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Lighting columns

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

National foreword

This British Standard is the UK implementation of EN 40-3-3:2013. It supersedes BS EN 40-3-3:2003, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee B/509/50, Street lighting columns.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Foreword

This document (EN 40-3-3:2013) has been prepared by Technical Committee CEN/TC 50 “Lighting columns and spigots”, the secretariat of which is held by AFNOR.

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of an identical text or by endorsement, at the latest by August 2013, and conflicting national standards shall be withdrawn at the latest by August 2013.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 40-3-3:2003.

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

There are seven parts to the series of standards EN 40 - Lighting columns, as follows:

- Part 1: Definitions and terms;
- Part 2 : General requirements and dimensions;
- Part 3: Design and verification:
  - Part 3-1: Specification for characteristic loads;
  - Part 3-2: Verification by testing;
  - Part 3-3: 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.

According to the CEN/CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: 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 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 lighting columns of nominal height (including any bracket) not exceeding 20 m. Special structural designs to permit the attachment of signs, overhead wires, etc. are not covered by this European Standard.

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. Fibre reinforced polymer composite lighting columns are covered in this standard in conjunction with EN 40-7.

This European 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 addressed. Such lighting columns will have additional requirements (see EN 12767).

The calculations used in this European 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.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 40-1:1991**,** *Lighting columns — Part 1: Definitions and terms*

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

EN 40-4, *Lighting columns — Part 4: Requirements for reinforced and prestressed concrete lighting columns*

EN 40-7:2002, *Lighting columns — Part 7: Requirements for fibre reinforced polymer composite lighting columns*

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

EN 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 document, 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	Clear length of door opening
a_r	Length of the door cut out in the column wall for type 5 reinforcement
A_e	Effective cross-sectional area of door reinforcement.
A_s	Cross-sectional area of door reinforcement
b	Clear width of the door opening
b_r	Width of the door cut out in the column wall for type 5 reinforcement
B_x	Factor defined in 5.6.2.3.2
B_y	Factor defined in 5.6.2.3.2
C	Length of halves of straight edge of door opening
d_w	Width of door reinforcement
e	Specified elongation
E	Modulus of elasticity
f_y	Characteristic yield strength
F	Factor defined in 5.6.2.2
g	Factor defined in 5.6.2.2
G	Shear Modulus
h	Nominal height
J	Mean dimension of flat side of octagonal cross section
J_o	Mean dimension of flat side at edge of door opening.
l	Length of Type 5 reinforcing. (Fig. 6e)
L	Effective length of door opening
m_{ox}	Distance from centroid of door reinforcement measured normal to the x-x axis.
m_{oy}	Distance from centroid of door reinforcement measured normal to the y-y axis.
m_x	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 moment of resistance for closed regular cross sections.
M_{ux}	Bending moment of resistance about x-x axis.
M_{uy}	Bending moment of resistance 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 defined in 5.6.2.3.2
R	Mean radius of cross-section.
R_w	Mean radius of cross-section of type 5 reinforcement
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 moment of resistance

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 the clear door opening.
θ_r	Half angle of the door cut out in the column for type 5 reinforcement
π	Constant = 3,1416
ε	Factor defined in 5.6.2.1
ϕ_1 / ϕ_2	Factors defined in 5.6.2.1
ϕ_3 / ϕ_5	Factors defined in 5.6.2.2
ϕ_6 / ϕ_7	Factors defined in 5.6.2.3.2

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 the positions of the door and the brackets can be changed relative to each other and are not specified, the lower edge of the door opening should be calculated about its weakest axis. If two or more door openings are provided, the strength of each opening shall be verified (see Figure 1);

c) in addition to b) 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 one piece, or the point at which the bracket is attached if the bracket is detachable and check the junction between the bracket arm and the column;

e) transition from one diameter to another or at a change in material thickness;

f) anti-rotation device between the columns and the bracket arm, if such a device is present and intended to transfer torsional forces between the bracket arm and the column;

g) any other critical position.

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

5.3.1 Metal lighting columns

The characteristic yield strength $f_{y,}$ in N/mm^2, of steel and aluminium alloys shall be calculated in accordance with EN 1993-1-1 and EN 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.

5.3.2 Concrete lighting columns

The characteristic strength shall be determined in accordance with EN 40-4.

5.3.3 Fibre reinforced polymer composite lighting columns

The characteristic strength shall be determined in accordance with EN 40-7.

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 the ultimate limit state calculation.

Table 1 — Partial load factors γ_f

	Wind load	**Dead load**
Class A	1,4	1,2
Class B	1,2	1,2
Serviceability Limit State	1,0	1,0

NOTE Refer to National Guidance or National Annex for selection of the correct class.

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 design 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 and 6.

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 gives the most adverse action on the column cross-section being considered and shall be calculated from the formula:

$$M_p = \sqrt{M_x^2 + M_y^2} \tag{1}$$

5.5.2 Torsional moments

On columns with asymmetric bracket/luminaire arrangements the torsional moment T_p ,in Nm, shall be calculated for each position specified in 5.1 using the design 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 luminaire weight and wind area shall be used.

For arrangements with permanent unsymmetrical brackets of different heights or lengths, verification shall be undertaken for the combination of both brackets in their relative positions. If brackets are removable, any relieving effect of the removable brackets on the member stresses shall be ignored.

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, 5.6.3 or 5.6.4, as appropriate. Where a particular cross section is at a transition in section properties, the section properties giving the minimum strength shall be used for calculating the bending and torsion resistance.

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_u in Nm of the particular cross-section shall also be calculated.

5.6.2 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 formulae:

a) Bending moment of resistance, in Nm

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

b) Torsional moment of resistance, in Nm

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

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 $\dfrac{0{,}474E}{f_y (R/t)^{1{,}5}}$ 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 yield 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 is given by:

for circular cross-sections $Z_p = 4R^2t$

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

Table 2 — Partial material factors, γ_m

Material	γ_m
Steel:	
Specified elongation e > 15 %	1,05
Specified elongation 5 % ≤ e ≤ 15 %	1,15
Aluminium:	
Specified elongation ≥ 5 %	1,15
Specified elongation < 5 %	1,30
Welded joints	1,30
Bonded joints	3,00
Concrete	1,50
Fibre reinforced polymer composite	1,50

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 formulae:

a) Bending moment of resistance, in Nm

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

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

b) Torsional moment of resistance, in Nm

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

where

ϕ_3 is a factor $\phi_3 = \dfrac{t^2 E}{t^2 E + 0{,}07 RLf_y} \leq \phi_1$:

ϕ_4 is a factor $\phi_4 = \dfrac{t^2 E}{t^2 E + 0{,}035 RLf_y} \leq \phi_2$:

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

for circular cross-sections g = 1,0;

for octagonal cross-sections $g = (15t/b_0)^{0,6} \leq 1{,}0$;

J_0 is the mean dimension of the flat side at the edge of the door opening (see Figure 5),

in mm. When $J_0 < 4t$ then $J_0 = J$;

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

F is a factor

For circular cross sections F = 2,0

For octagonal cross sections F = 2,16

L is the effective length of the door opening L = (a - 0,43N), in mm;

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

N is the corner radius of the door opening (see Figure 5), in mm where N ≤ b/2;

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 European Standard the following values of Z_{pn} and Z_{py} can be taken for circular sections and regular octagonal sections:

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

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

5.6.2.3 Reinforced openings in regular cross-sections

5.6.2.3.1 General

For the purpose of this European 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 $12t_0$.

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

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

a) Bending Moment of Resistance, in Nm

$$\mathrm{M_{ux}} = \frac{\mathrm{f_y}\phi_6\mathrm{Z_{pnr}}}{10^3\gamma_\mathrm{m}} \quad (7)$$

$$\mathrm{M_{uy}} = \frac{\mathrm{f_y}\phi_6\mathrm{Z_{pyr}}}{10^3\gamma_\mathrm{m}} \quad (8)$$

b) Torsional Moment of Resistance, in Nm

$$\mathrm{T_u} = \frac{\mathrm{f_y}\phi_6(\phi_5 + \mathrm{P}\phi_7)\mathrm{R}^3\mathrm{t}}{10^3\gamma_\mathrm{m}\mathrm{L}} \quad (9)$$

where

ϕ_5 is as defined in 5.6.2.2;

ϕ_6 is a factor

for reinforcement types 1, 2 and 3 (see Figure 6)

$$\phi_6 = \frac{\pi^2 E}{\pi^2 E + f_y (L/v)^2} \leq \phi_1$$

for reinforcement type 4 (see Figure 6)

$$\phi_6 = \frac{(2t+t_w)^2 E}{(2t+t_w)^2 E + 0{,}32RL\ \mathrm{f_Y}} \leq \phi_1$$

NOTE 1 For type 4 reinforcement ϕ_6 can be taken as the higher value of ϕ_6 calculated as type 4 or ϕ_6 calculated as type 2.

ϕ_7 is a factor having a value obtained from Figure 8 using the appropriate values of *R/L* and θ;

v is the radius of gyration of the actual door reinforcement (i.e. area A_s, (see Figure 6)) about its centroidal axis parallel to the wall of the column at point of attachment, in mm;

NOTE 2 A length of column wall, not greater than 10t, as indicated in Figure 6, can be assumed to act with the reinforcement for the purpose of calculating v.

P is a factor $P = A_e/Rt \leq L/4R \leq 1,6$

ϕ_1, E, γ_m are as defined in 5.6.2.1

θ and L are as defined in 5.6.2.2

f_y is the characteristic yield strength of the material used for the column or the reinforcement, as specified in 5.3; whichever is the lower value, in N/mm^2

R is the mean radius of cross-section (see Figure 6), in mm

t is the wall thickness (see Figure 6), in mm

t_0 is the lesser of the two values t and t_w, in mm

t_w is the thickness of reinforcement at the side of the door opening (see Figure 6), in mm

NOTE 3 For the purposes of the calculations t_w has a constant value, which can be taken as being less than the actual thickness.

A_e is the effective cross-sectional area, in mm^2, of the door reinforcement and shall be taken as equal to the least value of the following:

a) As, the actual cross-sectional area of the door reinforcement as indicated on Figure 6. Where the value for As is not uniform over the length of the door opening the minimum area shall be taken

b) St_0

c) the total shear strength, in N, of all fasteners in each length S divided by f_y

d) the total shear strength, in N, of all fasteners in each length C, see Figure 7, divided by f_y

The shear strength of fasteners shall be taken as the shear strength of fillet weld per unit length times the appropriate length or the shear strength of the individual fasteners times the appropriate number of fasteners, as appropriate. The shear strength shall be calculated using a shear stress equal to $\frac{f_y}{\sqrt{3}}$. The throat thickness of fillet welds shall be taken as being the lesser value of:

1) the actual throat thickness, or

2) the value of t_0

S is the length of the end connection of the door reinforcement (see Figure 7), in mm

Where the upper and lower end connections have different lengths the lesser value shall be taken:

C is half the length of the straight edge of the door opening (see Figure 7), in mm

Z_{pnr} is the plastic modulus of the section, including the effective door reinforcement, about the plastic neutral axis n-n, in mm^3

Z_{pyr} is the plastic modulus of the section, including the effective door reinforcement, about the plastic neutral axis y-y, in mm^3

NOTE 4 For the purposes of this European Standard the following values of Z_{pnr} and Z_{pyr} can be taken for circular sections and regular octagonal sections:

$$Z_{pnr} = FR^2 t\left[2\cos\left(\frac{\theta}{2} - \frac{90B_x}{\pi}\right) - \sin\theta + B_x\cos\theta\right]$$

$$Z_{pyr} = FR^2 t\left[1 + \cos\theta + B_y\sin\theta\right]$$

where

$$B_x = \frac{A_e}{Rt} \times \frac{m_{ox}}{m_x}$$

$$B_y = \frac{A_e}{Rt} \times \frac{m_{oy}}{m_y}$$

m_{ox} is the distance given from the centroid of the actual door reinforcement, (i.e. Area A_s) as given in Figure 6, to the x-x axis (see Figure 6) measured normal to the axis, in mm

m_{oy} is the distance from the centroid of the actual door reinforcement (i.e. area A_s) to the y-y axis (see Figure 6) measured normal to the axis, in mm

m_x is the distance from the centre of the column wall at the edge of the opening to the x-x axis (see Figure 6) measured normal to the axis, in mm

m_y is the distance from the centre of the column wall at the edge of the opening to the y-y axis (see Figure 6) measured normal to the axis, in mm

5.6.2.3.3 Calculation for reinforcement type 5 (with inner tube)

For type 5 reinforcement, where an inner tube is expanded into the lighting column, the bending strength of the section shall be the algebraic sum of the bending strength of the inner tube unreinforced door opening and the bending strength of the outer tube unreinforced door opening provided that the inner tube is a press fit in the outer shell. Formulae (4) and (5), section 5.6.2.2, shall be used for this type.

If the inner tube is not press-fitted then the contribution of the inner tube shall be disregarded. The torsional strength shall be the strength of the outer lighting column unreinforced door opening cross-section alone. Formula (6) shall be used.

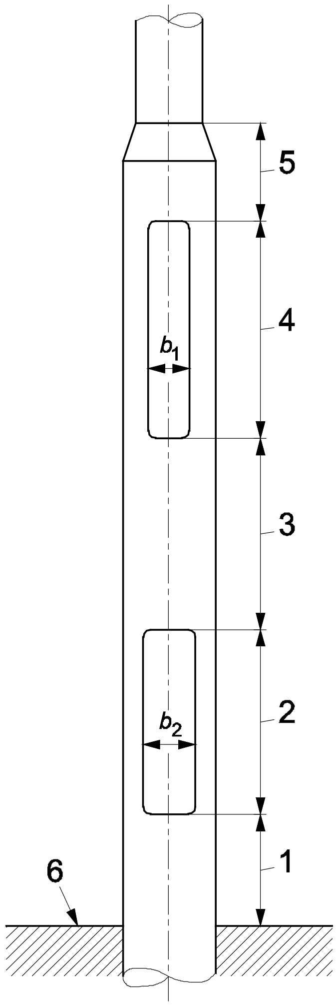
The length l (Figure 6e) of the inner tube shall be greater or equal to (a_r + 200) mm, to guarantee the participation of the inner tube in resisting bending deformations.

For Type 5 reinforcement where the inner tube is a press fit it is necessary to change the nomenclature used in Formulae (4) and (5) and their sub formulae for ϕ_3, Z_{pn} and Z_{py} as follows:

For t use t_w

R use R_w

as shown in Figure 6e).



Key

1 not less than 300 mm
2 as per standard
3 greater of b_1 or b_2 (minimum)
4 as per standard
5 100 mm minimum
6 ground level

Figure 1 — Door openings

5.7 Acceptance of design for strength

The strength of the column shall be considered acceptable if for all the critical cross-sections specified in 5.1, the following is satisfied for regular cross sections with unreinforced or reinforced openings:

$$\frac{M_x}{M_{ux}} + \frac{M_y}{M_{uy}} + \frac{T_p}{T_u} \leq 1 \tag{10}$$

and for closed regular sections:

$$\frac{M_p}{M_{up}} + \frac{T_p}{T_u} \leq 1 \qquad (11)$$

where

M_x, M_y and M_p are as defined in 5.5.1

T_p is as defined in 5.5.2

M_{ux}, M_{uy}, M_{up} and T_u are as defined in 5.6.2.

5.8 Concrete lighting columns

For concrete lighting columns, the strength of cross sections shall be determined in accordance with EN 40-4.

5.9 Fibre reinforced polymer composite lighting columns

For fibre reinforced polymer composite lighting columns, the strength of cross sections shall be determined in accordance with EN 40-7:2002, 5.7.

6 Deflection requirements (serviceability limit state)

6.1 Application of calculations

The horizontal and vertical deflections of the luminaire connection under the action of the characteristic design loads shall be calculated.

6.2 Serviceability limit state design loads

Design loads used for deflection requirements shall be the characteristic loads specified in EN 40-3-1.

6.3 Design values of material coefficients

The characteristic modulus of elasticity, *E*, and shear modulus, *G*, shall be taken from the specific Eurocode or from Table 3.

Table 3 — Characteristic modulus of elasticity, *E*, and shear modulus, *G*

Material	E	G
steel	210×10^3	81×10^3
aluminium	70×10^3	27×10^3
concrete	Refer to EN 40-4	Refer to EN 40-4
glass reinforced polymer composite	Refer to EN 40-7	Refer to EN 40-7

6.4 Calculation of deflections

6.4.1 Horizontal deflection of the luminaire connection(s)

6.4.1.1 General

The total horizontal deflection, in m, calculated from the effects of the loads specified in 5.4 shall be calculated for the appropriate arrangement as given below.

6.4.1.2 Column with asymmetric arrangement

The total horizontal deflection shall be taken as the sum of the following:

a) the horizontal deflection caused by flexure of the column shaft and the bracket due to the simultaneous effect of the wind on the column shaft, bracket or luminaire(s);

b) the horizontal deflection caused by torsion of the column shaft and any vertical section of the bracket due to the simultaneous effect of the wind on the section of the bracket deviating from the vertical and the luminaire(s).

6.4.1.3 Column with symmetric arrangement

The total horizontal deflection shall be taken as a) or b) whichever is the greater:

a) the horizontal deflection caused by the flexure of the column shaft and a single bracket due to the simultaneous effect of the wind on the column shaft, bracket and luminaire with torsion;

b) the horizontal deflection caused by the flexure of the column shaft and a double bracket due to the simultaneous effect of the wind on the column shaft, bracket arms and luminaires, without torsion (see also 5.5.2).

In both cases, the values for bracket projection and luminaire weight and wind area shall be the same.

6.4.2 Vertical deflection of the luminaire connection(s)

The vertical deflection, in m, calculated from the effects of the loads specified in 6.2 shall be taken as that caused by the flexure of the column and bracket due to the simultaneous effects of the weight of the section of the bracket deviating from the vertical and the luminaire mass.

6.5 Acceptance of design for deflection

6.5.1 Horizontal deflection

The horizontal deflection of each luminaire connection, calculated in accordance with 6.4.1, shall conform to one of the classes specified in Table 4:

Table 4 — Maximum horizontal deflection

Class	Maximum horizontal deflection
1	0,04 (h + w)
2	0,06 (h + w)
3	0,10 (h + w)

where

h is the nominal height of the lighting column, in m, as defined in EN 40-1;

w is the bracket projection, in m, as defined in EN 40-1.

6.5.2 Vertical deflection

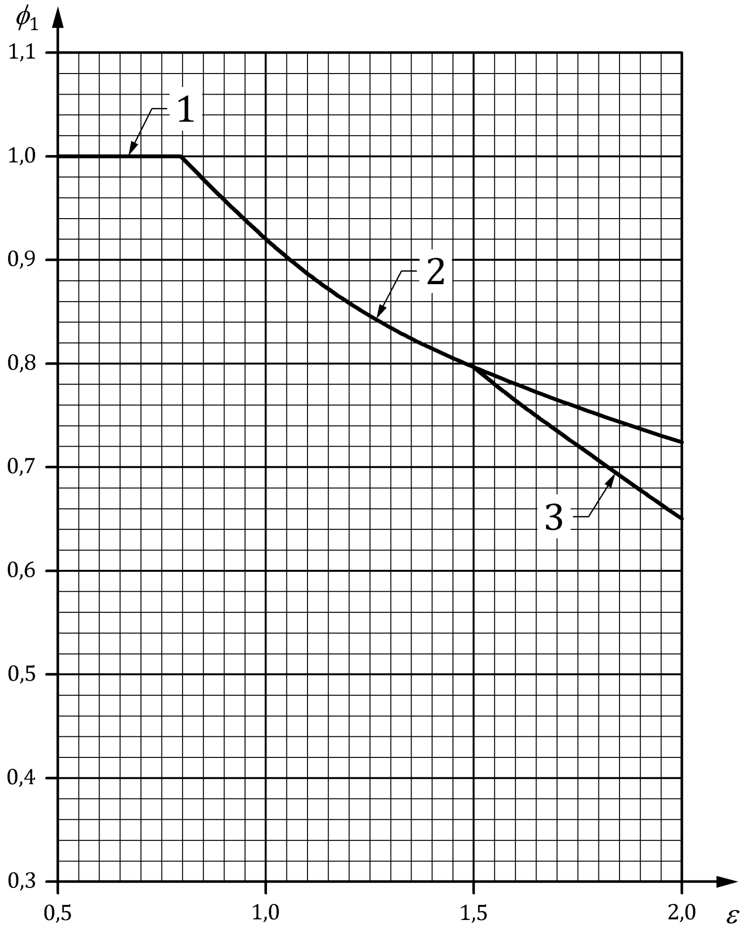
The vertical deflection of each luminaire connection, calculated in accordance with 6.4.2, shall not exceed 0,025 *w*, where *w* is as defined in 6.5.1.

7 Permissible modifications to verified column

The design calculations for a given column with a particular bracket arrangement and projection, luminaire(s) and wind load shall be considered acceptable for the same column with the same style of bracket(s) but with reduced bracket projection and/or smaller effective luminaire area(s) and/or smaller effective luminaire weight(s) and/or reduced wind load.

8 Fatigue requirements

Fatigue requirements are not covered in this standard. However when specified, the possibility of fatigue effects may be considered for metal lighting columns above 9 m in height.



Key

1 curve 3= ϕ_1 = 1,0 for $0 < \varepsilon \leq 0{,}8$

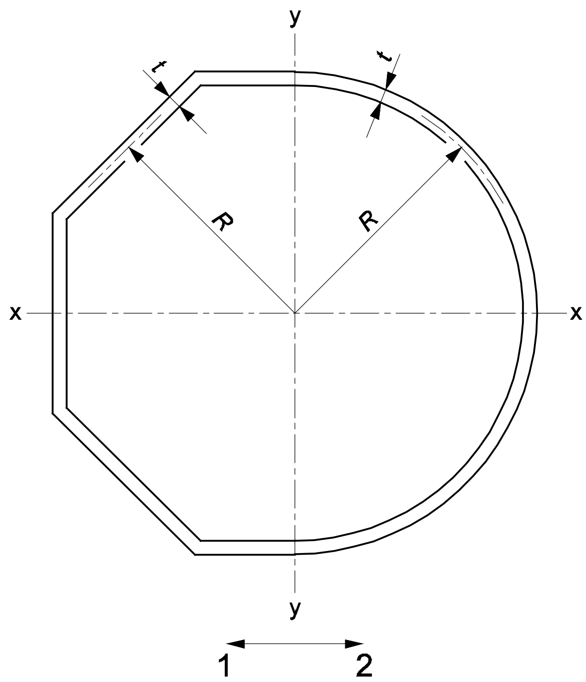
2 curve 4= $\phi_1 = \left(\frac{0{,}8}{\varepsilon}\right)^{0{,}35}$ for $0{,}8 < \varepsilon \leq 2{,}0$

3 curve 5= $\phi_1 = 0{,}81 - 0{,}3(\varepsilon - 1{,}5)^{0{,}9}$ for $1{,}53 < \varepsilon \leq 2{,}0$

NOTE 1 For circular cross-sections use curve 3 and 4.

NOTE 2 For octagonal cross-sections use curve 3, 4 and 5.

Figure 2 — Values of factor ϕ_1

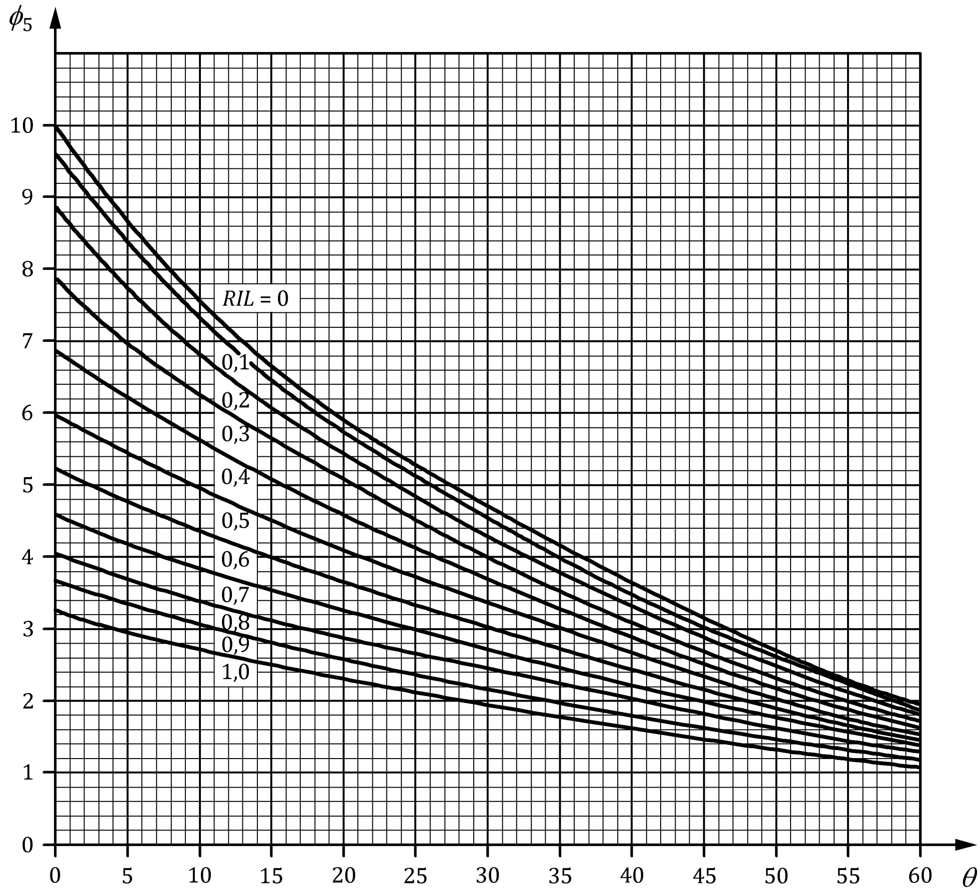


Key

1 octagonal

2 circular

Figure 3 — Closed regular cross-sections of metal lighting column



Key

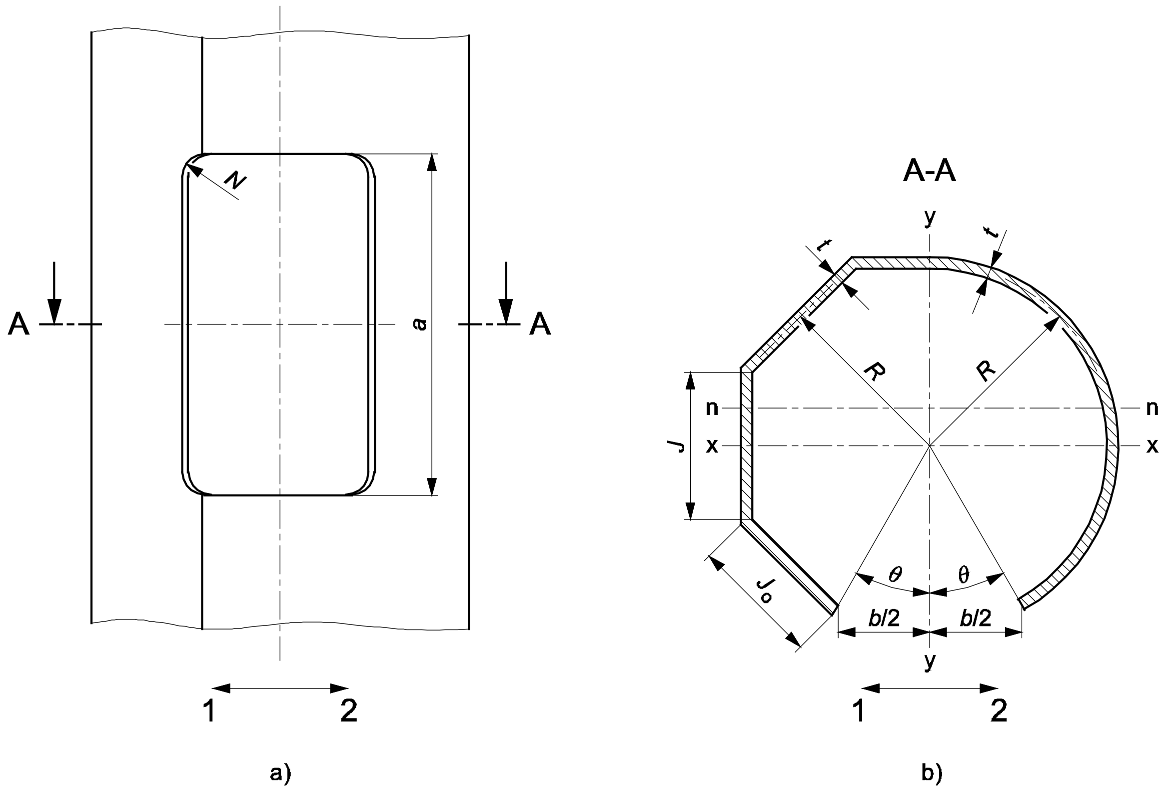
ϕ_5 factor having the value obtained from the Figure 4 using the appropriate value of R/L and θ;

θ half angle of the clear door opening

NOTE ϕ_5 can be obtained from the following expression:

$$\phi_5 = \frac{10\cos^2\left(\frac{\theta}{2}\right)}{1+1{,}73\tan\theta}\left(\frac{1+2{,}15\tan\theta+0{,}85\frac{R}{L}}{1+2{,}15\tan\theta+0{,}85\frac{R}{L}+3{,}8\left(\frac{R}{L}\right)^2}\right)$$

Figure 4 — Values of factor ϕ_5



a) Elevation **b) Cross-section**

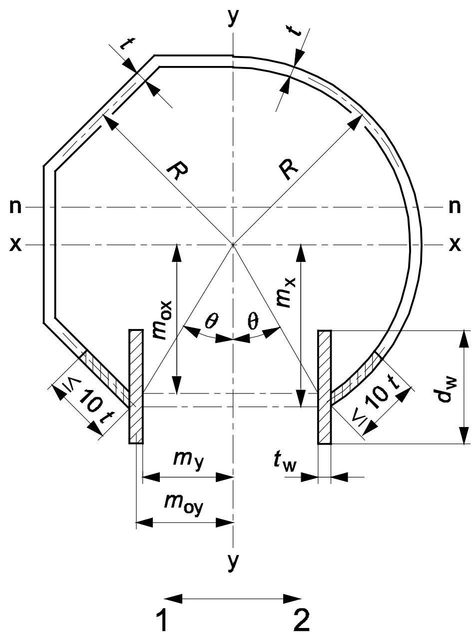
Key

1 octagonal

2 circular

NOTE *N* is the corner radius of the door opening

Figure 5 — Unreinforced door openings in metal lighting columns



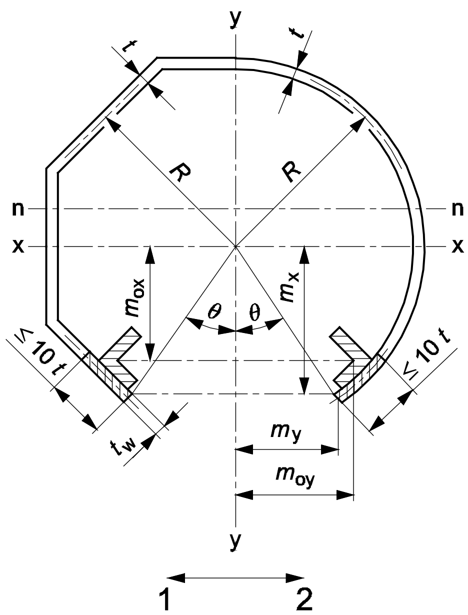
Key

1 octagonal

2 circular

NOTE $A_s = t_w \, d_w$

Figure 6 a) Type 1



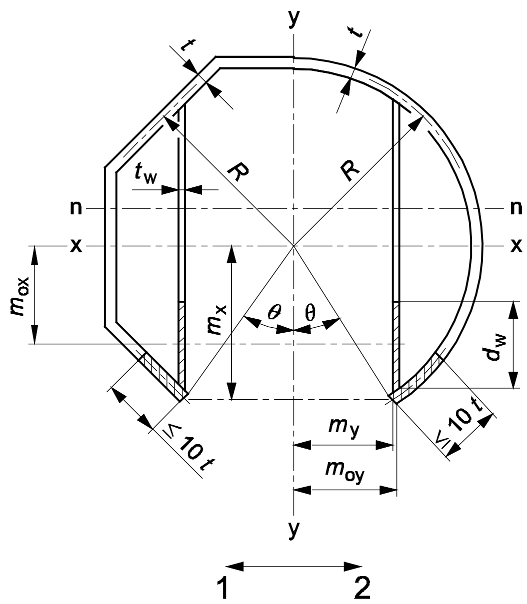
Key

1 octagonal

2 circular

NOTE As is the area of reinforcement, which can take the form of an angle or any other cross-section.

Figure 6 b) Type 2



Key

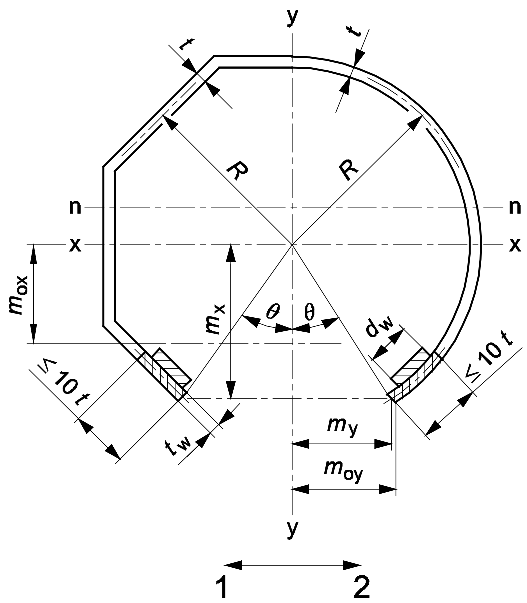
1 octagonal

2 circular

NOTE 1 $A_s = t_w\, d_w$

NOTE 2 d_w is taken as less than m_x or 20 t_w.

Figure 6 c) Type 3



Key

1 octagonal

2 circular

NOTE 1 $A_s = t_w\, d_w$

NOTE 2 For type (4) reinforcement, d_w is greater than 4 t_w and t_w has to be greater than t

Figure 6 d) Type 4

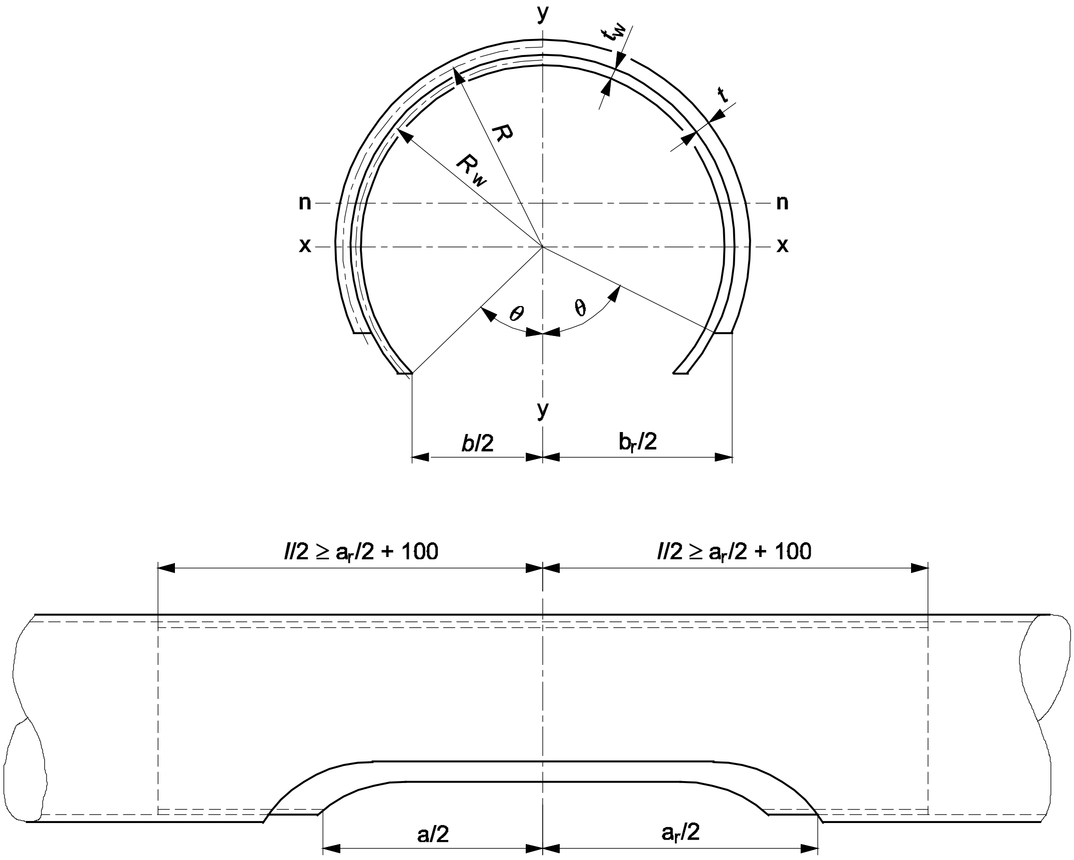
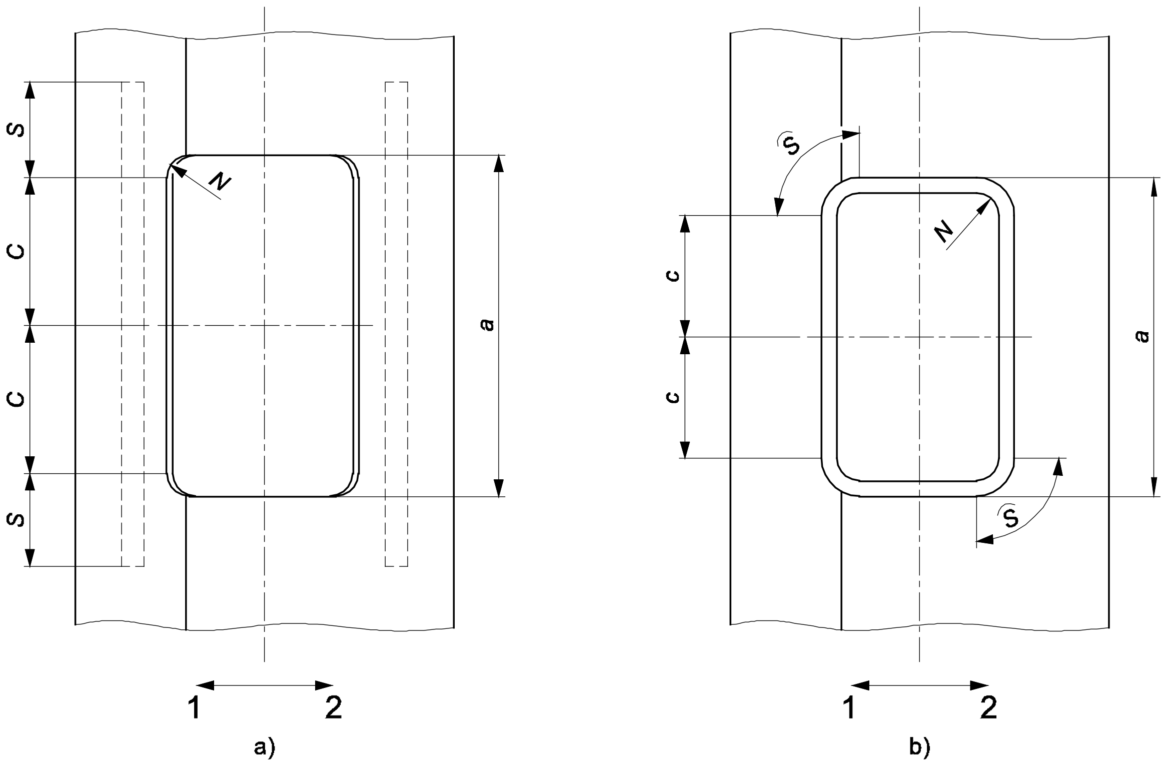


Figure 6 e) Type 5

Figure 6 — Cross-sections of reinforced door openings in metal lighting columns



a) Reinforcement projecting beyond the door opening

b) Reinforcement continuous around the door opening

NOTE 1 *N* is the corner radius of the door opening

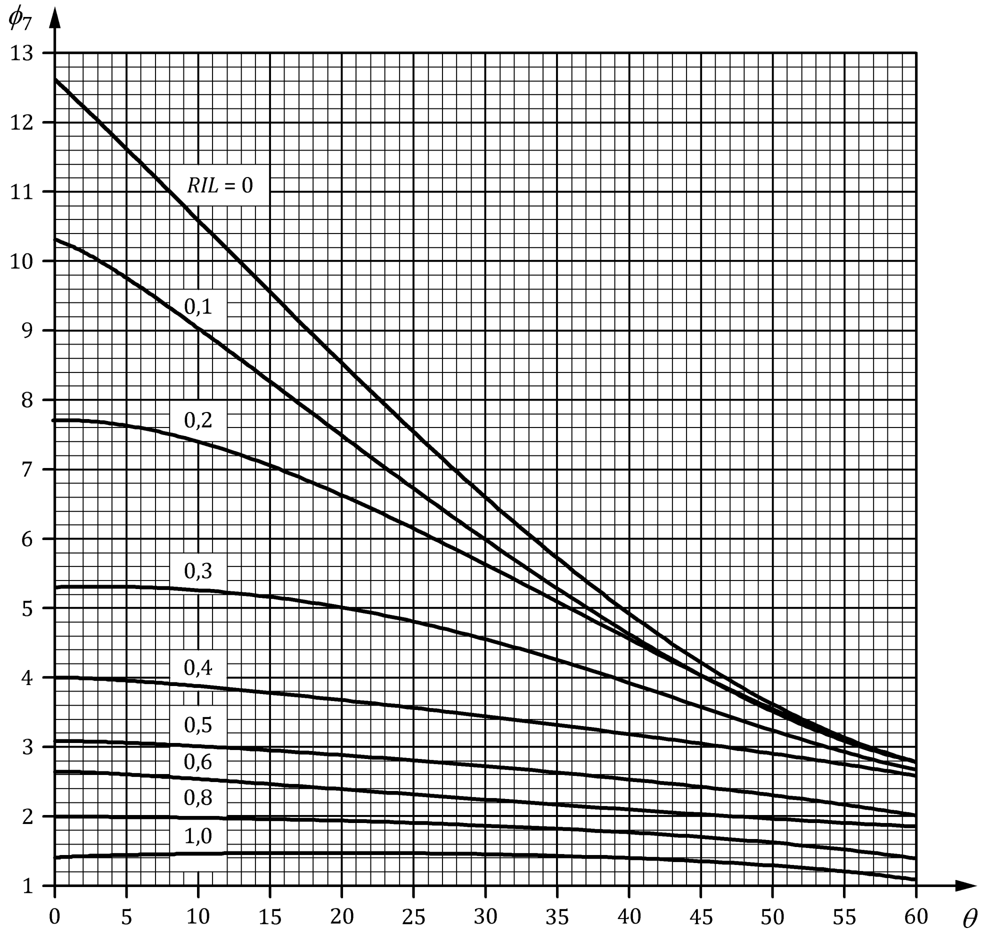
NOTE 2 For Reinforcement continuous around the door opening *S* is the length of connection of the curved portion of the reinforcement

Key

1 octagonal

2 circular

Figure 7 — Elevation of reinforced door openings in metal lighting columns



Key

φ_7 factor having a value obtained from Figure 8 using the appropriate values of *R/L* and θ;

θ half angle of the clear door opening

Figure 8 — Values of factor φ_7

NOTE In place of Figure 8, ϕ_1 can be calculated using the following formula:

$$\phi_7 = 12{,}6137 - 2{,}0293 \times (\theta/10) - 0{,}0571 \times (\theta/10)^2 + 0{,}0205 \times (\theta/10)^3 - 16{,}433 \times R/L + 9{,}9812 \times R/L \times (\theta/10) - 2{,}1222 \times R/L \times (\theta/10)^2 + 0{,}1453 \times R/L \times (\theta/10)^3 - 91{,}9666 \times (R/L)^2 + 10{,}6843 \times (R/L)^2 \times (\theta/10) + 7{,}3863 \times (R/L)^2 \times (\theta/10)^2 - 1{,}0161 \times (R/L)^2 \times (\theta/10)^3 + 314{,}5885 \times (R/L)^3 - 109{,}7109 \times (R/L)^3 \times (\theta/10) - 3{,}9352 \times (R/L)^3 \times (\theta/10)^2 + 1{,}9119 \times (R/L)^3 \times (\theta/10)^3 - 347{,}2925 \times (R/L)^4 + 165{,}6309 \times (R/L)^4 \times (\theta/10) - 6{,}927 \times (R/L)^4 \times (\theta/10)^2 - 1{,}4166 \times (R/L)^4 \times (\theta/10)^3 + 129{,}8994 \times (R/L)^5 - 74{,}523 \times (R/L)^5 \times (\theta/10) + 5{,}6642 \times (R/L)^5 \times (\theta/10)^2 + 0{,}351 \times (R/L)^5 \times (\theta/10)^3$$

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[2] EN 1992-1-3, *Eurocode 2: Design of concrete structures — Part 1-3: General rules — Precast concrete elements and structures*

[3] EN 1991-1-4:2005, *Eurocode 1: Actions on structures — Part 1-4: General actions — Wind actions*

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