SLOVENSKI STANDARD
oSIST prEN 1993-1-6:2023

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Evrokod 3 - Projektiranje jeklenih konstrukcij - 1-6. del: Trdnost in stabilnost lupinastih konstrukcij

Eurocode 3 - Design of steel structures - Part 1-6: Strength and Stability of Shell Structures

Eurocode 3 - Bemessung und Konstruktion von Stahlbauten - Teil 1-6: Festigkeit und Stabilität von Schalen

Eurocode 3 - Calcul des structures en acier - Partie 1-6: Résistance et stabilité des structures en coque

Ta slovenski standard je istoveten z: **prEN 1993-1-6**

ICS:

91.010.30	Tehnični vidiki	Technical aspects
91.080.13	Jeklene konstrukcije	Steel structures

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EUROPEAN STANDARD

NORME EUROPÉENNE

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Will supersede EN 1993-1-6:2007

English Version

Eurocode 3 - Design of steel structures - Part 1-6: Strength and Stability of Shell Structures

Eurocode 3 - Calcul des structures en acier - Partie 1-6: Résistance et stabilité des structures en coque

Eurocode 3 - Bemessung und Konstruktion von Stahlbauten - Teil 1-6: Festigkeit und Stabilität von Schalen

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 1993-1-6:2023) has been prepared by Technical Committee CEN/TC 250 "Structural Eurocodes", 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 matters by CEN.

This document is currently submitted to the CEN Enquiry.

This document will supersede EN 1993-1-6:2007 and its amendments and corrigenda.

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 recognize 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.

0 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, software 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[1], *Design of steel structures — Part 7: Design of sandwich panels.*

EN 1993-1 in itself does not exist as a physical document, but 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: Plate assemblies with elements under transverse loads;*

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: Selection of steel for fracture 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[2], *Design of Steel Structures — Part 1-13: Beams with large web openings;*

EN 1993-1-14[3], *Design of Steel Structures — Part 1-14: Design assisted by finite element analysis.*

All subsequent parts EN 1993-1-2 to EN 1993-1-14 treat general topics that are independent from the structural type such as 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 such as 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 prEN 1993-1-6

prEN 1993-1-6 gives design requirements for steel shell structures that are subject to forces and pressures that induce membrane and bending stress resultants in the shell. It also covers annular plates and ring stiffeners. Its provisions can be used for a wide variety of stiffened and unstiffened curved structures through the application of computational methods. It is applicable to silos, tanks, chimneys, wind turbine towers, biodigesters and piles.

[1] Under preparation.
[2] Under preparation.
[3] Under preparation.

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 prEN 1993-1-6

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 prEN 1993-1-6 can have a National Annex containing all national choices to be used for the design of buildings and civil engineering works 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 prEN 1993-1-6 through notes to the following:

4.4 (3) 6.3.2 (3) 6.3.4 (2) 9.8.2 (12)

National choice is allowed in prEN 1993-1-6 on the application of the following informative annexes:

Annex A Annex B Annex C

1 Scope

1.1 Scope of prEN 1993-1-6

(1) prEN 1993-1-6 provides rules for the structural design of plated steel structures that have the form of a shell of revolution (axisymmetric shell).

(2) This document is applicable to unstiffened fabricated axisymmetric shells formed from isotropic rolled plates using both algebraic and computational procedures, and to stiffened axisymmetric shells with different wall constructions using computational procedures. It also applies to associated circular or annular plates and to beam section rings and stringer stiffeners where they form part of the complete shell structure. The general computational procedures are applicable to all shell forms.

(3) This document does not apply to manufactured shells or to shell panels or to elliptical shell forms, except that its computational procedures are applicable to all shell structures. This document does not apply to structures under seismic or other dynamic loading. It does not cover the aspects of leakage of stored liquids or solids.

(4) Cylindrical and conical panels are not explicitly covered by this document. However, the provisions of subclause 9.8 can be used provided that appropriate boundary conditions are taken into account.

(5) This document defines the characteristic and design values of the resistance of the structure.

(6) This document is concerned with the requirements for design against the ultimate limit states of:

— plastic failure;

— cyclic plasticity;

— buckling;

— fatigue.

(7) Overall equilibrium of the structure (sliding, uplifting, overturning) is not included in this document. Special considerations for specific applications are included in the relevant application parts of EN 1993.

(8) Detailed formulae for the simple calculation of unstiffened cylinders, cones and spherical domes are given in the Annexes.

(9) Provisions for simple calculations on specific stiffened shell types are given in EN 1993-4-1.

(10) This document is intended for application to steel shell structures. Where no standard exists for shell structures made of other metals, including high strength steels, the provisions of this document are applicable provided the appropriate material properties of the metal are taken into account.

(11) The provisions of this document are intended to be applied within the temperature ranges defined in the relevant EN 1993 application parts.

(12) Where no application part defines a different range, this document applies to structures within the following limits:

— design metal temperatures lie within the range −50 °C to +100 °C, except when using the special provisions given in 5.1;

— radius to thickness ratios (r/t) within the range 50 to 2 000;

— manufactured circular hollow sections according to EN 10210 and EN 10219 are outside the scope of this standard and are covered by EN 1993-1-1. However, if no other provisions are available, the rules of this document are useful for manufactured circular hollow sections. In particular, this document is applicable to the design of manufactured piles (see EN 1993-5) provided the imperfections and tolerance requirements of EN 1993-5 are adopted in place of those specified in prEN 1993-1-6, and where no other standard covers the specific pile geometry.

NOTE 1 Experimental and theoretical data relating to manufactured circular hollow sections were not considered when this document was drafted. The application of this document to such structures therefore remains the responsibility of the user.

NOTE 2 The stress design rules of this document can be rather conservative if applied to some geometries and loading conditions for relatively thick-walled shells.

NOTE 3 Thinner shells than r/t = 2 000 can be treated using these provisions but the provisions have not been verified for such thin shells.

NOTE 4 The maximum temperature is restricted so that the influence of creep can be ignored where high temperature creep effects are not covered by the relevant application part.

NOTE 5 Where temperatures outside the above range are involved, the thermally adjusted properties can be found in EN 1993-1-2 or other CEN standards as appropriate. Where no other standard is available, refer to EN 1993-1-2 which, though intended for the design of steel structures against fire, gives general temperature-dependent material properties that can be more widely used (see 5.1(10)).

1.2 Assumptions

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

(2) The design methods given in prEN 1993-1-6 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 of EN 1993 (all parts), or in the relevant material and product specifications.

NOTE The buckling-related tolerance requirements of this document differ in some aspects from those of EN 1090-2 (see Clause 9).

(3) The provisions in this document apply to materials that satisfy the brittle fracture provisions given in EN 1993-1-4, EN 1993-1-10 and EN 1993-1-12.

(4) In this document, it is assumed that wind loading, seismic actions and bulk solids flow can, in general, be treated as quasi-static actions.

(5) Dynamic effects are outside the scope of prEN 1993-1-6, and are covered by the relevant application part of EN 1993 or EN 1998, including the consequences for fatigue. However, the stress resultants arising from dynamic behaviour are treated in this part as quasi-static.

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. in 'should' clauses), permissions ('may' clauses), possibilities ('can' clauses), and in notes.

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

EN 1990, *Eurocode: Basis of structural and geotechnical design*

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

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

ISO 8930, *General principles on reliability for structures — Vocabulary*

3 Terms, definitions and symbols

For the purposes of this document, the terms and definitions given in EN 1990, EN 1993-1-1, ISO 8930 and the following apply.

3.1 Definitions

3.1.1 Structural forms and geometry

3.1.1.1
base ring
structural member that passes around the circumference of the shell of revolution at the base and provides a means of attachment of the shell to a foundation or other structural member, needed to ensure that the assumed boundary conditions are achieved in practice

3.1.1.2
circumferential joint
joint that passes around the circumference of an axisymmetric shell

3.1.1.3
complete shell or shell assembly
shell composed of a number of shell segments (cylindrical, conical, spherical, etc.)

Note 1 to entry: In this standard, each segment of the shell assembly is assumed to be a shell of revolution.

3.1.1.4
constructional detail
part of a shell with a geometry that causes locally raised stresses relevant to the fatigue limit state (LS4), such as welded joints, bolted joints and connections.

Note 1 to entry: The geometric feature that causes the stress raising effect is also referred to as a "notch" in EN 1993-1-9.

3.1.1.5
course
set of rolled plates connected by vertical joints that make up a single layer of shell between horizontal joints

Note 1 to entry: Several courses of the same thickness can together become a strake.

3.1.1.6
fabricated shell
shell structure that is constructed by rolling plates into curved cylindrical panel sections and then assembling them by welding or bolting into a complete shell form

3.1.1.7
joint
line between two pieces of shell that are part of the same shell segment but fabricated from different pieces of shell plate

Note 1 to entry: A joint can be welded or bolted or connected in any other manner. The term "joint" is extensively used in shell structures, but it is used with a slightly different meaning from that found in EN 1993-1-8.

3.1.1.8
junction
line at which two or more shell segments meet

Note 1 to entry: A junction can include a stiffener, which can be treated as a junction at the circumferential line of attachment of a ring stiffener to the shell.

3.1.1.9
lap joint
joint in which the two shell plates overlap across the joint, increasing the total shell thickness locally

3.1.1.10
manufactured shell
shell or tubular member that is made in a factory by controlled processes in which the complete circular or elliptical form is achieved through folding, rolling or similar processes and using longitudinal or spiral welding

Note 1 to entry: Manufactured shells or tubular members are typically manufactured to meet the specifications of EN 10210 or EN 10219. Manufactured shells are outside the scope of this document except where permitted by 1.1 (3) and 1.1 (12).

3.1.1.11
meridian and meridional direction
line on a shell surface that lies in the plane through the axisymmetric shell axis

Note 1 to entry: The meridional direction is the tangent to the meridian at any point. In a cylinder, the meridian is parallel to the axis and the meridional direction is synonymous with the axial direction. In conical shells the meridian is straight but inclined to the axis. In other shell forms the meridional direction changes with axial position.

3.1.1.12
meridional joint
joint that lies on the meridian of an axisymmetric shell

3.1.1.13
middle surface
surface that lies midway between the inside and outside surfaces of the shell at every point, which is the reference surface for analysis, and can be discontinuous at changes of thickness or at shell junctions, leading to eccentricities that can be important to the shell structural behaviour

Note 1 to entry: In a shell stiffened on either one or both surfaces, the reference middle surface is still taken as the middle surface of the curved shell plate.

3.1.1.14
notch
position in a constructional detail where locally raised stresses arise that are relevant to the fatigue limit state (LS4)

Note 1 to entry: The term "notch" is widely used in EN 1993-1-9.

3.1.1.15
rib
local member that provides a primary load carrying path for bending down the meridian of the shell, representing a generator of the shell of revolution, used to transfer or distribute transverse loads by bending

3.1.1.16
ring beam or ring girder
circumferential stiffener that has bending stiffness and strength both in the plane of the shell circular section and normal to that plane, acting as a primary load carrying structural member and provided for the distribution of local loads into the shell

3.1.1.17
ring stiffener
local stiffening member that passes around the circumference of the shell of revolution at a given point on the meridian, normally assumed to have no stiffness for deformations out of its own plane (meridional displacements of the shell) but to be stiff for deformations in the plane of the ring, and provided to increase the stability or to introduce local loads acting in the plane of the ring

3.1.1.18
shell
structure or a structural component formed from a curved thin plate

Note 1 to entry: The curvature plays a vital role in its structural resistance and can be either in one direction (cylinder or cone) or two directions (spherical, ellipsoidal, toroidal, hyperboloid etc.).

3.1.1.19
shell of revolution
shell whose geometric form is defined by a middle surface that is formed by rotating a meridional generator line around a single axis through 2π radians

3.1.1.20
shell panel
incomplete shell of revolution

Note 1 to entry: The shell of revolution is termed incomplete if it has meridional boundaries that lie at circumferential locations less than 2π radians apart.

Note 2 to entry: Shell panels are outside the scope of this document except where permitted by 1.1 (4).