SLOVENSKI STANDARD
SIST EN 1993-4-1:2007/kFprA1:2014

01-november-2014

Evrokod 3: Projektiranje jeklenih konstrukcij - 4-1. del: Silosi

Eurocode 3 - Design of steel structures - Part 4-1: Silos

Eurocode 3 - Bemessung und Konstruktion von Stahlbauten - Teil 4-1: Silos

Eurocode 3 - Calcul des structures en acier - Partie 4-1: Silos

Ta slovenski standard je istoveten z: EN 1993-4-1:2007/FprA1

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

FINAL DRAFT
EN 1993-4-1:2007

FprA1

August 2014

ICS 65.040.20; 91.010.30; 91.080.10

English Version

Eurocode 3 - Design of steel structures - Part 4-1: Silos

Eurocode 3 - Calcul des structures en acier - Partie 4-1: Silos

Eurocode 3 - Bemessung und Konstruktion von Stahlbauten - Teil 4-1: Silos

This draft amendment is submitted to CEN members for unique acceptance procedure. It has been drawn up by the Technical Committee CEN/TC 250.

This draft amendment A1, if approved, will modify the European Standard EN 1993-4-1:2007. 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.

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

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.

Warning : This document is not a European Standard. It is distributed for review and comments. It is subject to change without notice and shall not be referred to as a European Standard.

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

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. EN 1993-4-1:2007/FprA1:2014 E

EN 1993-4-1:2007/FprA1:2014 (E)

Contents

Page

EN 1993-4-1:2007/FprA1:2014 (E)

Foreword

This document (EN 1993-4-1:2007/FprA1:2014) 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 Unique Acceptance Procedure.

EN 1993-4-1:2007/FprA1:2014 (E)

1 Modification to the Foreword

In the Section "National Annex for EN1993-4-1"*, replace the following entry:*

"

−   6.3.2.7 (3)"

with:

"

−   6.3.2.7 (4)"*.*

2 Modifications to 1.2, Normative references

In the entry dedicated to EN 1990, replace "EN 1990" *with* "EN 1990:2002"*.*

In the entry dedicated to EN 1993, in the list, replace "Part 1.6:" *with* "Part 1.6:2007:"*.*

3 Modification to 1.6.1, Roman upper case letters

Replace:

$"R_\phi$ local radius at the crest or trough of a corrugation."

with:

$"r_\phi$ local radius at the crest or trough of a corrugation.".

4 Modification to 1.6.2, Roman lower case letters

Replace:

$"\ell$ wavelength of a corrugation in corrugated sheeting;"

with:

$"l$ wavelength of a corrugation in corrugated sheeting;".

5 Modification to 2.7, Modelling of the silo for determining action effects

Replace Paragraph (1)P with:

"(1)P The general requirements set out in EN 1990 shall be followed.".

6 Modification to 2.9.1, General

Replace Paragraph (1)P with:

"(1)P The general requirements set out in EN 1990 shall be satisfied.".

7 Modification to 2.9.2.2, Partial factors for resistances

Add two new Paragraphs (4) and (5) after Paragraph (3)P:

4

"(4) Where hot rolled steel sections are used as part of a silo structure, the relevant partial factors for resistance should be taken from EN 1993-1-1.

(5) Where cold-formed steel sections are used as part of a silo structure, the relevant partial factors for resistance should be taken from EN 1993-1-3.".

8 Modification to 2.10, Durability

Replace Paragraph (1) with:

"(1) The general requirements set out in 2.4 of EN 1990:2002 should be followed.".

9 Modification to 4.2.2.1, General

After Paragraph (2), add the following new Paragraphs (3) to (5):

"(3) Where the silo is subject to any form of unsymmetrical bulk solids loading (patch loads, eccentric discharge, unsymmetrical filling etc.), the structural model should be designed to capture the membrane shear transmission within the silo wall and between the wall and rings.

NOTE: The shear transmission between parts of the wall and rings has special importance in construction using bolts or other discrete connectors (e.g. between the wall and hopper, between the cylinder wall and vertical stiffeners or support, and between different strakes of the cylinder).

(4) Where a ring girder is used to redistribute silo wall forces into discrete supports, and where bolts or discrete connectors are used to join the structural elements, the shear transmission between the parts of the ring due to shell bending and ring girder bending phenomena should be determined.

(5) The stiffness of the stored bulk solid in resisting wall deformations or in increasing the buckling resistance of the shell structure should only be considered where a rational analysis is used and there is clear evidence that the solid against the wall is not in motion at the specified location during discharge. In such situations, the relevant information on the flow pattern, the pressure in the solid and the properties of the specific stored bulk solid should be determined from EN 1991-4.

(6) Where a corrugated silo exhibits mass flow, the solid held stationary within the corrugations should not be considered as stationary in (5).".

10 Modification to 4.2.2.3, Consequence Class 2

Delete the following Paragraphs (10) to (12):

"(10) Where the silo is subject to any form of unsymmetrical bulk solids loading (patch loads, eccentric discharge, unsymmetrical filling etc.), the structural model should be designed to capture the membrane shear transmission within the silo wall and between the wall and rings.

> **NOTE:** The shear transmission between parts of the wall and rings has special importance in construction using bolts or other discrete connectors (e.g. between the wall and hopper, between different strakes of the barrel).

(11) Where a ring girder is used to redistribute silo wall forces into discrete supports, and where bolts or discrete connectors are used to join the structural elements, the shear transmission between the parts of the ring due to shell bending and ring girder bending phenomena should be determined.

EN 1993-4-1:2007/FprA1:2014 (E)

(12) Except where a rational analysis is used and there is clear evidence that the solid against the wall is not in motion during discharge, the stiffness of the bulk solid in resisting wall deformations or in increasing the buckling resistance of the structure should not be considered.".

11 Modifications to 4.4, Equivalent orthotropic properties of corrugated sheeting

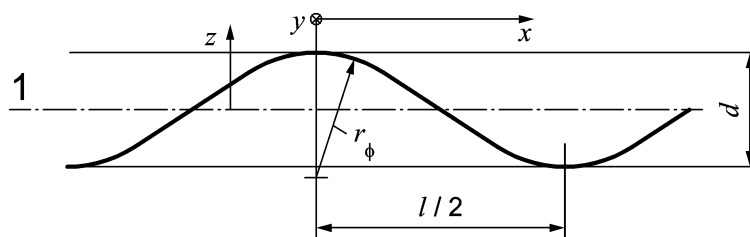*Replace the notation lines in Paragraph (3) with:*

"where:
d is   the crest to crest dimension;
l is   the wavelength of the corrugation;
r_ϕ is   the local radius at the crest or trough.".

Replace Figure 4.2 with:

"

Key
1   effective middle surface

Figure 4.2 — Corrugation profile and geometric parameters

".

Replace Paragraph (4):

"(4) All properties may be treated as one-dimensional, giving no Poisson effects between different directions."

with:

"(4) The equivalent properties of the sheeting in each of the two principal directions may be treated as independent, so that strains in one direction do not produce stresses in the orthogonal direction (no Poisson effects).".

Replace Paragraph (5) with the following paragraph and renumber accordingly all the following equations in the subclause:

"(5) The equivalent membrane properties (stretching stiffnesses) may be taken as:

$$C_x = Et_x \tag{4.2}$$

$$C_y = Et_y \tag{4.3}$$

$$C_{xy} = Gt_{xy} \tag{4.4}$$

where:

t_x is   the equivalent thickness for the smeared membrane stiffness normal to the corrugations, given by:

$$t_x = \frac{2t^3}{3d^2}$$

(4.5)

t_y is   the equivalent thickness for the smeared membrane stiffness parallel to the corrugations, given by:

$$t_y = t\left(1 + \frac{\pi^2 d^2}{4l^2}\right)$$

(4.6)

t_{xy} is   the equivalent thickness for the smeared membrane shear stiffness, given by:

$$t_{xy} = \frac{t}{\left(1 + \dfrac{\pi^2 d^2}{4l^2}\right)}$$

(4.7)".

Replace Paragraph (6) with:

"(6) The equivalent bending properties (flexural stiffnesses) are defined in terms of the flexural rigidity for moments causing bending stresses in that direction, and may be taken as:

$$D_x = EI_x$$

(4.8)

$$D_y = EI_y$$

(4.9)

$$D_{xy} = GI_{xy}$$

(4.10)

where:

I_x is   the equivalent second moment of area per unit width for the smeared bending stiffness to the corrugations, given by:

$$I_x = \frac{t^3}{12(1-v^2)} \frac{1}{\left(1 + \dfrac{\pi^2 d^2}{4l^2}\right)}$$

(4.11)

I_y is the equivalent second moment of area per unit width for the smeared bending stiffness parallel to the corrugations. For the corrugated profiles described in 4.4(2), it may be taken as:

$$I_y = \frac{td^2}{8}\left(1 + \frac{\pi^2 d^2}{8l^2}\right)$$

(4.12)

I_{xy} is   the equivalent second moment of area per unit width for the smeared twisting stiffness:

$$I_{xy} = \frac{t^3}{12}\left(1 + \frac{\pi^2 d^2}{4l^2}\right)$$

(4.13)

NOTE: The convention for bending moments in plates relates to the direction in which the plate becomes curved, so is contrary to the convention used for beams. Bending parallel to the corrugation engages the bending stiffness of the corrugated profile, induces stresses parallel to the corrugation, and is the chief reason for using corrugated construction.".
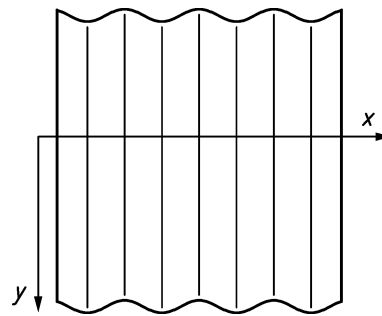
EN 1993-4-1:2007/FprA1:2014 (E)

Replace Paragraph (7) with the following text and figure:

"(7) In circular silos, the corrugations are commonly arranged to run circumferentially. In this arrangement, the directions x and y in the above expressions should be taken as the vertical x and circumferential θ directions respectively, see Figure 4.3 a). In the less common arrangement in which the corrugations run vertically, the directions x and y in the above expressions should be taken as the circumferential θ and vertical x directions respectively, see Figure 4.3 b).
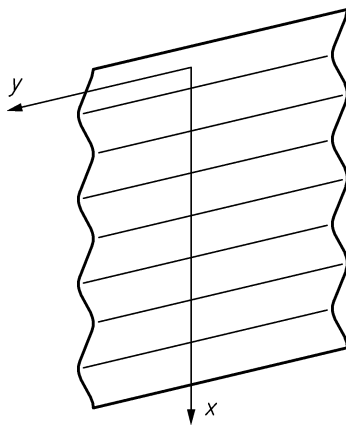
a) Corrugations running horizontally   b) Corrugations running vertically

Figure 4.3: Corrugated sheeting and silo wall orientations

".

Replace Paragraph (9) with the following text:

"(9) In rectangular silos, the corrugations are commonly arranged to run horizontally. In this arrangement, the directions x and y in the above expressions should be taken as the vertical x and horizontal y directions respectively, see Figure 4.3 a). In the less common arrangement where the corrugations run vertically, the directions x and y in the above expressions should be interchanged on the real structure and taken as the vertical y and horizontal x directions respectively, see Figure 4.3 b).".

12 Modifications to 5.3.2.4, Buckling under axial compression

In Paragraph (4), replace Formula (5.15) with:

"

$$\alpha_0 = \frac{0,83}{1 + 2,2\,\Psi\,(\Delta w_{ok}\,/\,t)^{0,88}}$$

(5.15)".

Replace Paragraph (7) with:

"(7) The plastic pressurised imperfection reduction factor α_{pp} should be based on the largest local internal pressure p_g at the location of the point being assessed where the local thickness is t, and coexistent with the local value of axial compression that may cause buckling: