SLOVENSKI PREDSTANDARD

SIST ENV 1993-1-6

prva izdaja
julij 2001

Eurocode 3: Projektiranje jeklenih konstrukcij - Del 1-6: Splošna pravila - Dodatna pravila za lupinaste konstrukcije (prevzet ENV 1993-1-6:1999 z metodo platnice)

Eurocode 3: Design of steel structures - Part 1-6: General rules - Supplementary rules for the shell structures

Eurocode 3: Calcul des structures en acier - Partie 1-6: Règles générales - Règles supplémentaires pour la résistance et la stabilité des structures en coque

Eurocode 3: Bemessung und Konstruktion von Stahlbauten - Teil 1-6: Allgemeine Bemessungsregeln - Ergänzende Regeln für Schalentragwerke

Deskriptorji: jeklene konstrukcije, konstrukcijska jekla, lupinaste konstrukcije, računanje, pravila dimenzioniranja, mehanska trdnost

ICS 91.010.30; 91.080.10

Referenčna številka
SIST ENV 1993-1-6:2001 ((sl),en)

Nadaljevanje na straneh od II do VI in od 1 do 82

NACIONALNI UVOD

Predstandard SIST ENV 1993-1-6 ((sl),en), Eurocode 3: Projektiranje jeklenih konstrukcij - Del 1-6: Splošna pravila - Dodatna pravila za lupinaste konstrukcije, prva izdaja, 2001, ima status slovenskega predstandarda in je z metodo platnice prevzet evropski predstandard ENV 1993-1-6 (en), Eurocode 3: Design of steel structures - Part 1-6: General rules - Supplementary rules for the shell structures, September 1999.

NACIONALNI PREDGOVOR

Evropski predstandard ENV 1993-1-6:1999 je pripravil tehnični odbor Evropskega komiteja za standardizacijo CEN/TC 250 Konstrukcijski evrokodi.

Pripravo tega predstandarda sta CEN poverila Evropska komisija in Evropsko združenje za prosto trgovino.

Odločitev za prevzem tega predstandarda po metodi platnice je sprejela delovna skupina USM/TC KON/WG 3 Jeklene konstrukcije, ki je pripravila tudi nacionalni dokument za uporabo v Sloveniji, potrdil pa tehnični odbor USM/TC KON Konstrukcije.

Ta slovenski predstandard se lahko uporablja samo v skladu z nacionalnim dokumentom, ki je sestavni del SIST ENV 1993-1-6:2001.

Ta slovenski predstandard je dne 2000-12-04 odobril direktor USM.

Rok veljavnosti tega predstandarda je do izdaje evropskega standarda EN 1993-1-6.

ZVEZE S STANDARDI

S prevzemom tega evropskega predstandarda veljajo za omejeni namen referenčnih standardov vsi standardi, navedeni v izvirniku, razen tistih, ki so že sprejeti kot nacionalni standardi:

SIST ENV 1991-1:1998	((sl),en)	Eurocode 1: Osnove projektiranja in vplivi na konstrukcije - 1. del: Osnove projektiranja
SIST ENV 1991-2-1:1998	((sl),en)	Eurocode 1: Osnove projektiranja in vplivi na konstrukcije - Del 2-1: Vplivi na konstrukcije - Gostote, lastna teža in koristne obtežbe
SIST ENV 1991-2-3:1998	((sl),en)	Eurocode 1: Osnove projektiranja in vplivi na konstrukcije - Del 2-3: Vplivi na konstrukcije - Obtežbe snega
SIST ENV 1991-2-4:1998	((sl),en)	Eurocode 1: Osnove projektiranja in vplivi na konstrukcije - Del 2-4: Vplivi na konstrukcije - Vplivi vetra
SIST ENV 1993-1-1:1996	((sl),en)	Eurocode 3: Projektiranje jeklenih konstrukcij - Del 1-1: Splošna pravila in pravila za stavbe
SIST ENV 1993-1-1:1996/A1:1996	((sl),en)	Projektiranje jeklenih konstrukcij - Del 1-1: Splošna pravila in pravila za stavbe - Dodatka D in K
SIST ENV 1993-1-1:1996/A2:2001	((sl),en)	Projektiranje jeklenih konstrukcij - Del 1-1: Splošna pravila in pravila za stavbe - Dodatki G, H, J, N in Z
SIST ENV 1993-1-2:1999	((sl),en)	Projektiranje jeklenih konstrukcij - Del 1-2: Splošna pravila - Projektiranje požarnovarnih konstrukcij

SIST ENV 1993-1-3:2001	((sl),en)	Projektiranje jeklenih konstrukcij - Del 1-3: Splošna pravila - Dodatna pravila za hladno oblikovane tankostenske profile in pločevine
SIST ENV 1993-1-4:2001	((sl),en)	Projektiranje jeklenih konstrukcij - Del 1-4: Splošna pravila - Dodatna pravila za nerjavna jekla
SIST ENV 1993-1-5:2001	((sl),en)	Projektiranje jeklenih konstrukcij - Del 1-5: Splošna pravila - Dodatna pravila za ravninske pločevinaste konstrukcije (ortotropne plošče) brez prečne obremenitve
SIST ENV 1993-1-7:2001	((sl),en)	Projektiranje jeklenih konstrukcij - Del 1-7: Splošna pravila - Dodatna pravila za ravninske pločevinaste konstrukcije (ortotropne plošče), obremenjene s prečno obtežbo
SIST ENV 1993-2:2001	((sl),en)	Projektiranje jeklenih konstrukcij – 2. del: Jekleni mostovi
SIST ENV 1993-3-1:2001	((sl),en)	Projektiranje jeklenih konstrukcij - Del 3: Stolpi, jambori in dimniki - Stolpi in jambori
SIST ENV 1993-3-2:2001	((sl),en)	Projektiranje jeklenih konstrukcij - Del 3: Stolpi, jambori in dimniki - Dimniki
SIST ENV 1993-4-1:2001	((sl),en)	Projektiranje jeklenih konstrukcij - Del 4-1: Silosi, rezervoarji in cevovodi - Silosi
SIST ENV 1993-4-2:2001	((sl),en)	Projektiranje jeklenih konstrukcij - Del 4-2: Silosi, rezervoarji in cevovodi - Rezervoarji
SIST ENV 1993-4-3:2001	((sl),en)	Projektiranje jeklenih konstrukcij - Del 4-3: Silosi, rezervoarji in cevovodi - Cevovodi
SIST ENV 1993-5:2001	((sl),en)	Projektiranje jeklenih konstrukcij – 5. del: Piloti in zagatne stene
SIST ENV 1993-6:2001	((sl),en)	Projektiranje jeklenih konstrukcij – 6. del: Žerjavne proge

OPOMBI

- Povsod, kjer se v besedilu predstandarda uporablja izraz “evropski predstandard”, v SIST ENV 1993-1-6:2001 to pomeni “slovenski predstandard”.
- Nacionalni uvod in nacionalni predgovor nista sestavni del predstandarda.

VSEBINA **Stran**

Nacionalni dokument za uporabo v Sloveniji

Zaradi napake pri tiskanju je besedilo natisnjeno brez grške črke γ, ki označuje delne varnostne faktorje odpornosti. Zato je do izdaje popravljene verzije ENV 1993-1-6 potrebno upoštevati naslednje popravke:

Poglavje 1.6:

(12) Parameters in strength assessment:

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k	power of interaction expressions in buckling strength interaction expressions,
n	number of cycles of loading,
α	elastic imperfection reduction factor in buckling strength assessment,
β	plastic range factor in buckling interaction,
γ	partial factor,
Δ	range of parameter when alternating or cyclic actions involved,
ε_p	plastic strain,
η	interaction exponent for buckling

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Poglavje 6.2.2

(1) The von Mises design strength should be taken from:

$$f_{eq.Rd} = f_y/\gamma_M \qquad \ldots (6.5)$$

(2) The partial factor for resistance γ_M should be taken as equal to γ_{M0} as given in ENV 1993-1-1.

Poglavje 8.5.2

(1) The buckling resistance should be represented by the buckling stresses as defined in 1.4.5. The design buckling stresses should be obtained from:

$$\sigma_{xRd} = \sigma_{xRk}/\gamma_M, \quad \sigma_{\theta Rd} = \sigma_{\theta Rk}/\gamma_M, \quad \tau_{x\theta Rd} = \tau_{x\theta Rk}/\gamma_M \qquad \ldots(8.11)$$

(2) The partial factor for resistance γ_M should be taken as given in the relevant application part of ENV 1993.

Poglavje 8.6.2

(14) The design buckling resistance R_d should be obtained from:

$$R_d = R_k/\gamma_M \qquad \ldots(8.28)$$

where:

γ_M is the partial factor for resistance according to 8.5.2 (2).

Poglavje 8.8.2

(2) The design buckling resistance R_d should be found directly from the imperfect elastic-plastic critical buckling resistance R_{GMNIA} together with a calibration factor k_{GMNIA} to find the characteristic buckling resistance R_k. The partial factor γ_M should then be used to obtain the design resistance.

Poglavje 9.2.4

(1) In every verification of this limit state the design stress range should satisfy the condition:

$$\gamma_{Ff}\,\Delta\sigma_E \le \Delta\sigma_R/\gamma_{Mf} \qquad \ldots(9.1)$$

where:

γ_{Ff}	is	the partial factor for the fatigue loading
γ_{Mf}	is	the partial factor for the fatigue resistance
$\Delta\sigma_E$	is	the equivalent constant amplitude stress range of the design stress spectrum
$\Delta\sigma_R$	is	the fatigue strength stress range for the relevant detail category and the number of cycles of the stress spectrum

(2) As an alternative to (1), a cumulative damage assessment may be made using the Palmgren-Miner rule:

$$D_d \le 1$$

in which:

$$D_d = n_i / N_i \qquad \ldots(9.3)$$

where:

n_i	is	the number of cycles of the stress range $\Delta\sigma_i$
N_i	is	the number of cycles of the stress range $\gamma_{Ff}\,\gamma_{Mf}\,\Delta\sigma_i$ to cause failure for the relevant detail category

Za vrednosti parametrov, podanih v okvirju (večinoma delni varnostni faktorji odpornosti ali zunanjih vplivov), se v SIST ENV 1993-1-6:2001 privzamejo priporočene vrednosti, podane v ENV 1993-1-6:1999.

EUROPEAN PRESTANDARD

PRÉNORME EUROPÉENNE

EUROPÄISCHE VORNORM

ENV 1993-1-6

September 1999

ICS 91.010.30; 91.080.10

English version

Eurocode 3: Design of steel structures - Part 1-6: General rules - Supplementary rules for the shell structures

Eurocode 3: Calcul des structures en acier - Partie 1-6: Règles générales - Règles supplémentaires pour la résistance et la stabilité des structures en coque

Eurocode 3: Bemessung und Konstruktion von Stahlbauten - Teil 1-6: Allgemeine Bemessungsregeln - Ergänzende Regeln für Schalentragwerke

This European Prestandard (ENV) was approved by CEN on 25 December 1998 as a prospective standard for provisional application.

The period of validity of this ENV is limited initially to three years. After two years the members of CEN will be requested to submit their comments, particularly on 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.

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

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

Ref. No. ENV 1993-1-6:1999 E

Contents

Foreword

Objectives of the Eurocode

(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 structures.

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

(9) This Part 1.6 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 and for the submission of comments.

(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/TC 250/SC 3 at the following address:

BSI Standards

British Standards House

389 Chiswick High Road

London W 4 4AL

England

or to your national standards organisation.

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) 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 Organisation.

(15) It is intended that this Prestandard is used in conjunction with the NAD valid in the country where the building or civil engineering works is located.

Matters specific to this Prestandard

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

ENV 1993-1-1 General rules and rules for buildings;

ENV 1993-1-2 Supplementary rules for structural fire design;

ENV 1993-1-3 Supplementary rules for cold formed thin gauge members and sheeting;

ENV 1993-1-4 Supplementary rules for stainless steels;

ENV 1993-1-5 Supplementary rules for planar plated structures without transverse loading;

ENV 1993-1-6 Supplementary rules for shell structures;

ENV 1993-1-7 Supplementary rules for planar plated structures loaded transversely;

ENV 1993-2 Steel bridges;

ENV 1993-3-1 Towers and masts;

ENV 1993-3-2 Chimneys;

ENV 1993-4-1 Silos;

ENV 1993-4-2 Tanks;

ENV 1993-4-3 Pipelines;

ENV 1993-5 Piling;

ENV 1993-6 Crane supporting structures,

ENV 1993-7 Marine and maritime structures;

ENV 1993-8 Agricultural structures.

(17) This Part 1.6 of Eurocode 3 complements Parts 3 and 4 by providing the rules for axisymmetric shell structures needed in the design of chimneys, towers, masts, silos, tanks and pipelines.

(18) Because these rules are not specific to chimneys, silos, tanks etc. they are presented as a separate document forming part of ENV 1993-1 General Rules.

1 General

1.1 Scope

(1)P This Part 1.6 of ENV 1993 applies to the structural design of plated steel structures that have the form of a shell of revolution. It is intended for use in conjunction with ENV 1993-1-1, ENV 1993-1-3, ENV 1993-1-4 and the relevant application parts of ENV 1993, which include:

- Part 3.1 for towers and masts;
- Part 3.2 for chimneys;
- Part 4.1 for silos;
- Part 4.2 for tanks;
- Part 4.3 for pipelines.

(2)P See the relevant parts of ENV 1993 for specific application rules for structural design.

(3)P See the relevant parts of ENV 1991 for general rules on actions, including:

- definition of an action;
- combination of actions;
- partial factors on actions.

(4) This prestandard is intended for use in conjunction with the relevant parts of ENV 1991, which include:

- Part 1 for basis of design;
- Part 2.1 for densities, self-weight and imposed loads;
- Part 2.3 for snow loads;
- Part 2.4 for wind loads;
- Part 2.5 for thermal actions;
- Part 4 for actions on silos and tanks.

(5)P This document defines the characteristic values of the resistance of the structure. For the partial factors for resistance to be used in the verification expressions, see ENV 1993-1-1.

(6)P This Part 1.6 is concerned with the requirements for design against the ultimate limit states of:

- plastic limit;
- cyclic plasticity;
- buckling;
- fatigue.

(7)P Overall equilibrium of the structure (sliding, uplifting, overturning) is not included in this Part 1.6, but is treated in ENV 1993-1-1. Special considerations for specific applications are included in the relevant applications parts of ENV 1993.

(8) The provisions in this Part 1.6 apply to axisymmetric shells and associated circular or annular plates and beam section rings and stringer stiffeners where they form part of the complete structure. The following shell forms are covered: cylinders, cones and spherical caps.

(9) Cylindrical, conical and spherical panels are not explicitly covered by this Part 1.6. However, the provisions can be applicable if the appropriate boundary conditions are duly taken into account.

(10) This prestandard is intended for application to structural engineering steel shell structures. However, its provisions can be applied to other metallic shells provided that the appropriate material properties are duly taken into account.

(11) The provisions of this Part 1.6 are intended to be applied within the temperature range defined in the relevant ENV 1993 application parts. The maximum temperature is restricted so that the influence of creep can be neglected if high temperature creep effects are not covered by the relevant application part.

(12) The provisions in this Part 1.6 apply to structures that satisfy the brittle fracture provisions given in annex C of ENV 1993-2.

(13)P The provisions in this Part 1.6 apply to structural design under actions that can be treated as quasi-static in nature.

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

(15) Dynamic effects should be taken into account according to the relevant application part of ENV 1993, including the consequences for fatigue. However, the stress resultants arising from dynamic behaviour are treated in this part as quasi-static.

(16)P The provisions in this Part 1.6 apply to structures that are constructed in accordance with ENV 1090.

(17)P This Part 1.6 does not cover the aspects of leakage of contents.

(18) This prestandard is not intended for application to structures outside the following limits:
- design metal temperatures outside the range -200 to +300°C;
- radius to thickness ratios outside the range 20 to 5000.

1.2 Distinction between principles and application rules

(1)P Depending on the character 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 recognised 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 to 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.

ENV 1090	*Execution of steel structures:*
Part 1:	*General rules and rules for buildings;*
ENV 1991	*Eurocode 1: Basis of design and actions on structures:*
Part 1:	*Basis of design;*
Part 2.1:	*Densities, self-weight and imposed loads;*
Part 2.3:	*Snow loads;*
Part 2.4:	*Wind loads;*
Part 2.5:	*Thermal actions;*
Part 4:	*Actions on silos and tanks;*
ENV 1993	*Eurocode 3: Design of steel structures:*
Part 1.1:	*General rules: General rules and rules for buildings;*

Part 1.3: *General rules: Supplementary rules for cold formed thin gauge members and sheeting;*

Part 1.4: *General rules: Supplementary rules for stainless steels;*

Part 2: *Steel bridges;*

Part 3.1: *Towers and masts;*

Part 3.2: *Chimneys;*

Part 4.1: *Silos;*

Part 4.2: *Tanks;*

Part 4.3: *Pipelines.*

1.4 Definitions

The terms that are defined in ENV 1991-1 for common use in the Structural Eurocodes apply to this Part 1.6 of ENV 1993. Unless otherwise stated, the definitions given in ISO 8930 also apply to this Part 1.6. Supplementary to Part 1 of ENV 1993, for the purposes of this Part 1.6, the following definitions apply:

1.4.1 Structural forms and geometry

1.4.1.1 shell. A structure or a structural component formed from a curved thin plate.

1.4.1.2 complete axisymmetric shell. A shell whose form is defined by a meridional generator line rotated around a single axis through 2π radians. The shell can be of any length.

1.4.1.3 shell of revolution. A shell composed of a number of parts, each of which is a complete axisymmetric shell.

1.4.1.4 shell segment. A part of shell of revolution in the form of a defined shell geometry with a constant wall thickness: a cylinder, conical frustum, spherical frustum, annular plate, toroidal knuckle or other form.

1.4.1.5 shell panel. An incomplete axisymmetric shell: the shell form is defined by a rotation of the generator about the axis through less than 2π radians.

1.4.1.6 middle surface. The surface that lies midway between the inside and outside surfaces of the shell at every point. Where the shell is stiffened on only one surface, the reference middle surface is still taken as the middle surface of the curved shell plate. The middle surface is the reference surface for analysis, and can be discontinuous at changes of thickness or shell junctions, leading to eccentricities that are important to the shell response.

1.4.1.7 junction. The point at which two or more shell segments meet: it can include a stiffener or not: the point of attachment of a ring stiffener to the shell may be treated as a junction.

1.4.1.8 stringer stiffener. A local stiffening member that follows the meridian of the shell, representing a generator of the shell of revolution. It is provided to increase the stability, or to assist with the introduction of local loads. It is not intended to provide a primary resistance for bending due to transverse loads.

1.4.1.9 rib. A 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. It is used to transfer or distribute transverse loads by bending

1.4.1.10 ring stiffener. A local stiffening member that passes around the circumference of the shell of revolution at a given point on the meridian. It is assumed to have no stiffness in the meridional plane of the shell. It is provided to increase the stability or to introduce axisymmetric local loads acting in the plane of the ring by a state of axisymmetric normal forces. It is not intended to provide primary resistance for bending.

1.4.1.11 base ring. A structural member that passes around the circumference of the shell of revolution at the base and provides means of attachment of the shell to a foundation or other element. It is needed to ensure that the assumed boundary conditions are achieved in practice.