SLOVENSKI STANDARD
oSIST prEN 1993-1-9:2023

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Evrokod 3: Projektiranje jeklenih konstrukcij – 1-9. del: Utrujanje

Eurocode 3: Design of steel structures - Part 1-9: Fatigue

Eurocode 3: Bemessung und Konstruktion von Stahlbauten - Teil 1-9: Ermüdung

Eurocode 3: Calcul des structures en acier - Partie 1-9: Fatigue

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ICS:

91.010.30	Tehnični vidiki	Technical aspects
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EUROPEAN STANDARD

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Will supersede EN 1993-1-9:2005

English Version

Eurocode 3: Design of steel structures - Part 1-9: Fatigue

Eurocode 3: Calcul des structures en acier - Partie 1-9: Fatigue

Eurocode 3: Bemessung und Konstruktion von Stahlbauten - Teil 1-9: Ermüdung

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 250.

If this draft becomes a European Standard, 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.

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Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

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

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European foreword

This document (prEN 1993-1-9:2023) has been prepared by Technical Committee CEN/TC 250 “Structural Codes”, the secretariat of which is held by BSI. CEN/TC 250 is responsible for all Structural Eurocodes and has been assigned responsibility for structural and geotechnical design matters by CEN.

This document is currently submitted to the CEN Enquiry.

This document will supersede EN 1993-1-9:2005 and EN 1993-1-9:2005/AC:2009.

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

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

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

Introduction

0.1 Introduction to the Eurocodes

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

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

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

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

0.2 Introduction to EN 1993 (all parts)

EN 1993 (all parts) 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.

EN 1993 (all parts) 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.

EN 1993 is subdivided in various parts:

- EN 1993-1, Design of Steel Structures — Part 1: General rules and rules for buildings;
- EN 1993-2, Design of Steel Structures — Part 2: Steel bridges;
- EN 1993-3, Design of Steel Structures — Part 3: Towers, masts and chimneys;
- EN 1993-4, Design of Steel Structures — Part 4: Silos and tanks;

- EN 1993-5, Design of Steel Structures — Part 5: Piling;
- EN 1993-6, Design of Steel Structures — Part 6: Crane supporting structures;
- EN 1993-7, Design of steel structures — Part 7: Design of sandwich panels.

EN 1993-1 in itself does not exist as a physical document, but as a document series that comprises the following 14 separate parts, the basic part being EN 1993-1-1:

- EN 1993-1-1, Design of Steel Structures — Part 1-1: General rules and rules for buildings;
- EN 1993-1-2, Design of Steel Structures — Part 1-2: Structural fire design;
- EN 1993-1-3, Design of Steel Structures — Part 1-3: Cold-formed members and sheeting;

  NOTE Cold formed hollow sections supplied according to EN 10219 are covered in EN 1993-1-1.

- EN 1993-1-4, Design of Steel Structures — Part 1-4: Stainless steels;
- EN 1993-1-5, Design of Steel Structures — Part 1-5: Plated structural elements;
- EN 1993-1-6, Design of Steel Structures — Part 1-6: Strength and stability of shell structures;
- EN 1993-1-7, Design of Steel Structures — Part 1-7: Strength and stability of planar plated structures transversely loaded;
- EN 1993-1-8, Design of Steel Structures — Part 1-8: Design of joints;
- EN 1993-1-9, Design of Steel Structures — Part 1-9: Fatigue strength of steel structures;
- EN 1993-1-10, Design of Steel Structures — Part 1-10: Material toughness and through-thickness properties;
- EN 1993-1-11, Design of Steel Structures — Part 1-11: Design of structures with tension components made of steel;
- EN 1993-1-12, Design of Steel Structures — Part 1-12: Additional rules for steel grades up to S960;
- EN 1993-1-13, Design of Steel Structures — Part 1-13: Beams with large web openings;
- EN 1993-1-14, Design of Steel Structures — Part 1-14: Design assisted by finite element analysis.

All subsequent parts numbered EN 1993-1-2 to EN 1993-1-14 treat general topics that are independent from the structural type like structural fire design, cold-formed members and sheeting, stainless steels, plated structural elements, etc.

All subsequent parts numbered EN 1993-2 to EN 1993-7 treat topics relevant for a specific structural type like steel bridges, towers, masts and chimneys, silos and tanks, piling, crane supporting structures, etc. EN 1993-2 to EN 1993-7 refer to the generic rules in EN 1993-1 and supplement, modify or supersede them.

0.3 Introduction to EN 1993-1-9

EN 1993-1-9 gives specific design rules for verification of fatigue resistance of steel structures. It is intended to be used with EN 1990, EN 1991 and EN 1993-1. Matters that are already covered in those documents are not repeated. The focus in EN 1993-1-9 is on design rules that supplement, modify or supersede the equivalent provisions given in EN 1993-1.

0.4 Verbal forms used in the Eurocodes

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

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

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

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

0.5 National annex for EN 1993-1-9

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

The national standard implementing EN 1993-1-9 can have a National Annex containing all national choices to be used for the design of steel structures to be constructed in the relevant country.

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

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

National choice is allowed in EN 1993-1-9 through notes to the following:

1.1(8)	4(6)	5(4)	5(6)
6.1(3) – 3 choices	7.1(4)	8.2(1) – 2 choices	9.1(1)
9.4(3)	B.2(1)	B.2(1)	C.2(4)
C.2(5)	F.2(2)	F.2(5)	F.2(6)
F.3.2(1)	F.4.2.1(3)		

National choice is allowed in EN 1993-1-9 on the application of the following informative annexes:

Annex D	Annex E	Annex F	Annex G

The National annex may contain, directly or by reference, non-contradictory complementary information for ease of implementation, provided it does not alter any provisions of the Eurocodes.

1 Scope

1.1 Scope of EN 1993-1-9

(1) EN 1993-1-9 gives design methods for the verification of the fatigue design situation of steel structures.

NOTE Steel structures consist of members and their joints. Each member and joint can be represented as a constructional detail or as several of the latter.

(2) Design methods other than the stress-based methods, such as the notch strain method or fracture mechanics methods, are not covered by EN 1993-1-9.

(3) EN 1993-1-9 only applies to structures made of all grades of structural steels which conform to EN 1993-1 (all parts), in accordance with the provisions noted in the detail category tables or annexes.

(4) EN 1993-1-9 only applies to structures where execution conforms to EN 1090-2.

NOTE Supplementary execution requirements are indicated in the detail category tables.

(5) EN 1993-1-9 applies to structures operating under normal atmospheric conditions and with sufficient corrosion protection and regular maintenance. The effect of seawater corrosion is not covered.

(6) EN 1993-1-9 applies to structures with hot dip galvanizing in accordance with the provisions noted in the detail category tables or annexes.

(7) Microstructural damage from high temperature (> 150°C) that occurs during the design service life is not covered.

(8) EN 1993-1-9 gives guidance of how to consider post-fabrication treatments that are intended to improve the fatigue resistance of constructional details.

1.2 Assumptions

(1) Unless specifically stated, EN 1990, EN 1991 (all parts) and the other relevant parts of EN 1993-1 (all parts) apply.

(2) The design methods given in EN 1993-1-9 are applicable if:

- the execution quality is as specified in EN 1090-2, and
- the construction materials and products used are as specified in the relevant parts on EN 1993 (all parts), or in the relevant material and product specifications.

(3) The design methods of EN 1993-1-9 are generally derived from fatigue tests on constructional details with large scale specimens that include effects of geometrical and structural imperfections from material production and execution (e.g. the effects of tolerances and residual stresses from welding).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

EN 1090-2, *Execution of steel structures and aluminium structures — Part 2: Technical requirements for steel structures*

EN 1990, *Eurocode - Basis of structural design*

EN 1991 (all parts), *Eurocode 1 - Actions on structures*

EN 1993-1 (all parts), *Eurocode 3 - Design of steel structures*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purpose of this document terms and definitions given in EN 1990, EN 1991 (all parts), EN 1993-1-1, EN 1993-1-5, EN 1993-1-8 and the following apply.

3.1.1 General

3.1.1.1

fatigue

gradually progressive, localised damaging process of a constructional detail within a structure subject to fatigue action (see 3.1.2.1) that may culminate in failure caused by crack initiation and propagation

Note 1 to entry: The type of failure depends on the definition of fatigue resistance, see 3.1.4.1.

3.1.1.2

design service life

reference period of time that depends on the type of structure for which its constructional details are required to perform safely with an appropriate level of reliability that failure by fatigue cracking will not occur

Note 1 to entry: EN 1990 gives provisions on design service life.

3.1.1.3

safe life concept

design concept in which an appropriate level of reliability for the fatigue design situation is obtained without the need for regular in-service inspection or monitoring for fatigue during the design service life

3.1.1.4

damage tolerant concept

design concept in which an appropriate level of reliability for the fatigue design situation is obtained by implementing prescribed inspection and maintenance for detecting and mitigating fatigue during the design service life

3.1.1.5

constructional detail

part of a member or joint containing a stress raising effect

3.1.1.6

hollow section joint

joint consisting of structural circular hollow sections (CHS) or structural rectangular hollow sections (RHS), or their combinations as used in uniplanar or multi-planar trusses or girders, such as T-, Y-, X-, K-, XX-, and KK-joints

3.1.1.7

rod

circular solid threaded member made of structural steel including stainless steel

3.1.1.8

stress raising effect

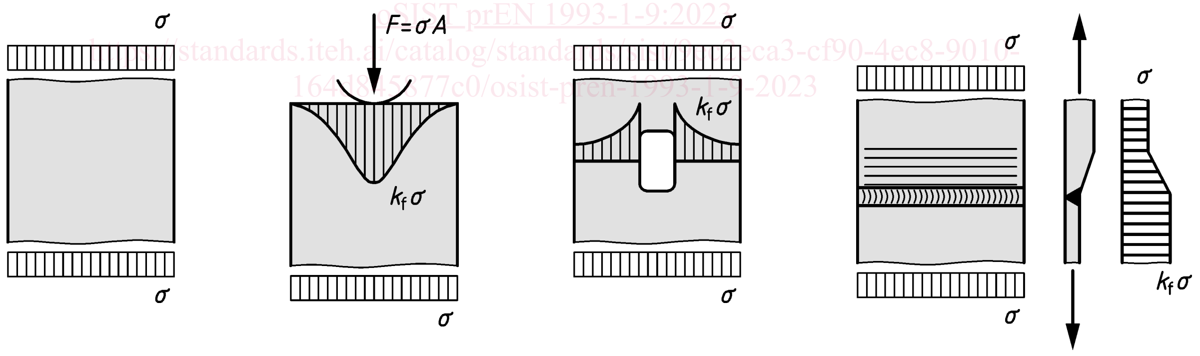
local increase in stress caused by discontinuity in loading and/or geometry and/or material

3.1.1.9

stress concentration

computable part of stress raising effect, expressed by the stress concentration factor k_f, see Figure 3.1

Note 1 to entry: Stress concentration factors are usually only available for concentrated load effects and geometric effects.



a) reference: without stress concentration ($k_f = 1$)

b) concentrated load effect

c) macro-geometric effects accounting for large opening

d) macro-geometric effects accounting for eccentricity (maximum tensile stress shown)

Key

σ	nominal stress
k_f	stress concentration factor
A	cross-sectional area
F	concentrated load

Figure 3.1 — Examples of stress concentration factor k_f

3.1.1.10

concentrated load effect

stress raising effect arising from discontinuity in loading caused by single loads, usually not taken into account in the detail category tables, e.g. Figure 3.1 b)

3.1.1.11

macro-geometric effect

stress raising effect arising from discontinuity in gross shape of a member, see e.g. Figure 3.1 c) and d), usually not taken into account in the detail category tables

Note 1 to entry: Examples are apertures, re-entrant corners, large openings, shear lag, curved members, secondary bending caused by eccentricities and misalignments beyond the limits accounted for by the detail category tables.

3.1.1.12

misalignment

unintended offset or out-of-straightness (angular mismatch) due to the arrangement or position of jointed elements arising during the manufacturing process

3.1.1.13

eccentricity

intended offset of jointed elements

3.1.1.14

joint-geometric effect

stress raising effect arising from discontinuity in local shape of a member caused by attachments or connected members, see Figure 3.2 c)

Note 1 to entry: Examples are shell bending stresses in addition to membrane stresses in plates caused by one-sided attachment.

3.1.1.15

notch-geometric effect

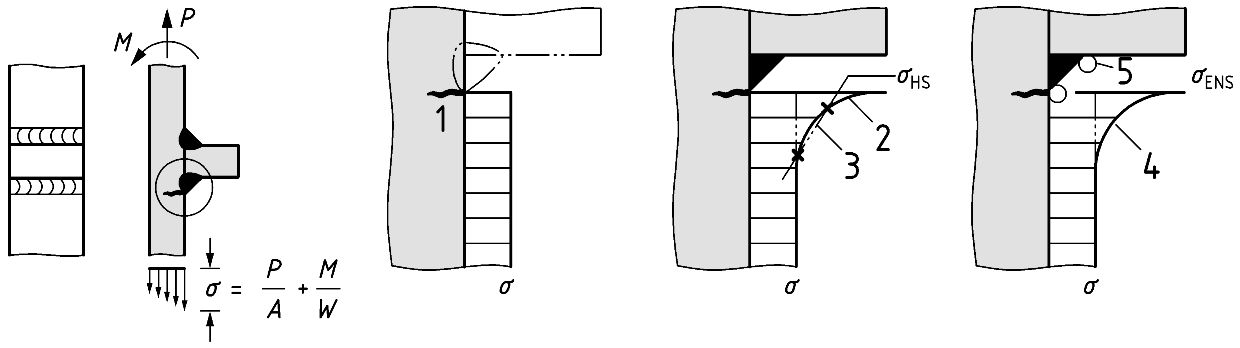
stress raising effect arising from discontinuity in local geometry of a member at a microscopic scale caused by notch geometry (notch radius), see Figure 3.2 d)

Note 1 to entry: Examples for non-welded member are scratches, corrosion pits and rolling defects. Examples for welded members are weld profile shape, weld toes, weld roots, lack of fusion, slag inclusion, lack of penetration, cold laps and porosity.

3.1.1.16

material effect

stress raising effect arising from discontinuity in material properties, such as regions with different yield strengths in the heat affected zone of welds, that are accounted for within the detail category tables



a) transverse weld toe b) nominal stress distribution c) hot spot stress distribution d) effective notch stress distribution

Key

1	potential crack
2	stress distribution on surface accounting for weld with sharply edged weld toes
3	linear stress extrapolation
4	stress distribution on surface accounting for weld with rounded off weld toes
5	round off radius for weld toe
σ	nominal stress at potential crack location (here: weld toe)
σ_{HS}	hot spot stress at potential crack location (see 3.1.1.20)
σ_{ENS}	effective notch stress at potential crack location (see 3.1.1.22)

Figure 3.2 — Examples of different types of normal stress distribution in the vicinity of transverse weld toe

3.1.1.17

nominal stress

σ or τ

elastic stress in a constructional detail adjacent to a potential crack location, disregarding any stress raising effect, Figure 3.2 b)

Note 1 to entry: The nominal stress as specified in EN 1993-1-9 can be a normal stress, a shear stress, a principal stress or an equivalent stress.

Note 2 to entry: The joint-geometric (see 3.1.1.14), the notch-geometric (see 3.1.1.15) and the material effects (see 3.1.1.16) are accounted for by the nominal stress-based detail categories. See 3.1.1.18 if macro-geometric and/or concentrated load effects exist.

Note 3 to entry: For beam-like components with uniform loading, the nominal stress can be calculated by beam theory.

3.1.1.18

modified nominal stress

nominal stress multiplied by an appropriate stress concentration factor k_f to allow for geometric and/or concentrated load effects, see Figures 3.1 b) to d)

Note 1 to the entry: Instead of stress concentration factors, fatigue notch factors k_t can be used. Examples are given in EN 1999-1-3.