SLOVENSKI STANDARD
SIST EN 1993-1-6:2007/oprA1:2016

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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: **EN 1993-1-6:2007/prA1:2016**

ICS:

91.010.30	Tehnični vidiki	Technical aspects
91.080.13	Jeklene konstrukcije	Steel structures

SIST EN 1993-1-6:2007/oprA1:2016 **en,fr,de**

EUROPEAN STANDARD

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

This draft amendment A1, if approved, will modify the European Standard EN 1993-1-6:2007. If this draft becomes an amendment, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for inclusion of this amendment into the relevant national standard without any alteration.

This draft amendment was established by CEN in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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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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Contents

European foreword

This document (EN 1993-1-6:2007/prA1:2016) has been prepared by Technical Committee CEN/TC 250 “Structural Eurocodes”, the secretariat of which is held by BSI.

This document is currently submitted to the CEN Enquiry.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

1 Modifications to the Foreword

In the Foreword, in the section "National Annex for EN 1993-1-6", *add the following entries into the list at the appropriate places:*

"

– 6.2.1(6);"

and

"

– 8.6.3(5);".

In the Foreword, in the section "National Annex for EN 1993-1-6", *replace:*

"

– 8.7.2 (7)

– 8.7.2 (16)

– 8.7.2 (18) (2 times)"

with:

"

– 8.8.2 (9)

– 8.8.2 (18)

– 8.8.2 (20) (2 times)".

2 Modification throughout the whole standard

Replace "r_R" *with* "R".

3 Modification to 1.2, Normative references

In the list of the parts of EN 1993, replace "Part 1.1:" *with* "Part 1.1:2005:".

4 Modifications to 1.3, Terms and definitions

Replace the whole Entry 1.3.2.1 with:

"1.3.2.1 plastic failure limit state (LS1)
ultimate limit state where the structure develops zones of yielding in a pattern such that its ability to resist increased loading is deemed to be exhausted".

Add a new Entry 1.3.5.3:

"1.3.5.3 semi-membrane theory analysis
analysis that predicts the behaviour of an unsymmetrically loaded or supported thin-walled cylindrical shell structure by assuming that only membrane forces and circumferential bending moments satisfy equilibrium with the external loads"

and renumber accordingly the former Entry 1.3.5.3 (as 1.3.5.4) and the following subclauses in 1.3.5.

Replace the former Subclause 1.3.5.6 (newly renumbered as 1.3.5.7) with:

"1.3.5.7 materially nonlinear analysis (MNA)
analysis based on shell bending theory applied to the perfect structure, using the assumption of small deflections, as in 1.3.5.4, but adopting an ideal elastic plastic material law (idealised perfectly plastic response after yield)".

Replace the former Subclause 1.3.5.7 (newly renumbered as 1.3.5.8) with:

"1.3.5.8 geometrically and materially nonlinear analysis (GMNA)
analysis based on shell bending theory applied to the perfect structure, using the assumptions of nonlinear large deflection theory for the displacements and a fully nonlinear elastic-plastic-hardening material law, where appropriate, and in which a bifurcation eigenvalue check is included at each load level".

Replace the former Subclause 1.3.5.9 (newly renumbered as 1.3.5.10) with:

"1.3.5.10 geometrically and materially nonlinear analysis with imperfections included (GMNIA)
analysis with imperfections explicitly included, based on the principles of shell bending theory applied to the imperfect structure (i.e. the geometry of the middle surface includes unintended deviations from the ideal shape), including nonlinear large deflection theory for the displacements that accounts fully for any change in geometry due to the actions on the shell and a fully nonlinear elastic-plastic-hardening material law, where appropriate

Note 1 to entry: The imperfections may also include imperfections in boundary conditions and residual stresses. A bifurcation eigenvalue check is included at each load level.".

5 Modifications to 1.4, Symbols

In Paragraph (12), replace the following line:

"α elastic imperfection reduction factor in buckling strength assessment;"

with:

"α elastic buckling reduction factor in buckling strength assessment;

α_G geometric reduction factor;

α_I imperfection reduction factor;".

In Paragraph (12), replace the following line:

"χ buckling reduction factor for elastic-plastic effects in buckling strengths assessment;"

with:

"χ elastic-plastic buckling reduction factor for elastic-plastic effects in buckling strength assessment;".

In Paragraph (12) , replace:

"χ_{ov} overall buckling resistance reduction factor for complete shell;"

with:

"χ_{ov} overall elastic-plastic buckling reduction factor for a complete shell;".

Delete the NOTE in Paragraph (12).

6 Modification to 2.2.5, Linear elastic bifurcation analysis (LBA)

In Paragraph (1), replace "8.6 and 8.7" *with* "8.7 and 8.8".

7 Modification to 2.2.6, Geometrically nonlinear elastic analysis (GNA)

In Paragraph (2), replace "8.6 and 8.7" *with* "8.7 and 8.8".

8 Modification to 2.2.7, Materially nonlinear analysis (MNA)

In Paragraph (1), replace "8.7" *with* "8.8".

9 Modification to 2.2.8, Geometrically and materially nonlinear analysis (GMNA)

Replace Paragraphs (1) and (2) with the following ones:

"(1) The result of a GMNA analysis, analogously to 2.2.7, gives the geometrically nonlinear plastic failure load of the perfect structure and the plastic strain increment, that may be used for checking the limit states LS1 and LS2.

(2) Where compression or shear stresses are predominant in some part of the shell, a GMNA analysis gives the elasto-plastic buckling load of the perfect structure. This perfect shell buckling load should always be determined when the limit state LS3 is verified using GMNIA analysis, see 8.8.".

10 Modification to 2.2.9, Geometrically nonlinear elastic analysis with imperfections included (GNIA)

In Paragraph (1), replace "8.7" *with* "8.8".

11 Modification to 2.2.10, Geometrically and materially nonlinear analysis with imperfections included (GMNIA)

In Paragraph (1), replace "8.7" *with* "8.8".

12 Modification to 3.3, Geometrical tolerances and geometrical imperfections

In Paragraph (3), replace twice "8.7" *with* "8.8".

13 Modifications to 4.1.1, LS1: Plastic limit

Replace the title itself of Subclause 4.1.1 with "LS1: Plastic failure limit state".

Replace Paragraph (1) with:

"(1) The limit state of the plastic failure should be taken as the condition in which the capacity of the structure to resist the actions on it is exhausted by plasticity in the material.

The plastic failure resistance should be distinguished from the plastic reference resistance which is derived as the plastic collapse load obtained from a mechanism based on small displacement theory using an ideal elastic-plastic material law.".

Replace Paragraph (3) with:

"(3) In the absence of fastener holes, verification at the limit state of tensile rupture may be assumed to be covered by the check for the plastic failure limit state. However, where holes for fasteners occur, a supplementary check in accordance with 6.2 of EN 1993-1-1:2005 should be carried out.".

Replace Paragraph (4) with:

"(4) In verifying the plastic failure limit state, plastic or partially plastic behaviour of the structure may be assumed (i.e. elastic compatibility considerations may be neglected).

NOTE Since the plastic failure limit state includes change of geometry, it may be noted that this limit state may also capture snap-through buckling, which may occur in the elastic state. The plastic reference resistance does not include change of geometry, so this apparent anomaly does not occur.".

14 Modification to 4.2.2.2,Primary stresses

Replace Paragraphs (1) and (2) with:

"(1) The primary stresses should be taken as the stress system required for equilibrium with the imposed loading. They may be calculated from any realistic statically admissible determinate system. The plastic failure limit state (LS1) should be deemed to be reached when the primary stress reaches the yield strength throughout the full thickness of the wall at a sufficient number of points, such that only the strain hardening reserve or a change of geometry would lead to an increase in the resistance of the structure.

(2) The calculation of primary stresses should be based on any system of stress resultants, consistent with the requirements of equilibrium of the structure. It may also take into account the benefits of plasticity theory. Alternatively, since linear elastic analysis satisfies equilibrium requirements, its predictions may also be used as a safe representation of the plastic failure limit state (LS1). Any of the analysis methods given in 5.3 may be applied.".

15 Modification to 4.2.4, Design by global numerical analysis

In Paragraph (6), replace "8.7" *with* "8.8".

16 Modification to 5.3, Types of analysis

In Table 5.2, replace the row:

"

Materially non-linear analysis (MNA)	linear	non-linear	perfect

"

with:

"

Materially non-linear analysis (MNA)	linear	ideal elastic-plastic	perfect

".

17 Modification to Clause 6, Plastic limit state (LS1)

Replace the title itself with "Plastic failure limit state (LS1)".

18 Modifications to 6.2.1, Design values of stresses

Replace Paragraph (1) with:

"(1) Although stress design is based on an elastic analysis and therefore cannot accurately predict the plastic failure limit state, it may be used, on the basis of the lower bound theorem, to provide a conservative assessment of the plastic collapse resistance which is used to represent the plastic failure limit state, see 4.1.1.".

Replace Paragraphs (5) and (6) with:

"(5) Where a membrane theory analysis is used, or where a linear bending theory analysis (LA) is used subject to the conditions defined in (6), the resulting two-dimensional field of stress resultants $n_{x,\,Ed}$, $n_{\theta,\,Ed}$ and $n_{x\theta,\,Ed}$ may be represented by the equivalent design stress $\sigma_{eq,\,Ed}$ obtained from:

$$\sigma_{\mathrm{eq,Ed}} = \frac{1}{t}\sqrt{n_{\mathrm{x,Ed}}^2 + n_{\theta,\mathrm{Ed}}^2 - n_{\mathrm{x,Ed}} \cdot n_{\theta,\mathrm{Ed}} + 3n_{\mathrm{x}\theta,\mathrm{Ed}}^2} \quad (6.1)$$

(6) Where an LA or GNA analysis is used, and the magnitude of the largest von Mises surface stress found using Formulae (6.2) to (6.4) exceeds *n* times the von Mises membrane stress found using Formula (6.1) at the same location, the equivalent stress should be taken as the value determined using Formulae (6.2) to (6.4).

$$\sigma_{\mathrm{eq,Ed}} = \sqrt{\sigma_{\mathrm{x,Ed}}^2 + \sigma_{\theta,\mathrm{Ed}}^2 - \sigma_{\mathrm{x,Ed}} \cdot \sigma_{\theta,\mathrm{Ed}} + 3\tau_{\mathrm{x}\theta,\mathrm{Ed}}^2} \quad (6.2)$$

in which:

$$\sigma_{\mathrm{x,Ed}} = \frac{n_{\mathrm{x,Ed}}}{t} \pm \frac{m_{\mathrm{x,Ed}}}{\left(t^2/4\right)} \qquad \sigma_{\theta,\mathrm{Ed}} = \frac{n_{\theta,\mathrm{Ed}}}{t} \pm \frac{m_{\theta,\mathrm{Ed}}}{\left(t^2/4\right)} \quad (6.3)$$

$$\tau_{\mathrm{x}\theta,\mathrm{Ed}} = \frac{n_{\mathrm{x}\theta,\mathrm{Ed}}}{t} \pm \frac{m_{\mathrm{x}\theta,\mathrm{Ed}}}{\left(t^2/4\right)} \quad (6.4)$$

NOTE 1 Formulae (6.2) to (6.4) give a simplified conservative equivalent stress for design purposes.

NOTE 2 The National Annex may choose the value of *n*. The recommended value is 3.".