SLOVENSKI STANDARD
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Drogovi za razsvetljavo – Del 3-3: Projektiranje in preverjanje – Preverjanje z izračunom

Lighting columns - Part 3-3: Design and verification - Verification by calculation

Lichtmaste - Teil 3-3: Bemessung und Nachweis - Rechnerischer Nachweis

Candélabres d'éclairage public - Partie 3-3 : Conception et vérification - Vérification par calcul

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EUROPEAN STANDARD

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English version

Lighting columns - Part 3-3: Design and verification - Verification by calculation

Candélabres d'éclairage public - Conception et vérification - Partie 3.3: Vérification par calcul

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This European Standard was approved by CEN on 17 January 2003.

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This European Standard exists 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 Management Centre has the same status as the official versions.

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

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Contents

Foreword

This document (EN 40-3-3:2003) has been prepared by Technical Committee CEN/TC 50 *"Lighting columns and spigots*", 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of an identical text or by endorsement, at the latest by December 2003, and conflicting national standards shall be withdrawn at the latest by December 2003.

There are seven parts to this standard as follows:

Part 1: Definitions and terms

Part 2: General requirements and dimensions

Part 3-1: Design and verification — Specification for characteristic loads

Part 3-2: Design and verification — Verification by testing

Part 3-3: Design and verification — Verification by calculation

Part 4: Requirements for reinforced and prestressed concrete lighting columns

Part 5: Requirements for steel lighting columns

Part 6: Requirements for aluminium lighting columns

Part 7: Requirements for fibre reinforced polymer composite lighting columns

Annexes A and B are informative.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European Standard specifies the requirements for the verification of the design of lighting columns by calculation. It applies to post top columns not exceeding 20 m height for post top lanterns and to lighting columns with brackets not exceeding 18 m height for side entry lanterns.

The calculations used in this standard are based on limit state principles, where the effects of factored loads are compared with the relevant resistance of the structure. Two limit states are considered:

a) the ultimate limit state, which corresponds to the load-carrying capacity of the lighting column;

b) the serviceability limit state, which relates to the deflection of the lighting column in service.

NOTE In following this approach, simplifications appropriate to lighting columns have been adopted, These are:

1) the calculations are applicable to circular and regular octagonal cross-sections;

2) the number of separate partial safety factors have been reduced to a minimum;

3) serviceability partial safety factors have a value equal to unity.

The requirements for lighting columns made from materials other than concrete, steel, aluminium or fibre reinforced polymer composite (for example wood, plastic and cast iron) are not specifically covered in this standard.

This standard includes performance requirements for horizontal loads due to wind. Passive safety and the behaviour of a lighting column under the impact of a vehicle are not included, this group of lighting columns will have additional requirements (see prEN 40-2).

2 Normative references

This European Standard 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 Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 40-1:1991, *Lightning columns;- Part 1: Definitions and terms.*

EN 40-3-1, *Lighting columns — Part 3-1: Design and verification — Specification for characteristic loads.*

ENV 1993-1-1, *Eurocode 3: Design of steel structures - Part 1-1: General rules and rules for buildings.*

ENV 1999-1-1, *Eurocode 9: Design of aluminium structures - Part 1-1: General rules - General rules and rules for buildings.*

3 Terms and definitions

For the purposes of this European Standard, the terms and definitions given in EN 40-1:1991 apply.

4 Symbols

The following symbols are used in this European Standard.

The definitions are abbreviated, the full definitions being given in the text.

a	Overall length of door opening.
a_s	Area of legs of closed hoops at section.
A_e	Effective cross-sectional area of door reinforcement.
A_s	Cross-sectional area of door reinforcement.
b	Mean dimension of flat side of octagonal cross section.
b_o	Mean dimension of flat side at edge of door opening.
B_x	Factor.
B_y	Factor.
C	Length of halves of straight edge of door opening.
d	Diameter of cross-section.
d_l	Mean diameter of hoop reinforcement.
d_o	Diameter of central bore.
d_w	Width of door reinforcement.
e	Specified elongation.
E	Modulus of elasticity.
f_y	Characteristic strength of material.
f_u	Ultimate limit of the material.
F	Factor.
g	Factor.
G	Modulus of rigidity.
h	Nominal height.
L	Effective length of door opening.
m_{ex}	Distance from centroid of door reinforcement measured normal to the *x-x* axis.
m_{ey}	Distance from centroid of door reinforcement measured normal to the *y-y* axis.
m_t	Distance from centre of column wall at the door opening measured normal to the *x-x* axis.
m_y	Distance from centre of column wall at the door opening measured normal to the *y-y* axis.
M_p	Combined bending moment for closed regular cross-sections.
M_{up}	Bending strength for closed regular cross sections.
M_{ux}	Bending strength about *x-x* axis.
M_{uy}	Bending strength about *y-y* axis.
M_x	Bending moment about *x-x* axis.
M_y	Bending moment about *y-y* axis.
N	Corner radius of door opening.
P	Factor.

R	Mean radius of cross-section.
s	Longitudinal spacing of hoops.
S	Length of end connection of door reinforcement.
t	Nominal wall thickness.
t_0	Lesser of t and t_w.
t_w	Nominal thickness of reinforcement at the side of the door opening.
T_p	Torsion moment.
T_u	Torsion strength.
v	Radius of gyration of door reinforcement.
w	Bracket projection.
Z_p	Plastic modulus of closed regular cross-section.
Z_{pn}	Plastic modulus of unreinforced door opening cross-section about n-n axis.
Z_{py}	Plastic modulus of unreinforced door opening cross-section about y-y axis.
Z_{pnr}	Plastic modulus of reinforced door opening cross-section about n-n axis.
Z_{pyr}	Plastic modulus of reinforced door opening cross-section about y-y axis.
γ_f	Partial load factor.
γ_m	Partial material factor.
θ	Half angle of door opening.
π	Constant = 3,1416.
ε	Factor.
σ_c	Effective compressive strength of concrete at transfer of prestress.
σ_s	Characteristic strength of material.
σ_t	Characteristic shear strength.
σ_p	Stress on cross-section from prestressing force after taking account of prestressing losses.
ϕ_1	

5 Structural strength requirements (ultimate limit state)

5.1 Application of calculations

The adequacy of the strength of the lighting column shall be calculated for the following cross sections:

a) the point at which the column is fixed (normally at ground level);

b) the lower edge of the door opening. If two or more door openings are provided, the strength of each opening shall be verified (see Figure 1);

c) for tapered lighting columns the top of the door opening. If two or more door openings are provided, the strength of each opening shall be verified (see Figure 1);

d) the point at which the bracket begins if the column and the bracket consist of piece, or the point at which the bracket is attached if the bracket is detachable;

e) transition from one diameter to another when the column is stepped;

f) any critical position, e.g. change of material thickness.

5.2 Characteristic loads

The characteristic loads for strength requirements shall be calculated in accordance with EN 40-3-1.

5.3 Characteristic strength of materials

Metal lighting columns

The characteristic strength f_y (in N/mm^2) of steel and aluminium alloys shall be calculated in accordance with ENV 1993-1-1 and ENV 1999-1-1 respectively.

The increase in yield strength due to any process (such as cold working) shall not be used for members which are subject to another process (such as heat treatment or welding) which may result in softening.

5.4 Design loads

The characteristic loads specified in 5.2 shall be multiplied by the appropriate partial load factors, γ_f shown in Table 1 to give the design load to be used for calculation.

Table 1 — Partial load factors γ_f

	Wind load	Dead load
Class A	1,4	1,2
Class B	1,2	1,2

NOTE Guidance on the selection of class is given in annex B.

5.5 Calculation of moments

5.5.1 Bending moments

The bending moments, M_x and M_y (in Nm), about the orthogonal axes *x-x* and *y-y*, respectively, shall be calculated for each position specified in 5.1 using the loads specified in 5.4.

For cross-sections with openings the *x-x* and *y-y* axes shall be taken as shown in Figures 5b, 6 and 9b.

NOTE For regular octagonal cross-sections the axes can be positioned through the centre of the flat side or through a corner.

For closed regular cross-sections, the bending moments M_x and M_y may be combined to give a single moment, M_p (in Nm) that give the most adverse action on the column cross-section being considered and shall be calculated from the equation:

$$M_p = \sqrt{M_x{}^2 + M_y{}^2} \qquad (1)$$

5.5.2 Torsional moments

On columns with asymmetric bracket/lantern arrangements the torsional moment T (in Nm) shall be calculated for each position specified in 5.1 using the loads specified in 5.4.

On lighting columns with symmetric brackets the following configurations shall also be calculated and the greatest moment used in design:

a) column with a single bracket, with torsion;

b) column with symmetrical brackets, without torsion.

In both cases the same values for bracket projection and lantern weight and windage shall be used.

5.6 Strength of cross-section

5.6.1 General

The strength in bending and the strength in torsion of particular cross-sections shall be calculated in accordance with 5.6.2 and 5.6.3, as appropriate.

The strength in bending for the particular cross-sections shall be calculated

EITHER

about the orthogonal axes *n-n* or *x-x*, and *y-y*

OR

where M_p has been calculated; in the direction of M_p.

The strength in torsion *T* (in Nm) of the particular cross-section shall also be calculated.

1.1.2 Metal columns

5.6.2.1 Closed regular cross-sections

For closed circular cross-sections and closed regular octagonal cross-sections, the strength of the sections shall be calculated from the following equations:

a) Bending strength (in Nm)

$$M_{ux} = M_{uy} = M_{up} = \frac{f_y \phi_1 Z_p}{10^3 \gamma_m} \qquad (2)$$

b) Torsional strength (in Nm)

$$T_u = \frac{f_y \phi_2 \pi R^2 t}{10^3 \gamma_m} \qquad (3)$$

where

ϕ_1 is a factor having the value obtained from the curve appropriate to the cross-section in Figure 2 where the value of $\varepsilon = (R/t)\sqrt{f_y / E}$;

ϕ_2 is a factor with a value equal to $\frac{0{,}474E}{f_y (R/t)^{1{,}5}}$ but not greater than 1,0;

E is the characteristic modulus of elasticity of the material as specified in 6.3 (in N/mm²);

R is the mean radius of the cross section (see Figure 3) (in mm);

t is the wall thickness (see Figure 3) (in mm);

γ_m is a partial material factor having the appropriate value given in Table 2;

f_y is the characteristic strength of the material as specified in 5.3.1 (in N/mm²);

Z_p is the plastic modulus of the closed regular cross-section (in mm³);

NOTE For the purpose of this standard Z_p can be taken as having a value of:

$4R^2t$ for circular cross-sections;

$4{,}32R^2t$ for octagonal cross-sections.

Table 2 — Partial material factors, γ_m

Material	γ_m
Steel:	
Specified elongation $e > 15$ %	1,05
Specified elongation 5 % $\leq e \leq$ 15 %	1,15
Aluminium:	
Specified elongation ≥ 5 %	1,15
Specified elongation < 5 %	1,30
Welded joints	1,30
Bonded joints	3,00

5.6.2.2 Unreinforced openings in regular cross-sections

For unreinforced openings in circular cross-sections and regular octagonal cross-sections, the strength of the sections shall be calculated from the following equations:

a) Bending strength (in Nm)

$$M_{ux} = \frac{f_y g \phi_3 Z_{pn}}{10^3 \gamma_m} \quad (4)$$

$$M_{uy} = \frac{f_y g \phi_3 Z_{py}}{10^3 \gamma_m} \quad (5)$$

b) Torsional strength (in Nm)

$$T_u = \frac{f_y g \phi_4 \phi_5 R^3 t}{10^3 \gamma_m L} \quad (6)$$

where

ϕ_3 is a factor having the value equal to $\frac{t^2 E}{t^2 E + 0{,}07 RL f_y}$ but not greater than ϕ_1:

ϕ_4 is a factor having the value equal to $\frac{t^2 E}{t^2 E + 0{,}035 RL f_y}$ but not greater than ϕ_2:

ϕ_5 is a factor having the value obtained from the Figure 4 using the appropriate value of R/L and θ;

ϕ_1, ϕ_2, E, f_y and γ_m are as defined in 5.6.2.1;

θ is the half angle of the door opening (see Figure 5) (in degrees);

g is a factor having the following values:

- circular cross-sections: 1,0;
- octagonal cross-sections: $(15t/b_0)^{0,6}$ but not greater than 1,0;

b_0 is the mean dimension of the flat side at the edge of the opening (see Figure 5) (in mm). When b_0 is less than $4t$ the value of b_0 shall be taken as equal to b;

b is the mean dimension of the flat side of an octagonal cross-section (see Figure 5) (in mm);

L is the effective length of the opening and has a value of (a - 0,43N) (in mm);

a is the overall length of the opening (see Figure 5) (in mm);

N is the corner radius of the opening (see Figure 5) (in mm); (max. value: half of the width of the door opening);

R is the mean radius of the cross-section (see Figure 5) (in mm);

t is the nominal wall thickness (see Figure 5) (in mm)

Z_{pn} is the plastic modulus of unreinforced door opening cross-section about the plastic neutral axis n-n (in mm^3)

Z_{py} is the plastic modulus of the section about the plastic neutral axis y-y (in mm^3)

NOTE For the purpose of this standard the following values of Z_{pn} and Z_{py} can be taken for circular sections and regular octagonal sections:

$$Z_{pn} = 2FR^2 t \cos\frac{\theta}{2}\left(1 - \sin\frac{\theta}{2}\right)$$

$$Z_{py} = FR^2 t(1 + \cos\theta)$$

where

F is a factor having the following values

circular cross-sections 2,0;

octagonal cross-sections 2,16.

5.6.2.3 Reinforced openings in regular cross-sections

5.6.2.3.1 General

For the purpose of this Part of this standard, the reinforced openings in circular and regular octagonal cross-sections shall be classified in accordance with Figure 6.

The reinforcement shall be fixed to the column wall at the door opening and the clear distance between individual fasteners or intermittent fillet welds shall be not greater than $12t_0$.

1.1.1.1.2 Calculation for reinforcement types 1,2,3 and 4

The strength of the sections shall be calculated from the following equations for reinforcement types 1,2,3 and 4.