

Lighting columns —

Part 7: Method for verification of structural design by calculation

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Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Road Engineering Standards Committee (RDB/-) to Technical Committee RDB/28 upon which the following bodies were represented:

- Aluminium Federation
- British Precast Concrete Federation Ltd.
- British Steel Industry
- Cement and Concrete Association
- County Surveyor’s Society
- Department of Transport
- Design Council
- Electricity Supply Industry in England and Wales
- Institution of Highways and Transportation
- Institution of Mechanical Engineers
- Institution of Municipal Engineers
- Institution of Public Lighting Engineers
- Lighting Column Manufacturers’ Association
- Lighting Industry Federation Ltd.

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Foreword

This Part of BS 5649 has been prepared under the direction of the Road Engineering Standards Committee. BS 5649 has been produced in Parts as the Parts of EN 40 have been produced by the European Committee for Standardization Technical Committee CEN/TC 50, Lighting columns and spigots.

BS 5649 consists of the following Parts:

- *Part 1: Definitions and terms;*
- *Part 2: Dimensions and tolerances;*
- *Part 3: Specification for materials and welding requirements;*
- *Part 4: Recommendations for surface protection of metal lighting columns;*
- *Part 5: Specification for base compartments and cableways;*
- *Part 6: Specification for design loads;*
- *Part 7: Method for verification of structural design by calculation;*
- *Part 8: Method for verification of structural design by testing;*
- *Part 9: Specification for special requirements for reinforced and prestressed concrete columns.*

CEN/TC 50, however, were unable to agree on a final version of Part 7 “Method for verification of structural design by calculation” and instead had to produce a Unification Report¹⁾, which give details of the sections of the draft Part 7 where agreement had been reached and highlighted the areas of difference. The British Standards Committee has therefore independently produced this Part of BS 5649. In doing so, the areas that obtained European agreement have been fully incorporated. The remainder of the document contains the information that the UK delegation of CEN/TC 50 supported, augmented with a limited amount of additional design criteria for door openings that has recently become available from research projects.

The method of calculation described in this standard is based on the principles contained in ISO 2394-1973 published by the International Organization for Standardization (ISO). ISO 2394 introduced the concept of limit state design where factored loading effects are compared with the relevant resistance of the structure.

BS 5649 has been issued in Parts as they were completed and approved, and until the nine Parts were published it was not possible to supersede the present British Standards for lighting columns. As the Parts were issued, recommendations were given for their implementation together with a list of clauses in the existing standards which they would eventually supersede. With the publication of this Part, the new standard is complete, and all Parts of the existing standards can be superseded after a suitable transition period.

¹⁾ Subsequently published as CEN Report CR 40-7 (May 1984) “Lighting columns, — verification of structural design by calculation”.

The British Standards affected by BS 5649 are BS 1308, BS 1840 and BS 3989, specifications for concrete, steel and aluminium street lighting columns, respectively. It is anticipated that BS 1840 and BS 3989 will be withdrawn one year from the publication of this Part of this standard and that BS 1308 will be withdrawn three years from the publication of this Part of this standard.

In the interim period it is permissible for lighting columns to be specified to comply with either BS 1308, BS 1840, BS 3989 or BS 5649. Purchasers specifying lighting schemes during the interim period should, where possible, permit either alternative.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 16, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This Part of BS 5649 describes the criteria to be used when verifying the structural design of a lighting column by calculation. It applies to steel and aluminium columns complying with BS 5649-3 and to concrete columns complying with BS 5649-9.

It applies to post top columns ≤ 20 m nominal height and to columns with brackets ≤ 18 m nominal height.

The calculations are applicable to circular cross sections and regular polygonal cross sections of not less than eight sides.

NOTE 1 Any changes to the calculations required because of the use of other cross sections are outside the scope of this standard and should be agreed between the purchaser and the supplier.

NOTE 2 Care should be taken when applying the formulae detailed in this standard as they include a factor, where appropriate, to produce an answer in the units specified. To assist reference, the major equations are numbered (1) to (14).

The structural design of a lighting column can be verified by calculation in accordance with this Part of BS 5649 or, if the manufacturer considers it necessary it can be verified by testing (see BS 5649-8).

NOTE 3 The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this Part of BS 5649, the definitions given in BS 5649-1 apply.

3 Symbols

The following symbols are used in this Part of BS 5649. The definitions are abbreviated, the full definitions being given in the text.

a	Overall length of door opening.	E	Modulus of elasticity.
a_s	Area of legs of closed hoops at a section.	F	Factor.
A_e	Effective cross-sectional area of door reinforcement.	g	Factor.
A_s	Cross-sectional area of door reinforcement.	G	Modulus of rigidity.
b	Mean dimension of flat side of a polygonal section.	h	Nominal height of lighting column.
b_o	Mean dimension of flat side at edge of door opening.	L	Effective length of door opening.
B_x	Factor.	m_{ox}	Distance from centroid of door reinforcement measured normal to the x-x axis.
B_y	Factor.	m_{oy}	Distance from centroid of door reinforcement measured normal to the y-y axis.
C	Length of halves of straight edge of door opening.	m_x	Distance from centre of column wall at the door opening measured normal to the x-x axis.
d	Diameter of cross section.	m_y	Distance from centre of column wall at the door opening measured normal to the y-y axis.
d_1	Mean diameter of hoop reinforcement.	M_p	Combined bending moment for closed regular cross section.
d_o	Diameter of central bore.	M_{up}	Bending strength for closed regular cross section.
d_w	Width of door reinforcement.	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	Wall thickness.
		t_o	Lesser of t and t_w .
		t_w	Thickness of reinforcement.
		T_p	Torsional moment.
		T_u	Torsional 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.
ρ	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 to ϕ_7	Factors as defined in text.

4 Basis of calculations

The approach to calculations used in this standard is based on limit state principles, where factored load effects are compared with the relevant resistance of the structure; two limit states shall be considered.

- The ultimate limit state, which corresponds to the load-carrying capacity of the column.
- The serviceability limit state, which relates to the deflection of the column in service.

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

- the number of separate partial safety factors have been reduced to a minimum;
- serviceability partial safety factors have been eliminated as these all have a value equal to unity.

5 Strength requirements (ultimate limit state)

5.1 Application of calculations

The adequacy of the strength of the column shall be calculated for the following critical cross sections.

- The point at which the column is fixed. (Normally at ground level.)
- The lower edge of the door opening(s). If two or more door openings are provided, the strength of each opening shall be verified.
- The point at which the bracket begins if the column and bracket consist of one piece, or the point at which the bracket is attached if the bracket is detachable.
- Transition from one diameter to another when the column is stepped.
- Any other critical position, e.g. change of material thickness.

5.2 Characteristic loads

The characteristic loads for strength requirements shall be the loads calculated in accordance with BS 5649-6.

5.3 Characteristic strength of materials

5.3.1 General. The characteristic strength with a statistical probability of 95 % shall be used in the calculation. Where statistical data is not available, the minimum values given in the relevant national or international standard shall be taken as the characteristic strength.

5.3.2 Metal lighting columns. The characteristic strength σ_s (in N/mm²) of steel and aluminium alloys shall be either:

- the lower yield stress; or
- the 0.2 % proof stress.

The values used shall make allowance for any reduction in material strength that may result from the jointing process used in the structure.

5.3.3 Concrete lighting columns

5.3.3.1 Concrete. The characteristic strength σ_s (in N/mm²) of concrete shall be taken as 0.85 of the compressive strength as specified in 3.1 or 4.1 of BS 5649-9:1982, as appropriate.

NOTE In BS 5649-9, the compressive strength relates to values obtained from test cylinders.

5.3.3.2 Reinforcing and prestressing steels. The characteristic strength σ_s (in N/mm²) of reinforcing and prestressing steel shall be taken as:

- the elastic limit or 0.2 % proof stress in the case of reinforcing steel;
- the ultimate tensile strength in the case of prestressing steel.

5.4 Loads to be used for calculations

The characteristic loads specified in 5.2 shall be multiplied by the appropriate partial load factors, γ_f , given in Table 1 to give the loads to be used for calculating bending and torsion moments.

Table 1 — Partial load factors, γ_f

Load	Partial load factor, γ_f
Dead loads	1.1
Wind loads	1.1