SLOVENSKI STANDARD
SIST EN 1993-4-1:2007/A1:2017

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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/A1:2017**

ICS:

65.040.20	Poslopja in naprave za predelavo in skladiščenje kmetijskih pridelkov	Buildings and installations for processing and storage of agricultural produce
91.010.30	Tehnični vidiki	Technical aspects
91.080.13	Jeklene konstrukcije	Steel structures

SIST EN 1993-4-1:2007/A1:2017 **en,fr,de**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 1993-4-1:2007/A1

June 2017

ICS 65.040.20; 91.010.30; 91.080.13

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 amendment A1 modifies the European Standard EN 1993-4-1:2007; it was approved by CEN on 3 March 2017.

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

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

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European foreword

This document (EN 1993-4-1:2007/A1:2017) has been prepared by Technical Committee CEN/TC 250 “Structural Eurocodes”, the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2018, and conflicting national standards shall be withdrawn at the latest by June 2018.

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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" and replace the title of this reference with "*Eurocode – Basis of structural design*".

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_{ϕ} local radius at the crest or trough of a corrugation."

with:

"r_{ϕ} local radius at the crest or trough of a corrugation.".

4 Modification to 1.6.2, Roman lower case letters

Replace:

"ℓ 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) 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 (6):

"(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).

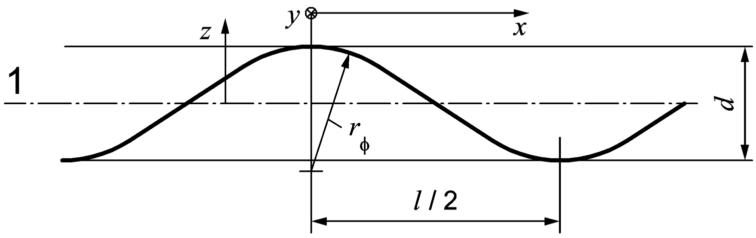
(11) Where a ring girder is used to redistribute silo wall forces into discrete supports, and where bolts or discrete connectors are used to join the structural elements, the shear transmission between the parts of the ring due to shell bending and ring girder bending phenomena should be determined.

(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 Figure 4.2 with:

"



Key

1 effective middle surface

Figure 4.2 — Corrugation profile and geometric parameters

".

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 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 (i.e. no Poisson effects).".

Replace Paragraph (5) with the following paragraph:

"(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:

$$t_x = \frac{2t^3}{3d^2} \tag{4.5}$$

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

$$t_y = t\left(1 + \frac{\pi^2 d^2}{4l^2}\right) \tag{4.6}$$

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

$$t_{xy} = \frac{t}{\left(1 + \frac{\pi^2 d^2}{4l^2}\right)} \tag{4.7}$$".

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:

$$D_x = EI_x \tag{4.8}$$

$$D_y = EI_y \tag{4.9}$$

$$D_{xy} = GI_{xy} \tag{4.10}$$

where:

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

$$I_x = \frac{t^3}{12\left(1-\nu^2\right)} \frac{1}{\left(1+\dfrac{\pi^2 d^2}{4l^2}\right)} \tag{4.11}$$

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:

$$I_y = \frac{td^2}{8}\left(1+\frac{\pi^2 d^2}{8l^2}\right) \tag{4.12}$$

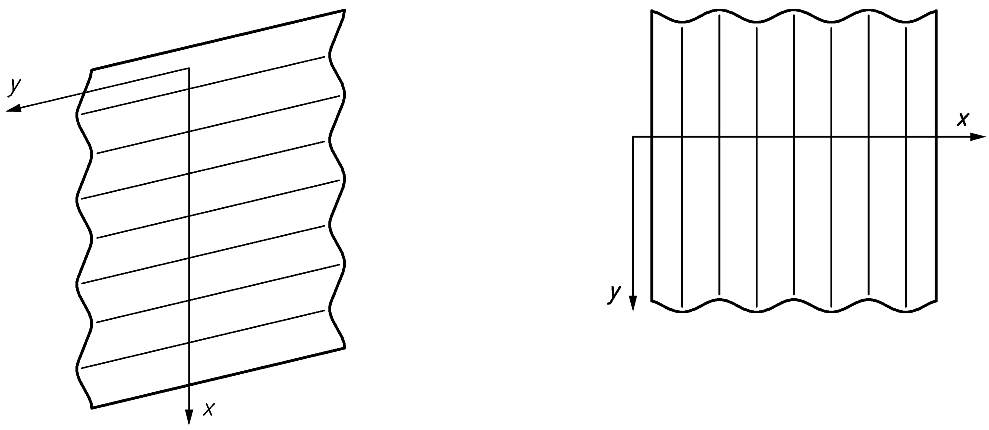
I_{xy} is the equivalent second moment of area per unit width for the smeared twisting stiffness:

$$I_{xy} = \frac{t^3}{12}\left(1+\frac{\pi^2 d^2}{4l^2}\right) \tag{4.13}$$

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.".

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:

"

$$\alpha_0 = \frac{0,83}{1 + 2,2\,\Psi\left(w_{ok}/t\right)^{0,88}} \qquad (5.15)".$$

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:

$$\alpha_{pp} = \left\{1 - \left(\frac{\bar{p}_g}{\bar{\lambda}_x^2}\right)\right\}\left[1 - \frac{1}{1,12 + s^{3/2}}\right]\left[\frac{s^2 + 1,21\,\bar{\lambda}_x^2}{s(s+1)}\right] \qquad (5.18)$$

with:

$$\bar{p}_g = \frac{p_g}{\sigma_{x,Rcr}} \cdot \frac{r}{t} \qquad (5.19)$$

$$s = \left(\frac{1}{400}\right)\left(\frac{r}{t}\right) \qquad (5.20)$$

$$\bar{\lambda}_x^2 = \frac{f_y}{\sigma_{x,Rcr}} \qquad (5.21)$$

where:

p_g is the largest design value of the local internal pressure (see EN 1991-4).

Different extremes of the material properties for a solid, defined in EN 1991-4, lead to different coupled values of axial force and internal pressure. A consistent pair of values should be used each time when applying Formulae (5.16) and (5.18).".

Add a new Paragraph (7a):

"(7a) The increase in buckling resistance of the shell structure due to the elastic stiffness of stationary bulk solid may only be considered using a rational analysis, where there is clear evidence that the solid against the wall is not in motion at the specified location during discharge and the relevant information