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Guidance on the use of BS EN 40-3-1 and BS EN 40-3-3



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Summary of pages

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Foreword

Publishing information

This Published Document is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 December 2023. It was prepared by Subcommittee B/509/50, *Street lighting columns*, under the authority of Technical Committee B/509, *Road equipment*. A list of organizations represented on these committees can be obtained on request to the committee manager.

Supersession

PD 6547:2023 supersedes [PD 6547:2004+A1:2009](#), which is withdrawn.

Relationship with other publications

This Published Document gives non-contradictory, complementary information for use in the UK with [BS EN 40-3-1](#) and [BS EN 40-3-3](#).

Information about this document

This is a full revision of the document, and introduces the following principal changes:

- corrections to R_{wf} table in [Annex B](#);
- addition of a standard flange plate design method;
- addition of a fatigue assessment method for steel products;
- guidance on future proofing lighting columns for Smart Cities and Internet of Things (IoT);
- guidance on typical weight and wind areas for different lighting column attachments;
- considerations when retrofitting attachments to lighting columns;
- considerations when retrofitting lighting columns for electric vehicle (EV) charging points;
- explanation of the original derivation of the R_{wf} values;
- guidance and figures showing various typical foundations arrangements;
- introduction of the *Andrée and Norsa* method of design for foundations for lighting columns; and
- structural assessment of cable slots.

This publication can be withdrawn, revised, partially superseded or superseded. Information regarding the status of this publication can be found in the Standards Catalogue on the BSI website at bsigroup.com/standards, or by contacting the Customer Services team.

Where websites and webpages have been cited, they are provided for ease of reference and are correct at the time of publication. The location of a webpage or website, or its contents, cannot be guaranteed.

Use of this document

As a guide, this Published Document takes the form of guidance and recommendations. It should not be quoted as if it were a specification or a code of practice.

Presentational conventions

The guidance in this standard is presented in roman (i.e. upright) type. Any recommendations are expressed in sentences in which the principal auxiliary verb is “should”.

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Where words have alternative spellings, the preferred spelling of the *Shorter Oxford English Dictionary* is used (e.g. “organization” rather than “organisation”).

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1 Scope

This Published Document gives guidance and background information to specifiers and manufacturers of lighting columns on the use of [BS EN 40-3-1](#) and [BS EN 40-3-3](#), which specify the design of lighting columns. In particular, it gives guidance on the information which the specifier is required to give to the manufacturer to allow a suitable lighting column to be designed, such as the topography factor, site wind speed, site altitude and terrain category, which are used to determine the design wind pressure.

This Published Document provides additional guidance, not included within the scope of [BS EN 40](#), on the design and fitting attachments to lighting columns, steel fatigue design checks, lighting column foundation designs and the installation of lighting columns on site.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes provisions, or limits the application, of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Standards publications

[BS EN 40-1:1992](#), *Lighting columns. Definitions and terms*

[BS EN 40-3-1:2013](#), *Lighting columns. Design and verification. Specification for characteristic load*

[BS EN 40-3-3](#), *Lighting columns. Design and verification. Verification by calculation*

[BS EN 1991-1-4:2005+A1:2010](#), *Eurocode 1 – Actions on structures. Part 1-4: General actions – Wind actions*

3 Terms, definitions, symbols and abbreviated terms

3.1 Terms and definitions

For the purposes of this document the terms and definitions given in [BS EN 40-1:1992](#), [BS EN 40-3-1:2013](#) and [BS EN 1991-1-4:2005+A1:2010](#) and the following apply.

3.1.1 administrative authority

national, regional or local government public body, but equally a private or corporate organization, for whom multiple lighting column installations are specified and installed

3.1.2 anchorage

interface between the holding down stud and the foundation medium through which the stud forces pass to the foundation

3.1.3 anchor plate

steel plate connected to the lower end of the holding down studs to form an anchor in the concrete foundation

NOTE Typically, a single plate connected to all the studs.

3.1.4 cast-in socket

internally threaded socket connector for anchoring holding down bolts in a flanged lighting column connection

3.1.5 coastal location

site defined as being within 5 km from mean sea level but also includes sites with a significant upwind fetch over water within 5 km from the site

NOTE For example, an inland lake, major river or estuary.

3.1.6 drag factor

force coefficient representing the ratio between the effective projected area and the silhouette area of an object subject to wind loads

3.1.7 edge distance

distance from the edge of the flange plate to the centre of the fixing hole

3.1.8 exposed location

site:

- a) with an elevated position;

NOTE For example, mounted on a bridge, overpass, or the top deck of a multi-storey car park.

- b) subject to local wind funnelling due to tall buildings or other structures;

- c) where topography is significant; or

- d) with ground level exceeding 250 m above sea level

3.1.9 foundation block

pad footing for the lighting column of either unreinforced or reinforced concrete and sized to prevent overturning of the lighting column due to wind loads

3.1.10 ground investigation

on-site investigation to access, sample and test the type and strengths of soils and the depths at which they occur

NOTE This information is used in the interpretative report.

3.1.11 holding down bolts

bolts connecting the lighting column flange plate to foundation structure typically used with cast-in sockets in foundation blocks

3.1.12 holding down studs

cast-in lengths of fully or partially threaded rod that secures the lighting column to the foundation block

3.1.13 interpretative report

report presenting the analysis of the ground investigation which aims to establish engineering values of the soil parameters used in the foundation design

3.1.14 mean sea level (MSL)

site altitude datum, equal to the level of Ordnance Datum Newlyn

3.1.15 retention socket

device designed to hold and support the lighting column, using a shortened root length

NOTE The retention socket is typically cast-in to an in situ reinforced concrete pad or structure.

3.1.16 root

planted section of the lighting column from the ground line marker to the lowest end of the column structure under the ground

3.1.17 topography factor

equivalent parameter to the orography factor

NOTE As defined in [BS EN 1991-1-4:2005+A1:2010](#).

3.1.18 vehicle impact

occurrence of a vehicle hitting a lighting column whether as part of a test or with an installed column on site

3.1.19 vortex shedding

observed *von Karman* street phenomenon where wind flowing around a circular cross-section tends to form vortices which peel from the face of the section first from one side and then from the other, causing structural vibration

3.2 Symbols

For the purposes of this document, the following symbols apply.

A	site altitude at the column location above mean sea level (m)
A_{et}	tensile stress area in the thread of the holding down fastener (mm ²)
A_{eq}	equivalent shear area of the holding down fasteners (mm ²)
a	holding down fastener square spacing as defined in Figure 2 (mm)
B_s	narrowest dimension of sign plate (mm)
C	width of the square foundation block for <i>Andrée and Norsa</i> method (m)
C_s	probability factor to adjust for the mean return period of wind speed exceedance
C_{stat}	average shape coefficient for the top half of the lighting column structure
C_{vs}	constant relating to the cross-section shape of the lighting column
c	width of the square flange plate (mm)
c_{alt}	altitude factor
$C_e(Z)$	factor depending on the terrain of the site and height above ground level, z
c_f	force coefficient of a sign plate or other lighting column attachment where the sign plate aspect ratio is not known
$c_{f,y}$	force coefficient of a thin, sharp-edged sign plate where sign plate aspect ratio is known
D	diameter or distance across flats (for multi-sided section shapes) of the lighting column base and/or root section (m)
D_{eff}	diameter of a rooted foundation with or without concrete surround (mm)
D_f	for a root section with concrete surround, D_f is the minimum diameter of the concrete surround but limited to $D \leq P/2(m)$

D_M	mean diameter of the column base at ground level equal to $2R$ (mm)
d	diameter of bolt hole in flange plate (mm)
d_{ts}	depth from ground level to the top of the cable slot (m)
d_0	diameter of the holding down fastener (mm)
F_A	shear force in anchorage (N)
F_i	lane allocation factor
F_{fd}	pad foundation design shear force (kN)
$F_{i,F}$	shear force in foundation resulting from vehicle impact (kN)
$F_{p,FL}$	ultimate factored horizontal force at the level of the flange plate (kN)
F_R	ultimate factored horizontal impact force (N)
$F_{R,B}$	resultant ultimate shear force at the base of the lighting column (N)
f	topography factor
f_q	yield stress of holding down fasteners (N/mm ²) as defined in 10.7.5
f_t	maximum allowable tensile stress of holding down fasteners as defined in 10.7.5 (N/mm ²)
f_y	characteristic yield strength of the column base section (N/mm ²)
$f_{y,f}$	characteristic yield strength of the flange plate (N/mm ²)
$f_{y,w}$	yield strength of the flange weld (N/mm ²)
G	maximum rupture intensity of soil (kN/m ² per m depth of the root)
H	overall height of the concrete foundation block (m)
h	nominal height of the lighting column (m)
h_v	distance between top of a high-sided vehicle and the underside of a cantilevered bracket directly above the carriageway
K	ratio of weld throat size to shaft thickness use in E.7
K_b	stress concentration factor for the flange to column external weld detail
K_f	stress concentration factor for the full weld detail
K_h	stress concentration factor for the flange hole weld detail
K_{si}	soil impact factor
K_t	stress concentration factor for the column base section
k_1	factor for design of welds used in 10.7.4
k_2	factor for capacity of welds used in 10.8.5
L	design life of the lighting column
L_s	longest dimension of sign plate (mm), as defined in 12.2
M_{fd}	pad foundation design moment (kNm)

$M_{i,F}$	overturning moment in foundation resulting from vehicle impact (kN)
$M_{P,B}$	resultant bending moment at the base of the lighting column. For rooted column this is the position at the top of the embedded root section and for flanged columns this is at the level of the flange plate (Nm)
$M_{P,CS}$	applied bending moment at the top of the cable slot in the most onerous direction (Nm)
$M_{P,F}$	total applied moment at the base of the foundation (Nm)
$M_{P,FB}$	applied overturning moment at the base of the foundation block (Nm)
$M_{P,FL}$	applied bending moment at the underside of the flange plate (Nm)
$M_{P,FL,u-u}$	applied bending moment at the underside of the flange plate about the $u-u$ axis (Nm)
$M_{P,FL,v-v}$	applied bending moment at the underside of the flange plate about the $v-v$ axis (Nm)
$M_{P,FT}$	applied overturning moment at the top of pad foundation (Nm)
$M_{P,G}$	applied overturning moment (factored) at ground level for rooted foundation (Nm)
$M_{R,B}$	moment of resistance of the column base (closed section) (Nm)
$M_{R,F}$	moment of resistance against overturning of the pad foundation (Nm)
$M_{R,FL}$	plastic moment of resistance of the flange plate (Nm)
$M_{R,FL,u-u}$	plastic moment of resistance of the flange plate about the $u-u$ axis (Nm)
$M_{R,FL,v-v}$	plastic moment of resistance of the flange plate about the $v-v$ axis (Nm)
$M_{R,G}$	moment of resistance at ground level of the rooted foundation (Nm)
m	slope of curve in Figure F.1 and Figure F.2
N	weight of lighting column plus foundation block (N)
N_f	frequency of structural vibration of the lighting column
N_1	number of fatigue cycles to failure due to wind loads
N_{2i}	number of fatigue cycles to failure due to high vehicle buffeting
n_b	number of holding down fasteners
n_{fe}	effective natural frequency
n_t	relates to the number of fasteners resisting tension and the assumed axis of bending, as defined in 10.10
n_1	number of fatigue cycles applied due to wind load vibration
n_{2i}	number of fatigue cycles applied due to high vehicle buffeting vibration
P	planting depth of the lighting column root section (m)
P_d	design pressure for high vehicle buffeting
P_1	width of upper door opening
P_2	width of lower door opening
Q	allowable bearing pressure of the excavation formation level (N/m ²)

$q(z)$	reference wind pressure at height, z above ground level (N/m^2)
$q(10)$	reference wind pressure at 10m above ground level (N/m^2)
R	mean radius of the column base from the centre to the mid thickness of the column wall (mm)
R_{wf}	rationalized wind loading factor
r	radius of the corner of an octagonal folded sheet lighting column
r_{d}	corner radius of door opening
s_{t}	concrete surround thickness (width of concrete annulus) for a rooted column foundation
T	number of lanes below the cantilever arm of the structure
T_{A}	maximum tensile force in the foundation anchorage (N)
t_{b}	wall thickness of the base section of the lighting column
t_{f}	thickness of the flange plate (mm)
t_{s}	wall thickness of the shaft section of the lighting column
t_{w}	leg length of fillet weld between flange plate and lighting column base section (mm)
$v_{\text{b},0}$	fundamental basic wind velocity (m/s)
$v_{\text{b,map}}$	fundamental basic wind velocity before altitude correction (m/s)
v_{ref}	reference wind speed (m/s)
$v_{\text{ref,alt-adj}}$	altitude adjusted value of the reference wind speed, v_{ref}
w	bracket projection (m)
X	horizontal opening width of cable slot (mm)
Y	vertical opening length of cable slot (mm)
z	height above ground level (m)
α	factor that relates to the position considered for the maximum bending in the flange plate. In lieu of more thorough analysis, can be based on the centroid of the welds on the tensile side, i.e. 0,63
β	factor depending on the dynamic behaviour of the lighting column
δ	factor depending on the lighting column size
γ	thin, sharp-edged, sign plate aspect ratio = L/B
γ_{f}	partial factor of safety for loads
$\gamma_{\text{f,dst}}$	partial factor of safety for destabilizing loads
$\gamma_{\text{f,stb}}$	partial factor of safety for stabilizing loads
γ_{m}	partial factor of safety for materials
ρ	air density (kg/m^3)
σ	tensile stress in the holding down fastener (N/mm^2)

σ_{bs}	maximum bearing stress about the v - v axis on the foundation medium assuming plastic analysis (N/mm ²)
$\sigma_{bs(u-u)}$	maximum bearing stress about u - u axis
$\sigma_{bs(v-v)}$	maximum bearing stress about v - v axis
σ_0	detail category
σ_{r1}	stress range for fatigue due to wind loads
σ_{r2l}	stress range for fatigue due to high vehicle buffeting
σ_s	stress calculated at a position for the design forces and moments
τ	shear stress in the holding down fastener (N/mm ²)
τ_1	stress in the fillet welds due to the bending moment of resistance, $M_{p,FL}$ (N/mm ²)
τ_2	stress in the fillet welds due to the equivalent shear force $F_{p,FL}$ (N/mm ²)
τ_R	resultant weld stress in 10.8.4 (N/mm ²)
τ_D	weld stress capacity in 10.8.5 (N/mm ²)

3.3 Abbreviated terms

For the purposes of this document, the following abbreviated terms apply.

EVCP	electric vehicle charge points
GL	ground level
FRPC	fibre reinforced polymer composite
MDPE	medium-density polyethylene
MSL	mean sea level

4 Specification of lighting columns

To specify a lighting column, reference should be made to the design and manufacture of lighting columns conforming to [BS EN 40](#), Part 4 to Part 7 for the appropriate material, along with the guidance provided in this published document. In addition, the information listed in [Annex A](#) should be provided for the lighting columns required.

5 Background information on the design wind loadings in BS EN 40-3-1

The current standard for deriving the wind loads on a lighting column is NA to BS EN 1991-1-4:2005+A1:2010, Figure NA.1.

6 Wind pressures

6.1 General

[BS EN 40-3-1:2013](#), [5.2.1](#), specifies an equation for calculating the characteristic wind pressure, $q_{(z)}$, in N/m² for any particular height above ground, z :

$$q(z) = \delta \beta f c_e(z) q(10) \quad (1)$$

where:

- $q(10)$ is the reference wind pressure at 10 m above GL in N/m²;
- δ is a factor depending on the column size;
- β is a factor depending on the dynamic behaviour;
- f is a topography factor, which is taken as 1 unless otherwise specified or where a lighting column is installed on a slope with a height of less than 5 m; and
- $c_e(z)$ is a factor depending on the terrain of the site and the height above ground, z in m.

6.2 Reference wind pressure $q(10)$

The reference wind pressure should be determined using the fundamental basic wind velocity, $v_{b,0}$. [BS EN 1991-1-4:2005+A1:2010](#), 4.2(1)P Note 2 references the NA to BS EN 1991-1-4:2005+A1:2010, in which Expression NA.1 states:

$$v_{b,0} = v_{b,map} c_{alt} \quad (2)$$

where:

- $v_{b,map}$ is the value of the fundamental basic wind velocity before the altitude correction is applied, and should be taken from [BS EN 1991-1-4:2005+A1:2010](#), Figure NA.1; and
- c_{alt} is the altitude factor.

$$c_{alt} = 1 + 0.001A \quad (3)$$

where:

- A is the altitude of the site in metres above MSL.

NOTE 1 Many administrative authorities are able to select one value of $v_{b,map}$ which covers most situations within their boundaries. Administrative authorities can select a maximum altitude to be used in specifications that cover most lighting column locations within their boundaries. [Table B.1](#) in [Annex B](#) gives maximum altitudes by administrative authority. An explanation of the derivation of the maximum altitude is provided in [Annex C](#).

NOTE 2 In [BS EN 40-3-1:2000](#), $v_{b,0}$ is equivalent to v_{ref} and $v_{b,map}$ is equivalent to $v_{ref,0}$ as used in [BS EN 1991-1-4:2005+A1:2010](#).

6.3 Exposure coefficient $c_e(z)$

6.3.1 Terrain categories

The exposure coefficient, $c_e(z)$ is a factor varying with height above ground and is dependent on the terrain category of the site where a lighting column is to be installed, as determined by [BS EN 40-3-1:2013](#), Table 1.

Where site-specific information regarding terrain is available, this should be specified to the manufacturer. Where the lighting column design is to cover columns in a number of different locations, the terrain categories indicated in [Table 1](#) should be used for inland locations.

[Table 1](#) assumes that lighting columns of nominal height below 8 m are generally installed in less exposed locations, e.g. residential areas with trees and buildings, which is represented by terrain category III. Columns 8 m and over are more likely to be used on through-routes and roads between towns which might be passing through more exposed countryside which is represented by terrain category II.

Table 1 — Terrain categories by lighting column height and location

Lighting column height	Terrain category (inland location)	Terrain category (coastal location)
Below 8 m	III	II
8 m and above	II	I

NOTE 1 Examples of the different terrain categories are given in [BS EN 1991-1-4:2005+A1:2010](#), Annex A.

NOTE 2 Terrain category 0 is not used in [BS EN 40-3-1:2013](#).

6.3.2 Coastal locations

When a lighting column is used at ground level in a coastal location or where there is 5 km of lake or river in the upwind fetch, a modification to the terrain category should be applied to reflect the increased site exposure. The normal terrain category should be adjusted towards coastal terrain by one level, as indicated in [Table 1](#) for coastal locations.

In coastal locations, lighting columns might be susceptible to wind-induced vibrations resulting from the presence of laminar wind flow conditions which can reduce the actual working life of the lighting column. Assessment and mitigation might be required to prevent such vibrations occurring.

6.3.3 Exposed locations

Where a lighting column is to be installed in an exposed location, as defined in [3.1.8](#), specialist advice should be obtained from a chartered structural or civil engineer in determining the wind loads to be applied for the structural analysis.

Confirmation should be provided to the lighting column manufacturer that the proposed mounting position and location is appropriate and suitable for the lighting column to be installed.

Where lighting columns are mounted in an elevated location, such as on a bridge or multilevel building, the increased flange height above ground level should be taken into account in calculating the exposure coefficient, $c_e(z)$. In these cases, the rationalized wind loading factor or for site-specific designs, the reference wind pressure, $q(z)$ can be increased by the ratio of the reference wind pressure at a height of 10 m above the column flange level and the wind pressure at 10 m above ground level, calculated in accordance with [BS EN 40-3-1:2013](#), [6.2.2](#).

Lighting columns positioned at the edge of the roof of a tall structure are exposed to increased localized wind speeds due to the flow of the wind over and around the building structure. A site-specific assessment would then be required.

Wind funnelling is the acceleration of wind as it passes between two closely spaced objects, e.g. tall buildings. A site-specific analysis is required to determine the localized increase in wind speeds at the column location.

Where the column is installed in a location where topography (renamed orography in [BS EN 1991-1-4:2005+A1:2010](#)) is significant, [BS EN 40-3-1:2013](#), [5.2.5](#) gives guidance on the methodology to include this. For complex topography or in case of doubt, obtain specialist advice as indicated above in paragraph 1 of this subclause.

Finally, there are a limited number of sites in the UK where the ground level exceeds 250 m above MSL. For lighting columns being installed in these locations, a site-specific wind speed calculation is required, allowing for the effects of the increased site altitude.

7 Rationalized wind loading factors (R_{wf})

[Clause 6](#) provides a site-specific lighting column design for the wind speed, terrain category and altitude at a single location. Where lighting columns of a single type are to be used over a wider

area, be it a parish, town, city, or countywide solution, it is often not practical to design a column for each location individually. In such cases, as an alternative to specifying the information detailed in Clause 6, the specifier can use rationalized wind loading factors (R_{wf}) applicable to a whole administrative area.

R_{wf} values have been calculated using the 10-minute mean wind velocity specified for each administrative region of the UK and adjusted for altitude, as detailed in Annex B. Five factors have been used for the UK, and the maximum altitude for each administrative area has been increased to take into account additional loading capacity arising as a result of standardization.

The rationalized wind loading factor, R_{wf} in N/m² is given by the following equation:

$$R_{wf} = \frac{1}{2} C_s^2 \rho v_{ref,alt-adj}^2 \quad (4)$$

where:

- C_s $\sqrt{0,92}$ for a mean return period of 25 years;
- ρ is air density taken as 1,226 kg/m³, in accordance with NA to BS EN 1991-1-4:2005+A1:2010, NA.2.18; and
- $v_{ref,alt-adj}$ is the altitude adjusted value of the reference wind speed, v_{ref}

The rationalized wind loading factor is substituted for $q(10)$ in the equation to find the characteristic wind pressure:

$$q(z) = \delta \beta f c_e(z) R_{wf} \quad (5)$$

NOTE 1 The value of in BS EN 40-3-1:2013 is specified as 1,25 kg/m³ unless otherwise recommended in the National Annex. NA to BS EN 1991-1-4:2005+A1:2010, NA 2.18, replaces 4.5(1), Note 2 and states the value to be used for air density, = 1,226 kg/m³.

The use of rationalized wind loading factors is limited to a maximum site altitude of 250 m above MSL in locations that are not exposed. For sites above this altitude, see 6.3.3.

NOTE 2 The rationalized wind loading factors in Annex B are all stated at 10 m above ground level, and for a mean return period of 25 years. A history of the derivation of the R_{wf} values in Table B.1 is provided in Annex C.

8 Design loads and horizontal deflection

8.1 General

In addition to the data required to determine the characteristic wind loadings on a lighting column, the classes of partial safety factors on loads (see 8.2) and horizontal deflection (see 8.3) are required by BS EN 40-3-3:2013, 5.4 and 6.5.1, respectively, to be specified to the column manufacturer.

8.2 Partial safety factors on loads, γ_f

Two classes of partial load factors, γ_f are specified in BS EN 40-3-3:2013, 5.4 Class B (wind load: $\gamma_f = 1,2$, dead load: $\gamma_f = 1,2$) should be specified.

8.3 Deflection classes

BS EN 40-3-3:2013, 6.5.1, requires the horizontal deflection of a lantern fixing to conform to one of three classes of maximum horizontal deflection specified in BS EN 40-3-3:2013, Table 3. Of these, Class 3 should be used in the UK unless specified otherwise. Class 3 limits horizontal deflection to:

$$0,10 (h + w) \quad (6)$$

where:

- h is the nominal height of the lighting column (m), as defined; and
 w is the bracket projection (m), as defined in [BS EN 40-1:1992](#).

9 Lighting column foundations

9.1 Planting depth

There are a variety of methods of installing lighting columns with the most common options outlined in [9.2](#) to [9.7](#). Foundation designs should be carried out by competent civil engineers.

NOTE Outline drawings of the typical foundation arrangements in [9.2](#) to [9.7](#) are provided in [Annex D](#) for information.

9.2 Planted root foundations

9.2.1 General

The planting depth is the vertical distance from the top of the rooted foundation and the bottom of the lighting column root section. The top of the rooted foundation is the lowest point of the ground level around the face of the lighting column base or the top of the concrete backfill or hard paving, where provided.

The planting depth does not include the depth of any concrete, anti-sink plate or other support below the bottom of the root length.

9.2.2 Choosing a planting depth, P

Where a lighting column is to be planted into the ground, the planting depth should be selected from the centre column of [BS EN 40-2:2004](#), Table 7, taking into account the nominal height of the lighting column.

9.2.3 Planting depth suitability

9.2.3.1 General

To check the suitability of the selected planting depth for the ground conditions at the site, the calculation procedure given in [9.2.3.2](#) should be adopted, unless a more sophisticated foundation design approach is selected by a competent civil or structural engineer.

9.2.3.2 Calculation of planting depth

The overturning moment should be obtained from the lighting column designer or by calculation, arising from the application of the full design wind pressure on the lighting column, bracket arm, luminaire and any other attachment, such as banners, about a fulcrum point located at $P / \sqrt{2}$ below ground level, and:

- multiply the overturning moment by a partial safety factor for loads, $\gamma_{f, \text{dst}}$ of 1,25;
- calculate the moment of resistance at the ground level, $M_{R,G}$ in kNm, using the following equation:

$$M_{R,G} = \frac{G D_{\text{eff}} P^3}{10} \quad (7)$$

where:

- G is the maximum rupture intensity for the soil in which the column is planted, see Table 2 (kN/m² per m depth). It assumes the elasticity of the soil can be neglected and the rupture intensity of stress is directly proportional to depth below ground level, giving a straight-line soil stress diagram and the fulcrum of rotation of the root section at $P / \sqrt{2}$ below ground level. This is described in detail in Morecombe, 1929 [1].
- D_{eff} is the rooted foundation diameter (m) being the minimum of either D or D_f :
- D is used for a rooted column with no concrete surround, the column root diameter or minimum distance across flats for multi-sided sections (m); or
 - D_f is used for a rooted column with diameter, D (m) and concrete surround thickness, s_c (m) can be taken as $D_f = D + 2s_c$; and
- P is the planting depth of the root section (m).
- if the overturning moment including the factor of safety exceeds the ground resistance moment, $M_{R,G'}$, it is necessary to specify an increase in either the planting depth of the lighting column and/or the effective diameter, D_{eff} of its foundation, until the ground resistance moment, $M_{R,G'}$, exceeds the applied overturning moment at ground level, $M_{P,B'}$, including the partial factor of safety for loads; and
 - the latter can be achieved by back-filling the excavation with mass concrete (see 9.5) and the effective diameter of the column can then be assumed to be the minimum diameter of the hole. Where concrete backfill is used to increase the effective diameter of the foundation in Equation (7), $D_f \leq P/2$ to prevent tension stresses cracking the mass concrete.

Table 2 — Ground factor, G and soil impact factor, K_{si}

Ground factor, G kN/m ² per m depth	Quality of soil	Soil impact factor, K_{si}
630	Good: Compact, well-graded sand and gravel, hard clay, well-graded fine and coarse sand, decomposed granite rock and soil. Good soils drain well.	0,2
390	Average: Compact fine sand, medium clay, compact well-drained sandy loam, loose coarse sand and gravel. Average soils drain sufficiently well that water does not stand on the surface.	0,3
230	Poor: Soft clay, clay loam, poorly compacted sand, clays containing a large amount of silt and vegetable matter, and well compacted made ground. Poor soils are normally wet and have poor drainage.	0,5

NOTE 1 Rooted foundations designed using poor ground but installed in uncompacted made ground can fail by rotation under wind loads. It is essential to ensure made ground surrounding the column installation is well compacted.

NOTE 2 The proposed method of calculating rooted foundations for lighting columns is from overhead power line poles (Morecombe, 1929) [1] and can be applied for use on a mast type structure with rooted foundation.

9.2.4 Back-filling

The calculation in 9.2.3.2 is based on the hole into which the lighting column is planted being back-filled with the excavated material or material of better quality.

The following should be specified to the installer:

- all back-filling material is to be placed in 150 mm thick layers and be well compacted;
- during compaction, care should be taken so that the corrosion protection system of the lighting column is not damaged by the impact of plant or tools employed for compaction;

- c) where the hole is back-filled with concrete to increase the effective diameter of the column root, the concrete should extend from the base of the lighting column root, up to ground level. The top of the concrete should be floated with a drainage fall, leading water away from the face of the lighting column;
- d) where paving or bituminous surfacing is to be applied around the lighting column, the top level of the concrete can be lowered by the thickness of this surfacing; and
- e) a duct with the same dimensions as the lighting column's cable entry slot should be formed in the concrete using a suitable preformed lining tube.

9.2.5 Cable entry slot

Typically, lighting columns manufactured from steel or aluminium are supplied with a single standard 150 mm × 75 mm cable entry slot. The cable slot, occurring below ground level, is not usually considered as a critical section for the design when a larger unreinforced door opening is provided at a similar distance above ground level. Where this is not the case, or where multiple cable slots are provided, the top of the cable entry slot should be deemed a critical section, as defined in [BS EN 40-3-1:2013](#), 5.1 and should be checked for ultimate limit state conditions.

9.2.6 Design bending moment at cable entry slot, $M_{P,CS}$

In the absence of a more detailed analysis, the applied moment at the position of the top of the cable slot, $M_{P,CS}$ (Nm) can be calculated assuming a linear reduction in applied bending moment from the moment at the base of the lighting column, typically ground level, to zero at the bottom of the root section:

$$M_{P,CS} = M_{P,B} \cdot \left(1 - \frac{d_{ts}}{P} \right) \quad (8)$$

where:

- $M_{P,B}$ is the factored bending moment at the base of the lighting column at ULS in Nm;
- d_{ts} is the depth from ground level to top of cable entry slot in m; and
- P is the planting depth in m.

For example, consider a typical 6 m column with a 1 m long root section and a standard 150 mm long by 75 mm wide cable slot positioned 500 mm below ground level to its lower edge. The top of the cable slot is positioned at $(500-150) = 350$ mm or 0.35 m below ground level. For an applied moment at ground level, $M_{P,G}$ of 3 300 Nm, the applied moment at the cable slot, $M_{P,CS}$ can be taken to be:

$$M_{P,CS} = 3\,300 \left(1 - \frac{0.35}{1.00} \right) = 2\,145 \text{ Nm} \quad (9)$$

9.2.7 Bending moment of resistance at cable entry slot

The moment of resistance for a single cable entry slot should be determined by using the methods in [BS EN 40-3-3:2013](#), 5.6 for openings in regular cross-sections.

For multiple cable slots a more detailed analysis should be undertaken, e.g. by using finite element modelling, see [BS EN 1993-1-5:2006+A2:2019](#), Annex C for further guidance.

9.3 Retention socket foundations for rooted lighting columns

Increasingly, retention socket foundations are being used for installing lighting columns. These can be convenient where passive safety lighting columns are installed, allowing quick removal and reinstallation in the event of a vehicle impact. They can allow a relatively low depth foundation to

be provided where utility services or other obstructions in the ground prevent a rooted or standard concrete pad foundation being installed.

The retention socket should be designed and constructed to enable the correct positioning in the concrete section of a steel reinforcement. This is to provide suitable cover for durability and sufficient separation to the compression face so that the full design moment capacity of the concrete section can be achieved. Retention socket foundations should have design calculations completed to confirm that stability and structural strength is acceptable.

9.4 Concrete pad foundations

9.4.1 Stability of concrete pad foundations

9.4.1.1 Columns for quick replacement following vehicle impact

The design principles of foundations should be based on the design methods given in [BS EN 1997-1](#).

The foundation should be designed to resist the foundation design moment, M_{fd} , and foundation design shear force, F_{fd} .

M_{fd} should be the greater of the impact moment, $M_{i,F}$, and the moment obtained from [BS EN 40-3-1](#), $M_{p,FL}$ factored by the appropriate partial factor for an action, γ_F (see [BS EN 1997-1](#)), for the failure mode under consideration.

F_{fd} should be the greater of the impact shear force, $F_{i,F}$, and the horizontal force obtained from [BS EN 40-3-1](#), factored by the appropriate partial factor for an action γ_F (see [BS EN 1997](#) for the failure mode under consideration).

The partial factor for an action should be taken as:

- a) $\gamma_{f,dst} \geq 1,5$ for destabilizing actions (such as overturning moment); and
- b) $\gamma_{f,stb} \geq 0,9$ for stabilizing actions (such as gravity).

The impact moment and impact shear force, $M_{i,F}$ and $F_{i,F}$, respectively should be designed as follows:

$$M_{i,F} = K_{si} M_{R,B} \quad (10)$$

where:

$M_{i,F}$ is the impact moment (in Nm);

$M_{R,B}$ is the ultimate moment of resistance of the closed section of the column at the flange plate level (in Nm); and

K_{si} is the soil impact factor, as given in [Table 2](#).

$$F_{i,F} = K_{si} F_{R,B} \quad (11)$$

where:

$F_{i,F}$ is the impact shear (in N);

$F_{R,B}$ is the equivalent ultimate shear force in the column base at the flange plate level (in N); and

K_{si} is the soil impact factor, as given in [Table 2](#).

The ultimate moment of resistance of the closed section of the column at the flange plate level, $M_{R,B}$, should be calculated in accordance with M_{up} , as defined in Equation (2) of [BS EN 40-3-3:2013](#), [5.6.2.1](#).

An upper bound value for the equivalent ultimate shear force, $F_{R,B}$ can be taken as:

$$F_{R,B} = \frac{M_{R,B}}{0,5} \quad (12)$$

NOTE This assumes that the point of impact is 0,5 m above the top of the foundation.

9.4.1.2 Columns with standard flange plates

Pad foundations should be designed with an appropriate method for the applied loads and ground conditions. Eurocode 7 (see [BS EN 1997-1:2004+A1:2013](#)) provides detailed methods for assessing stability of foundations.

Eurocode 2 (see [BS EN 1992-1-1:2004+A1:2014](#)) provides guidance on the design of unreinforced and reinforced concrete foundations. Where the applied loads are such that the concrete is subject to tensile stresses, the pad foundation should include tension reinforcement.

9.4.1.3 *Andrée and Norsa method*

As an alternative to [9.4.1.2](#), the *Andrée and Norsa* equation provides an acceptable solution for calculating the stability of unreinforced concrete foundations for lighting columns and similar structures.

NOTE The *Andrée and Norsa method* is not suitable for columns designed for quick replacement following vehicle impact.

To check the stability of the foundation, the bending moment, shear force and vertical load should be calculated for the lighting column in accordance with [BS EN 40-3-1](#). The *Andrée and Norsa* equation can then be used to calculate the moment of resistance of the foundation block against overturning. This method assumes an elastic behaviour of the ground and a rotation of the foundation block around its lower edge. It accounts for the vertical pressure on the ground as well as the lateral pressure on the side of the foundation block.

This method is suitable for lighting column foundations of depth similar to root lengths within the scope of [BS EN 40-3-3](#). It should not be used for foundation depths to a width ratio of less than 1.

The holding down bolt (anchorage length or anchor plate) should be located in the bottom face of the concrete block, subject to suitable cover. Tensile stress in the concrete block should be avoided by provision of tension reinforcement, where necessary.

Using this method, the foundation moment of resistance, $M_{R,F}$ (in Nm) is given by:

$$M_{R,F} = \left(\frac{NC}{2} - \frac{2N^2}{3CQ} \right) + \left(\frac{80}{6\,561} \right) \left(\frac{C^2 Q^2 H^3}{N} \right) \quad (13)$$

where:

- N is the weight of the lighting column plus foundation block in N;
- C is the width of the square foundation (minimum value) in m;
- H is the height of the foundation in m; and
- Q is the allowable bearing pressure of the excavation (N/m²).

[Figure 1](#) illustrates the dimensions in relation to two typical concrete foundation types.

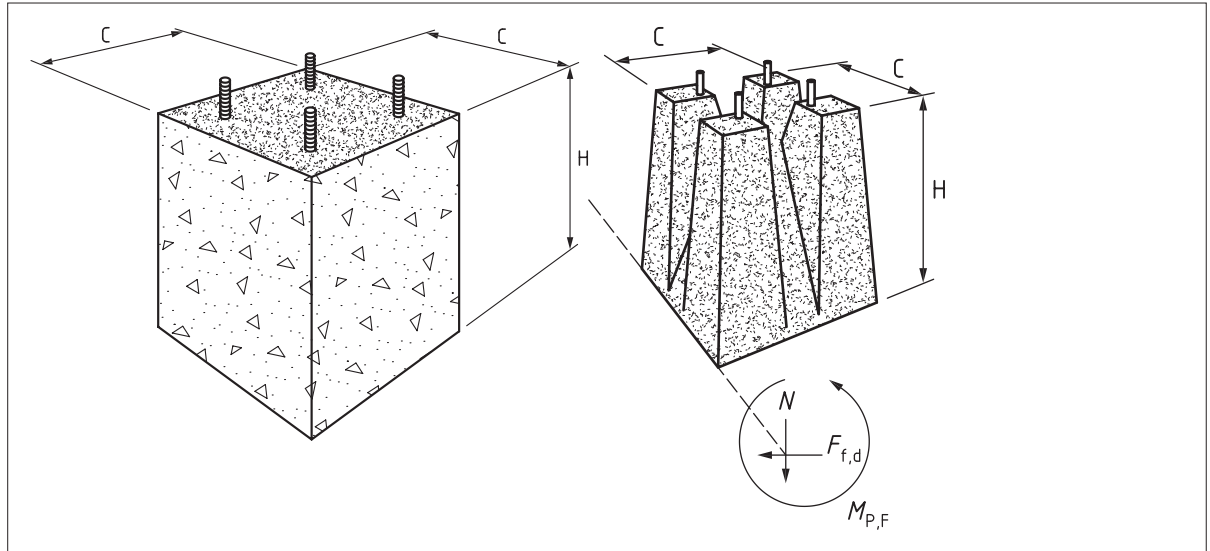
The factored design moment at the base of the foundation, $M_{P,F}$ (Nm) is given by:

$$M_{P,F} = M_{fd} + HF_{fd} \quad (14)$$

where:

- M_{fd} is the resultant bending moment at the base of the lighting column (Nm); and
 F_{fd} is the resultant shear force at the base of the lighting column (N).

Figure 1 — Definitions of the parameters in the Andrée and Norsa equation



The stability of the foundation is acceptable provided that:

$$\frac{M_{P,F}}{M_{R,F}} \leq 1 \quad (15)$$

9.4.2 Holding down systems

9.4.2.1 General

There are several widely used and acceptable systems for holding down lighting columns to a foundation pad. These include using J-bolts, straight holding down bolts with individual anchor plates, anchor stud cages with an anchor plate, cast-in anchor sockets with replaceable threaded studs and chemically anchored holding down studs.

9.4.2.2 J-bolts

J-bolts provide an economic and simple solution for lighting columns. J-bolts reduce the depth of the foundation pad by shortening the anchorage length relative to a straight stud without an anchor plate. J-bolts are typically manufactured from grade B500B deformed steel reinforcement which is turned and threaded to take metric nuts.

J-bolts should be installed vertically and in the correct plan position to suit the flange plate holes. A setting out template is often provided to assist with this. This setting out template should be removed before installing the lighting column. J-bolts are typically hot dipped galvanized. If supplied unfinished in black steel, corrosion protection should be provided using a high-quality petrolatum tape applied to the exposed length of the studs above and below the flange plate. Alternatively, the gap under the flange plate can be grouted with a non-shrink cementitious grout, see [9.4.3.1](#).

9.4.2.3 Straight holding down studs

Straight holding down studs with individual anchor plate washers are supplied by some manufacturers. Provided the anchor plate washer and the steel reinforcement spacings are co-ordinated, individual studs can be easy to install in the foundation. However, with the lower end of the studs not being held in place, this arrangement is more susceptible to being dislodged during

concrete pouring and the finished studs can move from the intended parallel and vertical alignment. As such, misalignment of the studs can make installing the flanged column more difficult or even impossible.

Straight holding down studs are typically made from cut lengths of fully threaded stud which can be unfinished, sherardized or galvanized for corrosion protection. Petrolatum tape and/or grouting the flange plate can extend the working life of the holding down studs.

9.4.2.4 Holding down studs with anchor plate and template

Holding down studs with an anchor plate and template are typically used for larger lighting column structures, including high masts. The provision of both a single shared anchor plate at the bottom of the studs and a template at the top of the studs ensures that the studs are securely held in place during concrete pouring and will typically reduce the problems with non-vertical or mis-aligned studs.

Anchor plates are usually unfinished mild steel. The anchor plate is cast into the concrete foundation, providing sufficient corrosion protection.

As the anchor plate needs to be located inside the steel reinforcement cage, the planning of the works should install the anchor stud assembly as the reinforcement cage is fixed. Placing the anchor stud cage after forming the reinforcement cage is usually difficult. Alternatively, the reinforcement cage design could include an opening for the anchor stud cage to be installed after fixing, with straight lap bars provided loose to allow the reinforcement cage to be closed on site.

Templates for four studs can be produced in timber sheet, however installations with more than four studs typically use templates manufactured from steel. The template needs to be removed as it does not form part of the permanent installation. However, it can be reused for multiple foundation installations while it is in good condition.

Holding down studs are typically manufactured from grade 8.8 fully-threaded studs conforming to [BS EN ISO 898-1](#). Care should be taken if higher grade steels are used as these can be susceptible to fatigue cracking under cyclic loading.

Carbon steel holding down bolts are usually finished either sherardized or galvanized to improve their durability. In very corrosive environments, Grade A2 or A4 stainless steel studs can be specified as necessary to increase the life of the foundation assembly.

9.4.2.5 Cast-in anchor sockets and holding down bolts

Cast-in anchor sockets are commonly used on national highways projects. These sockets have the advantage that in the event of a vehicle impact with the lighting column, damaged holding down bolts can be removed and quickly replaced in the undamaged socket. This ensures that a damaged lighting column can be removed and replaced quickly, safely minimizing the time a road would need to be closed for the work to be carried out. Stainless steel cast-in sockets can also be an advantage over carbon steel J-bolts or holding down bolts where corrosion conditions are severe as these allow the anchor stud to be removed and replaced, potentially extending the working life of the concrete foundation pad.

9.4.3 Grouted and ungrouted flange plate arrangements

9.4.3.1 General

Grouting of flange plates can be carried out using a non-shrink cementitious grout. The aim is to provide a firm surface on which the flange plate can sit, to reduce flange bending and to transfer compression loads into the foundation pad.

To provide drainage and prevent condensation water being sealed inside the lighting column, four 50 mm diameter ducts or pipes, feeding from the centre of the column to the outer edge of the flange, should be detailed to be installed before grouting. Periodic clearing of these drainage pipes should be included in the maintenance operations.

9.4.3.2 Grouted flange plates

There are some advantages to grouting flange plates. Done well, it can provide a barrier to water and de-icing salts reaching the holding down studs and therefore can extend the life of the foundation.

Also, provided the flange is shimmed or packed before grouting and levelling nuts under the flange are wound off the face of the flange, the holding down studs can be designed with purely tensile loads in the holding down studs reducing or removing the risk of fatigue.

Disadvantages of grouting flange plates relate to the relative flexibility of the flange, holding down studs and grout. The wind loading can lead to movement of the steel parts resulting in cracking of the grout, both around the stud and from the stud out to the edge of the flange. Where these cracks are not self-healing, air and water (including de-icing salts where present) enter the cracks through capillary action and pass to the interface between the grout and steel studs, allowing corrosion of the studs.

Where flanges are grouted, regular periodic inspection is required and signs of corrosion product or cracks in the grout require the grout to be broken out and replaced. However, once corrosion has initiated, it is likely this will continue as each new grout installation cracks and leaks. Given this, holding down studs need to be visually inspected periodically, which is made more difficult by the presence of the grout, which should be broken out and replaced after inspection is completed.

9.4.3.3 UngROUTED flange plates

Designing the flange plate connection without grout can reduced the complexity of maintenance operations, where regular inspection and maintenance of the grout cannot be assured. In this case, the flange plate design should reflect the use of levelling nuts and washers under the flange. This arrangement changes the load paths, leading to tension and compression applied to the holding down studs, creating the potential for fatigue. Stud fatigue should therefore be checked as part of the design calculations.

As the height of the flange above the top of the concrete increases, the horizontal wind loads increasingly create bending stresses in the unsupported length of the holding down studs. All additional stresses should be assessed and included in the design of the stud.

The top of the concrete foundation should be provided with a drainage fall to prevent standing water around the holding down studs.

9.5 Screw pile foundations

Screwed pile foundations for lighting columns take one of several forms.

Multiple small screw piles can be installed around the position of the lighting column and connected together with either a steel-framed, or reinforced concrete, pile cap. The lighting column is mounted in position on the pile cap and bolted in place as for normal flanged column installation.

An alternative arrangement is to use a single larger screw monopile. Depending on the length of the screw pile and the ground conditions, the screw pile can act either as a short rigid pile or a long pile. Different design methods are needed for each case.

The method in [9.2.3](#) is not suitable for long screw pile design. It can be used for short rigid pile design where it can be demonstrated that the screw pile behaves like a rooted column.