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Eurocode 3: Design of steel structures - Part 1-1: General rules and rules for buildings

Eurocode 3: Bemessung und Konstruktion von Stahlbauten - Teil 1-1: Allgemeine Bemessungsregeln und Regeln für den Hochbau

Eurocode 3: Calcul des structures en acier - Partie 1-1: Regles générales et regles pour les bâtiments

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ICS:

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Eurocode 3: Design of steel structures - Part 1-1: General rules and rules for buildings

Eurocode 3: Calcul des structures en acier - Partie 1-1: Règles générales et règles pour les bâtiments

Eurocode 3: Bemessung und Konstruktion von Stahlbauten - Teil 1-1: Allgemeine Bemessungsregeln und Regeln für den Hochbau

This European Standard was approved by CEN on 16 April 2004.

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

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Foreword

This European Standard EN 1993, Eurocode 3: Design of steel structures, 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of an identical text or by endorsement, at the latest by November 2005, and conflicting National Standards shall be withdrawn at latest by March 2010.

This Eurocode supersedes ENV 1993-1-1.

According to the CEN-CENELEC Internal Regulations, the National Standard Organizations of the following countries are bound to implement these 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, 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 harmonization of technical specifications.

Within this action programme, the Commission took the initiative to establish a set of harmonized 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 1980s.

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:	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

[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 1999 Eurocode 9: Design of aluminium structures

Eurocode standards recognize 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 recognize 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 harmonized 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 harmonized 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.

Links between Eurocodes and product harmonized technical specifications (ENs

[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 harmonizing 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 harmonized 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.

and ETAs)

There is a need for consistency between the harmonized 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 1993-1

EN 1993 is intended to be used with Eurocodes EN 1990 – Basis of Structural Design, EN 1991 – Actions on structures and EN 1992 to EN 1999, when steel structures or steel components are referred to.

EN 1993-1 is the first of six parts of EN 1993 – Design of Steel Structures. It gives generic design rules intended to be used with the other parts EN 1993-2 to EN 1993-6. It also gives supplementary rules applicable only to buildings.

EN 1993-1 comprises twelve subparts EN 1993-1-1 to EN 1993-1-12 each addressing specific steel components, limit states or materials.

It may also be used for design cases not covered by the Eurocodes (other structures, other actions, other materials) serving as a reference document for other CEN TC´s concerning structural matters.

EN 1993-1 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.

[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.

National annex for EN 1993-1-1

This standard gives values with notes indicating where national choices may have to be made. Therefore the National Standard implementing EN 1993-1 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 1993-1-1 through the following clauses:

- 2.3.1(1)
- 3.1(2)
- 3.2.1(1)
- 3.2.2(1)
- 3.2.3(1)
- 3.2.3(3)B
- 3.2.4(1)B
- 5.2.1(3)
- 5.2.2(8)
- 5.3.2(3)
- 5.3.2(11)
- 5.3.4(3)
- 6.1(1)
- 6.1(1)B
- 6.3.2.2(2)
- 6.3.2.3(1)
- 6.3.2.3(2)
- 6.3.2.4(1)B
- 6.3.2.4(2)B
- 6.3.3(5)
- 6.3.4(1)
- 7.2.1(1)B
- 7.2.2(1)B
- 7.2.3(1)B
- BB.1.3(3)B

1 General

1.1 Scope

1.1.1 Scope of Eurocode 3

(1) Eurocode 3 applies to the design of buildings and civil engineering works in steel. It complies with the principles and requirements for the safety and serviceability of structures, the basis of their design and verification that are given in EN 1990 – Basis of structural design.

(2) Eurocode 3 is concerned only with requirements for resistance, serviceability, durability and fire resistance of steel structures. Other requirements, e.g. concerning thermal or sound insulation, are not covered.

(3) Eurocode 3 is intended to be used in conjunction with:

- EN 1990 “Basis of structural design”
- EN 1991 “Actions on structures”
- ENs, ETAGs and ETAs for construction products relevant for steel structures
- EN 1090 “Execution of Steel Structures – Technical requirements”
- EN 1992 to EN 1999 when steel structures or steel components are referred to

(4) Eurocode 3 is subdivided in various parts:

EN 1993-1 Design of Steel Structures : General rules and rules for buildings.

EN 1993-2 Design of Steel Structures : Steel bridges.

EN 1993-3 Design of Steel Structures : Towers, masts and chimneys.

EN 1993-4 Design of Steel Structures : Silos, tanks and pipelines.

EN 1993-5 Design of Steel Structures : Piling.

EN 1993-6 Design of Steel Structures : Crane supporting structures.

(5) EN 1993-2 to EN 1993-6 refer to the generic rules in EN 1993-1. The rules in parts EN 1993-2 to EN 1993-6 supplement the generic rules in EN 1993-1.

(6) EN 1993-1 “General rules and rules for buildings” comprises:

EN 1993-1-1 Design of Steel Structures : General rules and rules for buildings.

EN 1993-1-2 Design of Steel Structures : Structural fire design.

EN 1993-1-3 Design of Steel Structures : Cold-formed thin gauge members and sheeting.

EN 1993-1-4 Design of Steel Structures : Stainless steels.

EN 1993-1-5 Design of Steel Structures : Plated structural elements.

EN 1993-1-6 Design of Steel Structures : Strength and stability of shell structures.

EN 1993-1-7 Design of Steel Structures : Strength and stability of planar plated structures transversely loaded.

EN 1993-1-8 Design of Steel Structures : Design of joints.

EN 1993-1-9 Design of Steel Structures : Fatigue strength of steel structures.

EN 1993-1-10 Design of Steel Structures : Selection of steel for fracture toughness and through-thickness properties.

EN 1993-1-11 Design of Steel Structures : Design of structures with tension components made of steel.

EN 1993-1-12 Design of Steel Structures : Supplementary rules for high strength steel.

1.1.2 Scope of Part 1.1 of Eurocode 3

(1) EN 1993-1-1 gives basic design rules for steel structures with material thicknesses $t \geq 3$ mm. It also gives supplementary provisions for the structural design of steel buildings. These supplementary provisions are indicated by the letter "B" after the paragraph number, thus ( )B.

NOTE For cold formed thin gauge members and plate thicknesses $t < 3$ mm see EN 1993-1-3.

(2) The following subjects are dealt with in EN 1993-1-1:

Section 1: General

Section 2: Basis of design

Section 3: Materials

Section 4: Durability

Section 5: Structural analysis

Section 6: Ultimate limit states

Section 7: Serviceability limit states

(3) Sections 1 to 2 provide additional clauses to those given in EN 1990 "Basis of structural design".

(4) Section 3 deals with material properties of products made of low alloy structural steels.

(5) Section 4 gives general rules for durability.

(6) Section 5 refers to the structural analysis of structures, in which the members can be modelled with sufficient accuracy as line elements for global analysis.

(7) Section 6 gives detailed rules for the design of cross sections and members.

(8) Section 7 gives rules for serviceability.

1.2 Normative references

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 referred to applies (including amendments).

1.2.1 General reference standards

EN 1090	Execution of steel structures – Technical requirements
EN ISO 12944	Paints and varnishes – Corrosion protection of steel structures by protective paint systems
EN 1461	Hot dip galvanized coatings on fabricated iron and steel articles – specifications and test methods

1.2.2 Weldable structural steel reference standards

EN 10025-1:2004	Hot-rolled products of structural steels - Part 1: General delivery conditions.
EN 10025-2:2004	Hot-rolled products of structural steels - Part 2: Technical delivery conditions for non-alloy structural steels.
EN 10025-3:2004	Hot-rolled products of structural steels - Part 3: Technical delivery conditions for normalized / normalized rolled weldable fine grain structural steels.

EN 10025-4:2004 Hot-rolled products of structural steels - Part 4: Technical delivery conditions for thermomechanical rolled weldable fine grain structural steels.

EN 10025-5:2004 Hot-rolled products of structural steels - Part 5: Technical delivery conditions for structural steels with improved atmospheric corrosion resistance.

EN 10025-6:2004 Hot-rolled products of structural steels - Part 6: Technical delivery conditions for flat products of high yield strength structural steels in the quenched and tempered condition.

EN 10164:1993 Steel products with improved deformation properties perpendicular to the surface of the product - Technical delivery conditions.

EN 10210-1:1994 Hot finished structural hollow sections of non-alloy and fine grain structural steels – Part 1: Technical delivery requirements.

EN 10219-1:1997 Cold formed hollow sections of structural steel - Part 1: Technical delivery requirements.

1.3 Assumptions

(1) In addition to the general assumptions of EN 1990 the following assumptions apply:

- fabrication and erection complies with EN 1090

1.4 Distinction between principles and application rules

(1) The rules in EN 1990 clause 1.4 apply.

1.5 Terms and definitions

(1) The rules in EN 1990 clause 1.5 apply.

(2) The following terms and definitions are used in EN 1993-1-1 with the following meanings:

1.5.1
frame
the whole or a portion of a structure, comprising an assembly of directly connected structural elements, designed to act together to resist load; this term refers to both moment-resisting frames and triangulated frames; it covers both plane frames and three-dimensional frames

1.5.2
sub-frame
a frame that forms part of a larger frame, but is be treated as an isolated frame in a structural analysis

1.5.3
type of framing
terms used to distinguish between frames that are either:

- **semi-continuous**, in which the structural properties of the members and joints need explicit consideration in the global analysis
- **continuous**, in which only the structural properties of the members need be considered in the global analysis
- **simple**, in which the joints are not required to resist moments

1.5.4
global analysis
the determination of a consistent set of internal forces and moments in a structure, which are in equilibrium with a particular set of actions on the structure

1.5.5
system length
distance in a given plane between two adjacent points at which a member is braced against lateral displacement in this plane, or between one such point and the end of the member

1.5.6
buckling length
system length of an otherwise similar member with pinned ends, which has the same buckling resistance as a given member or segment of member

1.5.7
shear lag effect
non-uniform stress distribution in wide flanges due to shear deformation; it is taken into account by using a reduced "effective" flange width in safety assessments

1.5.8
capacity design
design method for achieving the plastic deformation capacity of a member by providing additional strength in its connections and in other parts connected to it

1.5.9
uniform member
member with a constant cross-section along its whole length

1.6 Symbols

(1) For the purpose of this standard the following symbols apply.

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

NOTE Symbols are ordered by appearance in EN 1993-1-1. Symbols may have various meanings.

Section 1

x-x axis along a member

y-y axis of a cross-section

z-z axis of a cross-section

u-u major principal axis (where this does not coincide with the y-y axis)

v-v minor principal axis (where this does not coincide with the z-z axis)

b width of a cross section

h depth of a cross section

d depth of straight portion of a web

t_w web thickness

t_f flange thickness

r radius of root fillet

r_1 radius of root fillet

r_2 toe radius

t thickness

Section 2

P_k nominal value of the effect of prestressing imposed during erection

G_k nominal value of the effect of permanent actions

X_K characteristic values of material property

X_n nominal values of material property

R_d design value of resistance

R_k characteristic value of resistance

γ_M general partial factor

γ_{Mi} particular partial factor

γ_{Mf} partial factor for fatigue

η conversion factor

a_d design value of geometrical data

Section 3

f_y yield strength

f_u ultimate strength

R_{eh} yield strength to product standards

R_m ultimate strength to product standards

A_0 original cross-section area

ε_y yield strain

ε_u ultimate strain

Z_{Ed} required design Z-value resulting from the magnitude of strains from restrained metal shrinkage under the weld beads.

Z_{Rd} available design Z-value

E modulus of elasticity

G shear modulus

ν Poisson's ratio in elastic stage

α coefficient of linear thermal expansion

Section 5

α_{cr} factor by which the design loads would have to be increased to cause elastic instability in a global mode

F_{Ed} design loading on the structure

F_{cr} elastic critical buckling load for global instability mode based on initial elastic stiffnesses

H_{Ed} design value of the horizontal reaction at the bottom of the storey to the horizontal loads and fictitious horizontal loads

V_{Ed} total design vertical load on the structure on the bottom of the storey

$\delta_{H,Ed}$ horizontal displacement at the top of the storey, relative to the bottom of the storey

h storey height

$\bar{\lambda}$ non dimensional slenderness

N_{Ed} design value of the axial force

ϕ global initial sway imperfection

ϕ_0 basic value for global initial sway imperfection

α_h reduction factor for height h applicable to columns

h height of the structure