%;

- the ultimate strain ε_u is at least 15 times the yield strain ε_y.

NOTE: For testing see EURONORM 18.

(2) The steel grades listed in table 3.1 may be accepted as satisfying these requirements.

3.2.4 Fracture toughness

(1)P The material shall have sufficient fracture toughness to avoid brittle fracture at the lowest service temperature expected to occur within the intended life of the structure.

(2) The lowest service temperature to be adopted in design should be stated in the project specification.