Highway Structures & Bridges
Design

CD 354
Design of minor structures

(formerly BD 94/17)

Version 2.0.0

Summary
This document covers the design of minor highway structures including lighting columns, cantilever masts for traffic signals and/or speed cameras, CCTV masts, and fixed vertical road traffic signs. It incorporates the provisions of BS EN 40, BS EN 12899 and supersedes BD 94/17.

Feedback and Enquiries
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This is a controlled document.

Latest release notes

Document code	Version number	Date of publication of relevant change	Changes made to	Type of change
CD 354	2.0.0	July 2024	Core document	Change to policy, major revision, new document development

Release notes: The update is required to transfer some of the design information to PD 6547, following a redraft of that document. Changes relate to the following:
Any reference to Environmental barrier has been amended to Noise barrier to align with LD 119
Section 5 – The requirements for the fatigue design of minor structures has been moved to PD 6547
Section 9 – Brief introduction to smart devices which may be attached to lighting columns and PAS 191 which gives guidance on their design.
Section 10 – Design of flange plates. This section is to be partly deleted with the design of flange plates being in accordance with PD 6547
Section 11 – This section has been deleted and replaced with a statement stating that fatigue checks shall in accordance with section 5 of CD 354
Section 12 – Design of planted sockets has been removed from CD 354 and shall be in accordance with PD 6547 as will the design of reinforced concrete foundations.
Appendix A – Section deleted, with the information now being published in PD 6547: 2023 [Publication in July 2024]

Previous versions

Document code	Version number	Date of publication of relevant change	Changes made to	Type of change
CD 354	1.1.0	February 2022	Core document	Incremental change to requirements
CD 354	1	March 2020		
CD 354	0	December 2019		

Foreword

Publishing information

This document is published by National Highways.

This document supersedes CD 354 version 1.1.0, which is withdrawn.

Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

Introduction

Background

This document describes the requirements for the design of minor structures. It gives guidance on the information required to allow the suitable design of lighting columns, cantilever masts, CCTV masts, road traffic sign/signal posts, noise barriers, high masts, and other mast type structures.

This document covers the use of BS EN 40 (all) [Ref 17.N], PD 6547 [Ref 13.N], ILP PLG07 [Ref 27.N], BS EN 12899-1 [Ref 12.N] and BS EN 14388 [Ref 31.N] as relevant for the design of specific types of minor structures.

CD 354 sets out the Overseeing Organisation's requirements where these augment, or are additional to those given in the British Standards. In addition, the document gives the requirements for lighting columns made from glass fibre reinforced polymers (FRP or FRPC). The technical basis for the clauses on FRPC is limited and it may become necessary to review the requirements in due course, on the basis of their performance in service.

Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 16.N] apply to this document.

Mutual Recognition

Where there is a requirement in this document for compliance with any part of a "British Standard" or other technical specification, that requirement may be met by compliance with the Mutual Recognition clause in GG 101 [Ref 16.N].

Abbreviations and symbols

Abbreviations

Abbreviation	Definition
FRP	Fibre-reinforced polymer
FRPC	Fibre-reinforced polymer composite

Symbols

Symbol	Definition
β	Factor for the dynamic behaviour
c_{prob}	Probability factor
γ_F	Partial safety factor for loads
$\gamma_{G;dst}$	Partial safety factor destabilising action
$\gamma_{G;stb}$	Partial safety factor stabilising action
$\gamma_{s;d}$	Partial safety factor applied to destabilising moments for planted foundations
F_{fd}	Foundation design shear force
F_i	Impact shear force
F_R	Ultimate shear force
k_{si}	Soil impact factor
M_{DS}	Destabilising moment applied to planted foundations
M_{fd}	Foundation design moment
M_g	Ground resistance moment for planted foundations
M_i	Impact moment
M_R	Ultimate moment of resistance
M_{up}	Bending moment of resistance for closed rectangular cross sections
p	Design annual probability of exceedence

1. Scope

Aspects covered

1.1 This document shall be used for the structural design of the following minor structures:

1) lighting columns and wall-mounted brackets made from concrete, steel, aluminium, and FRPC, including lighting columns mounted on other structures such as on bridges;
2) steel CCTV masts mounted on foundations in the ground;
3) cantilever masts made from steel for traffic signals and/or speed cameras;
4) fixed vertical road traffic sign/signal posts;
5) noise and other 'fence type' barriers;
6) steel high masts; and,
7) other mast type structures.

NOTE 1 *Requirements for the assessment or design of other structures and structural elements onto which a minor structure is mounted are outside the scope of this document.*

NOTE 2 *The collective term 'minor structures' is used to describe those structures within this clause.*

NOTE 3 *The scope of this document is limited to minor structures within the identified dimensions and parameters listed in the following clauses.*

1.2 Where different structural materials such as aluminium, concrete, steel or FRPC are proposed for other minor structures, the design methods and criteria, performance limits and specification shall be:

1) in accordance with the standards relevant for the proposed materials; and
2) agreed with the Overseeing Organisation.

NOTE 1 *The design requirements for lighting columns are covered in the relevant parts of BS EN 40 (all) [Ref 17.N].*

NOTE 2 *The design requirements for aluminium, concrete and steel are given in the relevant parts of BS EN 1999 [Ref 11.N], BS EN 1992 [Ref 4.N] and BS EN 1993 [Ref 1.I].*

NOTE 3 *PD 6547 [Ref 13.N] contains design information for lighting columns, steel welded connections, fatigue and specific design information for foundations that is equally relevant to other minor structures.*

1.3 This document shall not be used for the design of temporary or permanent cantilever sign/signal gantries.

NOTE *The design requirements for portal and cantilever sign/signal gantries are given in CD 365 [Ref 5.I].*

1.4 This document shall not be used for the design of lattice structures.

NOTE *Structural requirements for lattice structures are covered by BS EN 1993-3-1 [Ref 6.N].*

1.5 Structural requirements for passively safe minor structures shall be in accordance with this document but the passive safety characteristics of such structures are dealt with in BS EN 12767 [Ref 4.I].

Implementation

1.6 This document shall be implemented forthwith on all schemes involving the design and construction of minor highway structures on the Overseeing Organisations' motorway and all-purpose trunk roads according to the implementation requirements of GG 101 [Ref 16.N].

Use of GG 101

1.7 The requirements contained in GG 101 [Ref 16.N] shall be followed in respect of activities covered by this document.

2. General principles

2.1 The siting of minor structures shall be in accordance with CD 109 [Ref 14.N], CD 146 [Ref 26.N], CD 377 [Ref 28.N], and TD 501 [Ref 29.N], as shown in Table 2.1 below.

Table 2.1 DMRB documents relevant for the siting of minor structures

Type of minor structure	DMRB documents relevant to the structure under consideration			
	CD 109	CD 146	CD 377	TD 501
Lighting columns	✓	✓	✓	✓
Cantilever masts	✓	✓	✓	
CCTV masts	✓		✓	
Road traffic signs	✓	✓	✓	
Noise barriers and screens	✓	[1]	✓	[1]
Other mast type structures	✓	✓[2]	✓	✓
Note 1: [1] applicable depending on location and impact Note 2: [2] applicable depending on type of mast				

2.1.1 Cantilever masts should not be located on bridges.

Layout of minor structures

2.2 All elements of minor structures shall have clearances in accordance with CD 127 [Ref 2.N] after allowing for deflections due to dead loads (permanent action), and live, wind and high vehicle buffeting loads (variable action).

2.3 The clear new construction headroom for routes other than high load routes shall be as defined in CD 127 [Ref 2.N].

2.4 Where cantilever masts are sited on high load routes, the clear new construction headroom as defined in CD 127 [Ref 2.N] for all permanent structures over high load routes shall be taken as the minimum allowable clear headroom.

2.5 The clear new construction headroom shall not be infringed by calculated settlement and deformation of the structure.

Protection for road users and structure

2.6 Protection for minor structures shall be in accordance with CD 377 [Ref 28.N].

2.7 The available working width from the front of the vehicle restraint system to the face of the minor structure shall be in accordance with CD 377 [Ref 28.N].

2.8 Where the post of the cantilever mast or CCTV mast is located behind a vehicle restraint system meeting the requirements of BS EN 1317-2 [Ref 30.N] and CD 377 [Ref 28.N], further vehicle restraint systems shall not be required.

Equipment

2.9 All ancillary equipment such as luminaires, lanterns, brackets, signs, traffic signals, speed cameras and associated equipment shall be securely attached to the structure.

2.10 Vibration-resistant fixings shall be designed and used to withstand the design loads.

2.11 The structural design shall make provision for the attachment of equipment.

2.12 The structural design shall include built in redundancy so that failure of a single component, such as a fixing, does not lead to collapse of the structure.

2.13 Any post-design modifications to structural members shall only be carried out with the approval of the Technical Approval Authority in accordance with CG 300 [Ref 33.N].

In-situ connections

2.14 In-situ connections of main structural metal elements shall be by means of bolts.

2.15 Where other forms of in-situ connection are proposed, their static and fatigue design strength shall be calculated from first principles and agreed with the Technical Approval Authority.

2.15.1 Alternatively, the design strength may be based on the results of full-scale load tests, subject to the agreement of the Technical Approval Authority.

Identification of minor structures

2.16 Identification marking of structures shall be:

1) in accordance with CG 305 [Ref 15.N]; or,
2) agreed with the Overseeing Organisation.

2.17 Minor structures that have been designed to be passively safe to BS EN 12767 [Ref 4.I] shall be marked to differentiate them from other types of structures.

2.17.1 Where the form of structure is unique and easily recognisable, specific marking may not be necessary.

NOTE *Marking allows the structure to be easily recognised during a road safety audit.*

2.18 The marking system shall incorporate the phrase "Crash Friendly" and be placed on the post or column in a position that does not affect the functionality of any part of the assembly or the identification marks required by CG 305 [Ref 15.N] or the Overseeing Organisation.

2.19 The form of marking appropriate for individual products shall be agreed with the Overseeing Organisation.

Use of dissimilar metals to minor structures

2.20 Where dissimilar metals are to be used, the connections shall be designed to avoid the risk of galvanic corrosion.

2.21 The electrical bonding of all metal components shall be maintained.

Protection against corrosion

2.22 Surface preparation and paint protection of steel shall be in accordance with MCHW Series 1900 [Ref 25.N].

NOTE *Preparation and protection is applicable to all parts of the structure including fasteners (bolts, nuts, washers, packing plates), stiffeners, brackets, etc.*

2.23 Materials, other than steel, shall have a life expectancy greater than the service life, (such as from galvanic corrosion of aluminium due to local ground conditions and ultraviolet degradation of FRPC columns).

3. Dimensional limitations

Lighting columns

3.1 Dimensional requirements for lighting columns are given in BS EN 40-2 [Ref 21.N] within which the overall dimensional limitations for lighting columns covered by this document (for steel, aluminium, FRPC and concrete columns) shall be:

1) post top columns <20 metres nominal height;
2) columns with brackets <18 metres nominal height; and,
3) bracket projections not exceeding the lesser of 0.25 x nominal height or 3 metres.

NOTE *Nominal heights and bracket projections are defined in BS EN 40-2 [Ref 21.N].*

CCTV masts

3.2 The nominal height of steel CCTV masts covered by this document shall be less than or equal to 25 metres.

Figure 3.2a General arrangement of mast and CCTV

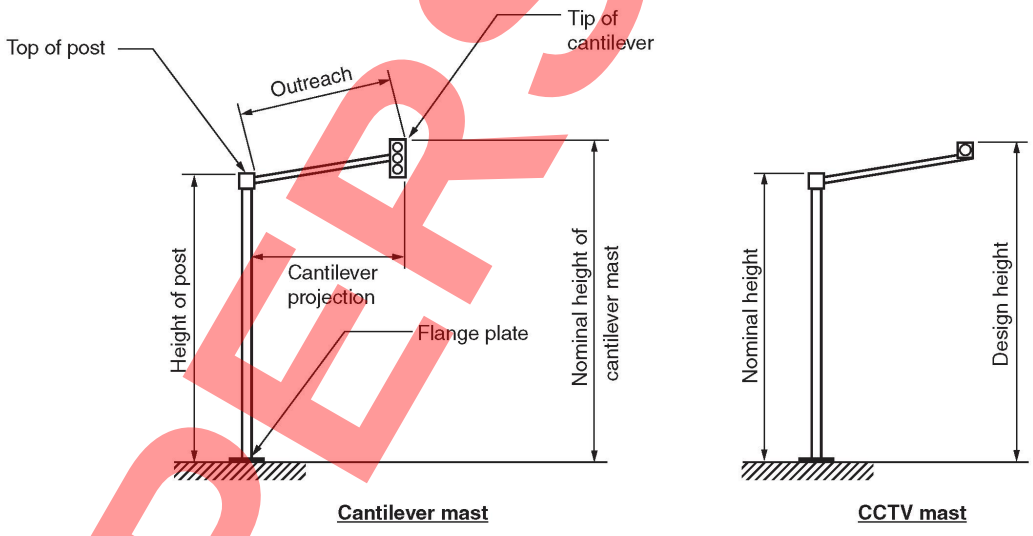
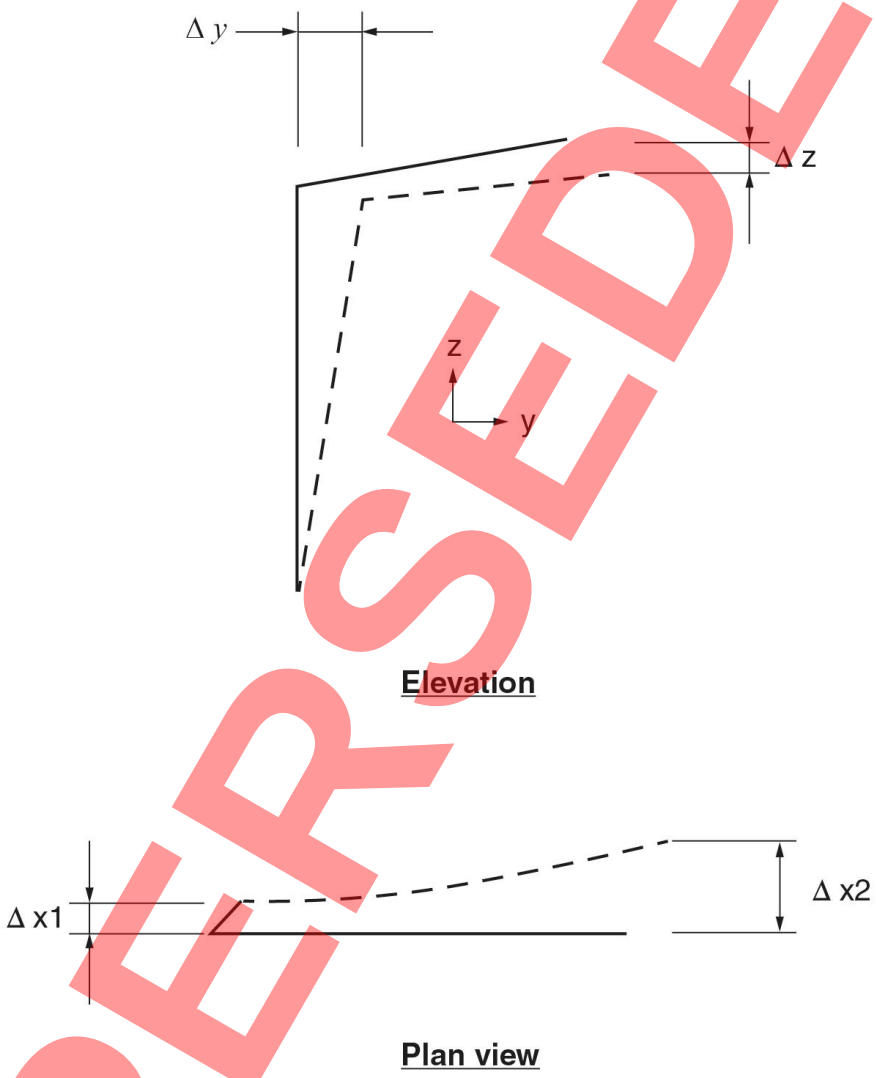


Figure 3.2b Structural deformation of cantilever mast



NOTE 1 *For CCTV masts the nominal height excludes the height of camera, mounting, etc. (refer to Figure 3.2a).*

NOTE 2 *Values for the deformation limits shown in Figure 3.2b are given in Section 5.*

3.3 The design height of a CCTV mast shall be taken as the vertical distance between the underside of the flange plate and the top of the CCTV mast or camera in its operating position, or other attachments, whichever is greater.

NOTE *The "design height" is different to the "nominal height" and is required for wind loading calculations (refer to Figure 3.2a).*

3.4 For CCTV masts, the definitions given in ILP PLG07 [Ref 27.N]: Section 1.4, shall be interpreted as follows:

1) 'High Mast' also refers to CCTV masts, meaning the support intended to hold one or more CCTV camera with their mountings and housings; and,
2) the term 'Luminaire' includes CCTV cameras, their mountings and housings.

3.4.1 CCTV masts less than 10 m in height may be designed using ILP PLG07 [Ref 27.N].

Cantilever masts

3.5 The following shall apply for steel cantilever masts, as shown in Figure 3.2a:

1) nominal height ≤8.5 metres; and,
2) cantilever projection ≤8.5 metres.

NOTE *The nominal height is taken as the vertical distance between the underside of the flange plate and the highest point on the mast (refer to Figure 3.2a).*

3.6 The horizontal projected area of any signs, traffic signals, speed cameras and associated equipment, suspended above the carriageway shall not exceed 1.20 m^2.

3.7 The vertical projected area of any signs, traffic signals, speed cameras and associated equipment shall not exceed 0.3 m^2

Traffic sign/signal posts

3.8 The nominal height of steel traffic sign/signal posts shall be ≤9 metres.

3.9 Dynamic and fatigue checks shall be carried out for traffic sign/signal posts above nine metres nominal height.

Noise barriers

3.10 The requirements for noise barriers shall be determined in accordance with LA 111 [Ref 3.I] and LD 119 [Ref 32.N].

Other mast type structures

3.11 The nominal height of other mast type structures shall be agreed with the Overseeing Organisation based on the required end use.

3.11.1 Minor structures such as CCTV masts, cantilever masts or traffic sign/signal posts made from materials such as concrete, aluminium or FRPC may have dimension limits different to similar structures made from steel.

3.11.2 The dimensional limitations given for lighting columns, steel CCTV masts, steel cantilever masts, traffic sign/signal posts or noise barriers may be used as guidance for determining the dimension limits for similar structures that are not made from steel.

4. Use of British Standards and standards issued by the Overseeing Organisations

4.1 Minor structures shall be designed in accordance with the following:

1) lighting columns and cantilever signal masts - the relevant parts of BS EN 40 [All Parts] [Ref 18.N];
2) CCTV masts - ILP PLG07 [Ref 27.N];
3) noise barriers - BS EN 14388 [Ref 31.N]; or,
4) road traffic sign posts - BS EN 12899-1 [Ref 12.N].

NOTE 1 *Guidance and background information in the use of BS EN 40-3-1 [Ref 19.N] and BS EN 40-3-3 [Ref 20.N] for the design of lighting columns is given in PD 6547 [Ref 13.N].*

NOTE 2 *PD 6547 [Ref 13.N]contains design information for steel welded connections, fatigue, and specific design information for foundations that is equally relevant to other minor structures.*

NOTE 3 *This document covers the use of ILP PLG07 [Ref 27.N] for the design of CCTV masts. This guide was originally developed for high mast lighting and has been revised to include CCTV masts as they have similar features.*

NOTE 4 *This document gives minimum requirements for the design of components of fixed vertical road signs that would otherwise fall within the scope of BS EN 12899-1 [Ref 12.N]. The electronic design requirements of certain traffic signs as defined in BS EN 12899-1 [Ref 12.N] are excluded from this document.*

4.2 The installation of minor structures shall be in accordance with the requirements of the design and manufacturers' instructions.

5. Design

General requirements for the design of minor structures

5.1 Minor structures shall be designed in accordance with the requirements of the design guide and standards given in Section 4 as applicable for the type of structure.

5.2 The requirements of CG 300 [Ref 33.N] shall be applicable to the design of minor structures.

NOTE *The design of minor structures could require technical approval, depending upon the structures size and location. Further information on the types of minor structure requiring technical approval and the relevant design category can be found in clause 3.3 of CG 300 [Ref 33.N]*

5.3 Minor structures in very exposed areas shall be classified as Category 1 in accordance with CG 300 [Ref 33.N].

5.4 Very exposed sites shall be defined as follows:

1) sites at high altitude, above 250 metres;
2) sites within 5 km from the coast; or,
3) sites subject to significant local funnelling.

NOTE *Note - PD 6547 [Ref 13.N] recommends increasing terrain category for lighting columns - for all minor structures this is subject to agreement with the Technical Approval Authority but it is expected that the wind loading at very exposed sites will be derived using BS EN 1991-1-4 [Ref 3.N].*

Structural criteria for minor structures

5.5 The design life shall be 25 years, unless otherwise required by the Technical Approval Authority.

5.5.1 For some minor structures, such as noise barriers, the design life required for the superstructure may be different to that of the substructure.

NOTE *The design life of the foundation can be much longer where the superstructure is to be renewed on the existing foundations.*

Limit states

5.6 Minor structures shall be designed to satisfy the relevant ultimate limit states and the serviceability limit state.

5.7 Where steel structures are used they shall be designed to meet the fatigue criteria.

Lighting columns

5.8 For lighting columns, the partial safety factors and criteria for serviceability and ultimate limit states shall be taken as Class B, as given in BS EN 40-3-3 [Ref 20.N].

5.9 Horizontal deflections of each lantern connection shall conform to class 2 in Table 4 of BS EN 40-3-3 [Ref 20.N].

Steel CCTV masts

5.10 For CCTV masts, the partial safety factors and criteria for serviceability and ultimate limit states shall be as given in ILP PLG07 [Ref 27.N], clauses 2.4 and 2.5.

5.11 The torsional rotation and linear deflection limits shall be:

1) in accordance with serviceability limit state given in clause 2.3.2.3 of ILP PLG07 [Ref 27.N]; and,
2) verified for a wind load derived by setting $p = 0.9$ in Equation (4.2) in BS EN 1991-1-4 [Ref 3.N] ($c_{prob} = 0.684$.)

5.12 The torsional rotation at the top of the mast shall not exceed 25 minutes of arc (0.0073 radians).

5.13 The linear deflection at the top of the pole shall not exceed 150 mm.

5.14 For serviceability limit state the calculation shall take full account of the actual weights of the CCTV mast, cameras, mountings, housings and any other attachments.

5.15 Vehicle collision loads shall not be included for the serviceability limit state because of the requirements to protect CCTV masts in accordance with CD 377 [Ref 28.N].

5.16 The proposed limits shall be used unless more stringent rotation and deflection criteria are agreed with the Overseeing Organisation.

5.17 The operational limits of the CCTV cameras shall be checked and confirmed that the performance will not be affected by the proposed limits.

Steel cantilever masts for traffic sign/signals and/or speed cameras.

5.18 Where any permanent load has a relieving effect, γ_F shall be taken as 1.0 in both the ultimate limit state and serviceability limit state.

5.19 The partial factors, γ_F , in Table 5.19 below shall be applied for strength, fatigue and deflection verification.

Table 5.19 Limit states and partial factors

Limit state description	Partial factor on load, γ_F				
	Limit state type	Dead load	Superimposed dead load	Wind load	Buffeting from high vehicles
Strength (STR)	ULS	1.20	1.20	1.20	-
Fatigue	SLS	1.00	1.00	1.00	1.00
Deflection	SLS	1.00	1.00	1.00	0.50*

Note: *The partial load factor, γ_F , given here in Table 5.19 is 0.5. This is because the design pressures for buffeting due to high-sided vehicles given in PD 6547 [Ref 13.N] have been set to calculate the total stress range experience. That is, the response from peak positive pressure to peak negative pressure. All that is required for calculation of headroom is the deflection due to peak negative pressure from the static equilibrium position. This is approximately half the peak-to-peak response, hence the partial load factor, γ_F , of 0.5.

5.20 Cantilever masts for traffic signal/signals and/or speed cameras shall not be designed for vehicle collision loads.

5.21 For the serviceability limit state under combined effects of permanent loads acting with all the primary live loads, the deflections and rotations due to wind loading only, shall be limited such that the deformations do not exceed the values given in Table 5.21.

Table 5.21 Limiting structural deformations of cantilever masts (see Figure 3.2b)

Element and position	Direction of deformation	Limiting
Top of post	Horizontal Δx_1 or Δy	1/100 of height of post
Tip of cantilever	Horizontal Δx_2	1/100 of outreach plus height of post
Tip of cantilever	Vertical Δz	1/100 of outreach plus height of post

5.22 More stringent deflection limits than those in table 5.21 shall be applied in accordance with the performance requirements of the equipment to be mounted.

5.23 Deformation at the extremities of the structural support shall be derived from the sum of the components of the effects of the load in the support posts, cantilever and sign supports (see Figure 3.2a and Figure 3.2b).

Noise barriers and screens

5.24 Partial factors and criteria for serviceability and ultimate limit states shall be in accordance with:

1) BS EN 14388 [Ref 31.N]; and,
2) specific requirements agreed with the Overseeing Organisation.

5.25 Noise barriers and screens shall meet the requirements of LD 119 [Ref 32.N].

Road traffic sign posts

5.26 Partial safety factors and criteria for serviceability and ultimate limit states given in BS EN 12899-1 [Ref 12.N] shall be used for road traffic sign posts.

Minimum thickness of steel sections for cantilever masts

5.27 The minimum thickness of structural steel sections used in cantilever masts shall be as given in Table 5.27.

Table 5.27 Minimum thickness of steel sections for cantilever masts

Structural steel sections used for cantilever masts	Minimum section thickness
Plates and sections other than hollow sections	6 mm
Hollow sections effectively sealed by welding, having other than a small drain hole of diameter 10 mm to 15 mm	5 mm

5.28 Where other structural materials such as aluminium are used, the minimum section thicknesses shall be agreed with the Overseeing Organisation.

Closed hollow sections for cantilever masts

5.29 Steel hollow sections used in cantilever masts shall be designed to resist the ingress and retention of water or moisture by gravity flow, capillary action or condensation.

5.30 The plates used to close the open ends of hollow sections shall be of thickness not less than the lesser of the following:

1) the thickness of the walls of the hollow section; or,
2) 8 mm.

5.31 The end plates shall be joined by continuous structural quality welding to BS EN 1011-1 [Ref 34.N] and BS EN 1011-2 [Ref 35.N].

5.32 Closed hollow sections shall be detailed to prevent water from entering and subsequently freezing anywhere in the closed hollow steel section.

5.32.1 Water may be prevented from collecting and freezing in closed hollow steel sections by providing suitably sized drain holes.

5.32.2 Where specified, drain holes should be no less than 10 mm nor greater than 15 mm in diameter.

Fatigue criteria for steel structures

5.33 Fatigue assessment shall be required for:

1) steel lighting columns 9 m and above in height;
2) all steel cantilever masts; and
3) steel CCTV masts classified as category 1 in accordance with CG 300 [Ref 33.N]that are sited in very exposed locations.

NOTE 1 *Fatigue rules are set out in PD 6547 [Ref 13.N], which gives guidance on the design of steel lighting columns and cantilever masts in very exposed sites.*

NOTE 2 *The stringent deflection requirements for the design of steel CCTV masts mean that stress ranges induced by dynamic response to wind loading are likely to be low. Thus fatigue is unlikely to be a critical design condition provided suitable details are used.*

5.34 In all cases, the procedures to be used for fatigue assessment shall be agreed with the Overseeing Organisation.

5.35 Fatigue susceptible details shall be avoided throughout the structure.

Determination of shape coefficients

5.36 Where wind tunnel tests are necessary for the determination of shape coefficients for columns, brackets and lanterns, the testing shall be carried out in accordance with Appendix A of this document.

Fatigue criteria for materials other than steel structures

5.37 Structures in materials other than steel are not covered by the fatigue rules in this document and in such cases, the design shall be subject to technical approval in accordance to CG 300 [Ref 33.N].

5.38 Fatigue susceptible details shall be avoided throughout the structure.

5.38.1 The criteria given for steel structures may be used as the reference for avoiding fatigue susceptible details in structures made from other materials.

5.38.2 The fatigue requirements given in BS EN 1999-1-3 [Ref 9.N] may be used for aluminium structures.

5.39 The procedures to be used for fatigue assessment for materials other than steel shall be agreed with the Overseeing Organisation.

6. Fibre-reinforced polymer composite (FRPC) lighting columns

Design

6.1 Design loads and moments shall be determined in accordance with BS EN 40-3-1 [Ref 19.N] and BS EN 40-7 [Ref 22.N] as implemented by this document.

6.2 The factor β for the dynamic behaviour of the FRPC column shall be determined by reference to BS EN 40-7 [Ref 22.N] Annex B: Figure B.1.

Verification of structural design

General

6.3 The structural design of FRPC columns shall be verified either by calculations or by testing.

6.4 Test results shall take precedence in all cases.

Calculations

6.5 Design calculations for FRPC columns shall be in accordance with the requirements in BS EN 40-7 [Ref 22.N].

6.6 Flexural strength and the moduli in both longitudinal and transverse directions, together with the shear modulus and the Poisson's ratio, shall be determined by testing.

6.6.1 The mechanical properties of the FRP material to be used in the structural design calculations should be determined from tests using flat sheet samples manufactured in the same manner as that proposed for the production column.

6.7 A statistical assessment shall be made of the results to determine 95% confidence limits of the values to be used.

7. Door openings

7.1 The sizes of door openings shall be as given in Table 7.1.

Table 7.1 Door opening sizes in columns

Nominal column height (h) in metres	Type of door	Door opening for metal columns (height x width) in mm	Door openings for concrete columns (height x width) in mm
5 and 6	single door	500 x 100	680 x 95
8, 10 and 12	single door	600 x 115	680 x 130
8, 10 and 12	extended single door	-	900 x 130
8, 10 and 12	double doors	500 x 120 or 600 x 115 each	-

7.1.1 Alternative door openings selected from the sizes given in BS EN 40-2 [Ref 21.N] may be provided where they are suitable for the size of equipment to be housed and maintained in the column.

7.2 Doors shall be hinged or held captive by a chain or strap where:

1) columns are mounted on structures; or,
2) there is a risk of a detached door falling on the area below.

NOTE *A falling detached door can cause an accident and injure workers or road users.*

7.3 Where a metal chain or strap is used, it shall be capable of supporting the door in severe gales.

7.4 Doors shall include features to reduce vandalism and prevent access by unauthorised persons.

7.5 Where the section containing the door opening is steel or aluminium and circular or polygonal with eight or more sides, design strengths shall be calculated in accordance with BS EN 40-3-3 [Ref 20.N].

7.6 In all other cases, the design strength shall be calculated from first principles or based on the results of full-scale load tests with the procedures to be used agreed with the Overseeing Organisation.

8. Wall-mounted brackets

8.1 Wall-mounted brackets shall be designed to suit the column brackets to be attached to them.

8.2 The mounted bracket shall be fixed to its support by means of flange plate and anchorage, designed in accordance with the provisions in Section 10.

8.3 The design of the bracket shall provide the loads necessary for assessing the adequacy of the wall.

8.4 The wall on which the wall-mounted brackets are fixed shall be capable of carrying the additional loads and other forces transmitted by the bracket.

9. Attachments

General requirements for lighting columns, cantilever masts, high masts and other mast type structures

9.1 Minor structures, other than CCTV masts, fixed traffic sign/signal posts and noise barriers shall be designed for the attachment proposed in clause 9.2.

NOTE *Requirements for attachments to steel CCTV masts are provided separately in this section.*

9.2 The attachment shall be taken as a sign with the following characteristics:

1) rectangular in elevation, with a surface area of 0.3 m^2;
2) eccentricity from the centre line of the column to the centre of area of the sign of 300 mm;
3) the height above ground level at the column to the centre of area of the sign of 2500 mm; and,
4) orientation of the sign selected to produce the most adverse effects for the design condition being proposed.

9.3 Attachments shall not be allowed on cantilever masts.

9.4 The forces due to the dead (permanent action) and wind loads (variable actions) on the sign and bracket projecting from the column shall be determined in accordance with PD 6547 [Ref 13.N].

9.5 The shape coefficient of the sign shall be taken as 1.8 unless derived from BS EN 1991-1-4 [Ref 3.N] for the specific shape and aspect ratio of the sign.

9.6 Where larger signs, waste paper containers, flower baskets, smart devices and similar, are to be attached, the column shall be designed to resist the additional loading.

NOTE *Multi-function columns allow for the attachment of smart devices to columns including CCTV cameras and safety devices; Internet of things (IoT) sensors; electric vehicle (EV) charging points; digital advertising; variable message signs; electronic telecommunications; and local energy generation and storage including small wind turbines, solar panels and batteries. PAS 191 [Ref 2.I] offers guidance on the design of these attachments.*

9.7 Additional loading shall be calculated in accordance with BS EN 1991-1-4 [Ref 3.N] and BS EN 40-3-1 [Ref 19.N].

9.8 Minor structures designed to carry attachments greater than those defined in clause 9.2 shall have identifying manufacturer's features or marks to enable them to be clearly and unambiguously identified throughout their service life.

9.9 The unique identifying mark shall be listed as required by CG 302 [Ref 1.N].

Attachments to CCTV masts

9.10 CCTV masts shall not be designed for attachments other than CCTV cameras and their associated equipment.

9.11 Where attachments are specified, they shall be incorporated into the design of the CCTV masts.

9.12 Where attachments are to be used, the mast shall be designed to resist the additional loading.

9.13 The additional permanent (dead loads) and wind actions as a result of the attachments shall be calculated in accordance with ILP PLG07 [Ref 27.N].

9.14 Where attachments are required, the CCTV pole and the attachments shall be designed such that the operation of the CCTV camera is not impeded.

9.15 Access for installation, inspection or maintenance of an attachment shall not interfere with the operation of the CCTV camera.

9.16 Where attachments are located below the operating position of the camera, they shall be designed as demountable to allow the CCTV mounting to be raised and lowered.

10. Design of flange plates

Design of flange plates to minor structures

10.1 The procedures in this Section shall be applied for the design of the connection between the structure and its support structure.

NOTE *A support structure can include a bridge deck, wall, reinforced concrete foundation block or pile cap.*

Attachment system and anchorage

10.2 A structure with a flange plate shall be fixed to the support structure by an attachment system and anchorage.

NOTE *The attachment system usually takes the form of holding-down bolts that connect with an anchorage.*

10.3 The attachment system and anchorage shall provide structural restraint without causing damage to the support structure.

10.4 Anchorages of expanding type shall not be used unless their long-term in-situ performance under fatigue loading can be demonstrated to the satisfaction of the Technical Approval Authority.

10.5 The attachment system shall allow the structure to be demounted.

10.6 The attachment system shall be such that damaged minor structures are readily removed and replaced.

10.7 The attachment system and anchorages for cantilever masts shall be designed for damaged cantilever masts to be readily removed and replaced where they are located:

1) within 4.5 metres of the 'point from which set-back is measured ', in accordance with CD 377 [Ref 28.N]; or,
2) within the central reserve.

10.8 To make the damaged cantilever mast readily removable and replaceable, an internally threaded component shall be provided in the anchorage to receive the holding down bolts.

Typical arrangement of flange plates

10.9 The procedures given in PD 6547 [Ref 13.N]shall apply to square flange plates:

1) with bolt holes for four symmetrically disposed holding down bolts; and,
2) connected to circular or octagonal columns.

10.10 For flange plates not complying with clause 10.9, other suitable design methods, or full scale load methods shall be adopted, as agreed with the Overseeing Organisation.

Flange plate design for structures not subject to vehicle impact

10.11 Minor structures shall not be designed for vehicle impact where they are protected by a vehicle restraint system designed in accordance with CD 377 [Ref 28.N].

10.12 Where the minor structure is not designed for vehicle impact, the flange plate and connection shall be designed for dead loads and wind loads only.

Flange plate design for structures subject to vehicle impact

10.13 Where structures are subject to vehicle impact the flange plate and its connections shall be designed to resist vehicle impact.

11. Fatigue checks of steel structures

11.1 Fatigue checks shall be undertaken in accordance with the general criteria given in Section 5 of this document.

12. Foundations

12.1 The foundation design shall be subject to:

1) technical approval in accordance with CG 300 [Ref 33.N]; and,
2) geotechnical certification in accordance with CD 622 [Ref 23.N].

12.1.1 The CD 622 [Ref 23.N] geotechnical certification procedures may be varied as agreed with the Overseeing Organisation to reflect the complexity of the proposed foundation design.

12.2 Foundations shall consist of one of the following:

1) planted columns and posts, designed in accordance with PD 6547 [Ref 13.N] and clauses 12.7 to 12.8;
2) planted prefabricated concrete or metal columns designed in accordance with clauses 12.9 to 12.16; or,
3) reinforced concrete, designed in accordance with clauses 12.17 to 12.28.

12.3 Alternative forms of foundations shall be subject to approval by Overseeing Organisation.

NOTE 1 *Unreinforced concrete spread foundations rely on the tensile strength of concrete and are unlikely to meet the requirements for durability.*

NOTE 2 *Alternative forms of foundation includes those which are to incorporate retention sockets.*

12.4 The design rules given in this Section shall not apply to foundations on slopes, where stability of the ground needs to be included in the design.

12.5 For foundations on slopes and where stability of the ground needs to be factored into the design, the advice of a geotechnical advisor complying with clause 2.12 of CD 622 [Ref 23.N] shall be sought.

NOTE *Some guidance on the design of supports for sign structures can be found in Sign Structures Guide 2021 [Ref 6.I] Chapter 5.*

12.6 Foundation types adopted for columns and posts for CCTV masts or speed cameras shall be designed to include the effects of ground movements on the operation of equipment on the column or post.

NOTE *The general provisions in this Section for planted foundations are unlikely to provide the restraint required to limit deflection for CCTV masts or speed cameras, so more detailed geotechnical investigation and design is necessary.*

Foundations for planted columns, posts and prefabricated foundations

Planting depth

12.7 Where a minor structure is to be planted directly in the ground, the minimum design planting depth shall be selected from Table 7 of BS EN 40-2 [Ref 21.N] related to the overall height of the structure.

12.7.1 Where the nominal height is less than 2 m, a depth of 600 mm may be adopted, provided that:

Equation 12.7.1 Planting depth

$$M_g > \gamma_{s;d} \times M_{DS}$$

where:

M_g is the ground resistance moment (in kNm)

$\gamma_{s;d}$ is the safety factor applied to destabilising moments

M_{DS} is the destabilising moment applied at the fulcrum point (in kNm)

12.8 The calculation procedure given in PD 6547 [Ref 13.N]shall be used to check the adequacy of the selected planting depth taking into account the ground conditions at the site.

NOTE 1 *When calculating the planting depth in accordance with the calculation given in PD 6547 [Ref 13.N], the value of D is to be taken as D_0 and not D_r.*

NOTE 2 *The calculation of planting depth requires the categorisation of the ground factor, with descriptions of the soil types being given in PD 6547 [Ref 13.N]. For any soil conditions encountered which would be classified as weaker than poor, such as peat, topsoil or alluvial fill, specialist geotechnical advice will be required.*

12.9 For prefabricated foundations, the planting depth and effective diameter shall be selected to ensure compliance with the planting depth calculation method provided in PD 6547 [Ref 13.N].

12.10 The effective diameter (m) of the column shall be the column root diameter or minimum distance across the flats for multi-sided sections.

Backfilling for foundations

12.11 Backfilling material shall be mass concrete or an acceptable material in accordance with MCHW Series 0600 [Ref 24.N].

12.11.1 Excavated material from the hole dug for the minor structure foundation may be reused as acceptable material.

12.12 All backfilling material shall be placed in 150 mm-thick layers and well compacted.

12.13 Where precast foundations are used, the backfilling material and procedure shall be in accordance with the foundation manufacturers requirements.

12.14 Where the excavated hole is backfilled with concrete, the concrete shall extend from the base of the minor structure to ground level.

12.15 Planted columns shall incorporate a mechanism which prevents rotation of the column or post in the ground under wind loading to resist the torsional effects of the loading.

12.16 Settlement due to ground movement shall be reflected in the design of planted columns.

NOTE *Settlement of the planted column or post due to ground movement can affect the headroom, clearances or height limits allowed in the design.*

Foundations for columns with flange plates

12.17 The design principles of foundations shall be based on the design methods given in BS EN 1997-1 [Ref 8.N].

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

12.19 M_{fd} shall be the greater of the impact moment, M_i , and the moment obtained from BS EN 40-3-1 [Ref 19.N], BS EN 12899-1 [Ref 12.N], ILP PLG07 [Ref 27.N] or BS EN 1991 [Ref 10.N] factored by the appropriate partial factor for an action, γ_F (refer to BS EN 1997-1 [Ref 8.N]), for the failure mode under consideration.

12.20 F_{fd} shall be the greater of the impact shear force, F_i , and the horizontal force obtained from BS EN 40-3-1 [Ref 19.N], BS EN 12899-1 [Ref 12.N] , ILP PLG07 [Ref 27.N], BS EN 1991 [Ref 10.N], or BS EN 1991 [Ref 10.N] factored by the appropriate partial factor for an action, γ_F (Refer to BS EN 1997 [Ref 7.N]), for the failure mode under consideration).

12.21 The partial factor for an action shall be taken as:

1) $\gamma_{G;dst} \geq 1.5$ for destabilising actions (such as overturning moment); and,
2) $\gamma_{G;stb} \leq 0.9$ for stabilising actions (such as gravity).

12.22 The impact moment and impact shear force, M_i and F_i respectively shall be derived as follows:

Equation 12.22a Impact moment

$$M_i = k_{si} M_R$$

where:

M_i	is the impact moment (in Nm);
M_R	is the ultimate moment of resistance (in Nm); and,
k_{si}	is the soil impact factor as given in Table 2 of PD 6547 [Ref 13.N]

Equation 12.22b Impact shear force

$$F_i = k_{si} F_R$$

where:

F_i	is the impact shear force (in N);
F_R	is the equivalent ultimate shear force (in N); and,
k_{si}	is the soil impact factor as given in Table 2 of PD 6547 [Ref 13.N]

12.23 The ultimate moment of resistance of the actual column at the base level, M_R , and the equivalent ultimate shear force, F_R , shall be calculated in accordance with clause 5.6.2 of BS EN 40-3-3 [Ref 20.N] .

12.23.1 An upper bound value for the equivalent ultimate shear force may be taken as: $F_R = 2 \times M_{up}$. This assumes that the point of impact is 0.5 m above the top of the foundation.

NOTE *Refer to BS EN 40-3-3 [Ref 20.N] for the calculation of M_{up} , which is the bending moment of resistance for closed rectangular cross sections.*

Foundations for cantilever masts with flange plates

12.24 Cantilever masts positioned in locations where the quality of soil is unknown, and therefore taken as being poor, the foundations shall be designed in accordance with the procedure given in the clauses below.

12.25 Foundations shall consist of reinforced concrete blocks designed in accordance with BS EN 1992-1-1 [Ref 5.N].

12.26 The design loads for the foundation shall be the nominal loads and nominal wind loading applied by the cantilever mast when designed in accordance with this document, factored by the relevant partial factor for actions, γ_F , taken from BS EN 1997-1 [Ref 8.N].

12.27 The design of the foundation shall be based on the design methods given in BS EN 1997-1 [Ref 8.N], using the partial factors on actions taken as:

1) $\gamma_{G;dst} \geq 1.5$ for destabilising actions (such as overturning moment); and,
2) $\gamma_{G;stb} \leq 0.9$ for stabilising actions (such as gravity).

12.27.1 There is a difference in the structural behaviour of the cantilever mast and its foundation, hence in the absence of more accurate information, the following may be assumed:

1) the basic wind load transferred from the cantilever mast to the substructure at the top of the substructure reduces to $\frac{1}{\beta}$ of this value, at the bottom of the substructure and foundation.
2) β is the factor for dynamic behaviour given in BS EN 40-3-1 [Ref 19.N] Clause 5.2.4.

12.28 Unless otherwise agreed with the Technical Approval Authority, the criteria given for foundations for columns with flange plates shall apply when cantilever masts are:

1) positioned in the locations outlined in paragraph 10.7; or

2) not positioned behind a vehicle restraint system meeting the requirements of BS EN 1317-2 [Ref 30.N]and CD 377 [Ref 28.N]; or

3) positioned on a slope such that the underside of the flange plate is less than 2 m vertically above the carriageway closest to the post.

13. Normative references

The following documents, in whole or in part, are normative references for 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.

Ref.	Document
Ref 1.N	National Highways. CG 302, 'As-built, operational and maintenance records for highway structures'
Ref 2.N	National Highways. CD 127, 'Cross-sections and headrooms'
Ref 3.N	BSI. BS EN 1991-1-4, 'Eurocode 1: Actions on structures: General actions – Wind actions'
Ref 4.N	BSI. BS EN 1992, 'Eurocode 2. Design of concrete structures'
Ref 5.N	BSI. BS EN 1992-1-1, 'Eurocode 2: Design of concrete structures. General rules and rules for buildings'
Ref 6.N	BSI. BS EN 1993-3-1, 'Eurocode 3 - Design in steel structures - Towers, masts and chmineys - towers and masts'
Ref 7.N	BSI. BS EN 1997, 'Eurocode 7. Geotechnical Design.'
Ref 8.N	BSI. BS EN 1997-1, 'Eurocode 7. Geotechnical design. General rules'
Ref 9.N	BSI. BS EN 1999-1-3, 'Eurocode 9: Design of aluminium structures. Structures susceptible to fatigue'
Ref 10.N	BSI. BS EN 1991, 'Eurocode 1: Actions on structures'
Ref 11.N	BSI. BS EN 1999 , 'Eurocode 9: Design of Aluminium Structures'
Ref 12.N	BSI. BS EN 12899-1, 'Fixed, vertical road traffic signs. Fixed signs (Designated Standard - CPR)'
Ref 13.N	BSI. PD 6547, 'Guidance on the use of BS EN 40-3-1 and BS EN 40-3-3.'
Ref 14.N	National Highways. CD 109, 'Highway link design'
Ref 15.N	National Highways. CG 305, 'Identification marking of highway structures'
Ref 16.N	National Highways. GG 101, 'Introduction to the Design Manual for Roads and Bridges'
Ref 17.N	BSI. BS EN 40 (all), 'Lighting columns (all) (some parts harmonised)'
Ref 18.N	BSI. BS EN 40 [All Parts], 'Lighting Columns (Some parts harmonised)'
Ref 19.N	BSI. BS EN 40-3-1, 'Lighting columns. Design verification. Specification for characteristic loads '
Ref 20.N	BSI. BS EN 40-3-3, 'Lighting columns. Design verification. Verification by calculation'
Ref 21.N	BSI. BS EN 40-2, 'Lighting columns. General requirements and dimensions'
Ref 22.N	BSI. BS EN 40-7, 'Lighting columns. Requirements for fibre reinforced polymer composite lighting columns (Designated Standard - CPR)'
Ref 23.N	National Highways. CD 622, 'Managing geotechnical risk'
Ref 24.N	Highways England. MCHW Series 0600, 'Manual of Contract Documents for Highway Works, Volume 1 Specification for Highway Works. Series 600 Earthworks'

Ref 25.N	Highways England. MCHW Series 1900, 'Manual of Contract Documents for Highway Works, Volume 1 Specification of Highways Works, Series 1900, Protection of Steelwork against Corrosion'
Ref 26.N	National Highways. CD 146, 'Positioning of signalling and advance direction signs'
Ref 27.N	Institution of Lighting Professionals. ILP PLG07, 'Professional Lighting Guide 7 - High Masts for Lighting and CCTV'
Ref 28.N	National Highways. CD 377, 'Requirements for road restraint systems'
Ref 29.N	National Highways. TD 501, 'Road lighting design'
Ref 30.N	BSI. BS EN 1317-2, 'Road restraint systems. Performance classes, impact test acceptance criteria and test methods for safety barriers including vehicle parapets '
Ref 31.N	BSI. BS EN 14388, 'Road traffic noise reducing devices. Specifications (Designated Standard - CPR)'
Ref 32.N	National Highways. LD 119, 'Roadside environmental mitigation and enhancement'
Ref 33.N	National Highways. CG 300, 'Technical approval of highway structures'
Ref 34.N	BSI. BS EN 1011-1, 'Welding. Recommendations for welding metallic materials. Guidance for arc welding'
Ref 35.N	BSI. BS EN 1011-2, 'Welding. Recommendations for welding of metallic materials. Arc welding of ferritic steels'

14. Informative references

The following documents are informative references for this document and provide supporting information.

Ref.	Document
Ref 1.I	BSI. BS EN 1993 , 'Eurocode 3: Design of steel structures'
Ref 2.I	BSI. Department for Science, Innovation and Technology. PAS 191, 'Multifunctional columns. Design. Specification'
Ref 3.I	National Highways. LA 111, 'Noise and vibration'
Ref 4.I	BSI. BS EN 12767, 'Passive safety of support structures for road equipment. Requirements, classification and test methods.'
Ref 5.I	National Highways. CD 365, 'Portal and cantilever signs/signals gantries'
Ref 6.I	Institute of Highway Engineers. Gallagher, J; Lewis, M; Morris, K; Morgan, S; Hocombe T; Ford, M; Salter, J. Sign Structures Guide 2021, 'Support design for permanent UK traffic signs to BS EN 12899-1 and Eurocodes'

Appendix A. Determination of shape coefficients by testing

A1 Shape coefficients for columns

Properly conducted wind tunnel tests on columns and brackets have to be undertaken only when shape coefficients are not available from BS EN 40-3-1 [Ref 19.N] or from recognised International Standards. Adoption of values from these standards or from wind tunnel tests are to be agreed with the Technical Approval Authority. Particular care should be taken to ensure that the values of shape coefficients relate to cross-sections of members of infinite length.

Wind tunnel tests to establish shape coefficients should be carried out using full scale specimens, which accurately represent the final proposed column. The forces on the specimen should be measured in the direction of the air flow and the direction normal to the air flow.

Previous wind tunnel tests have indicated that small angular rotations of specimens can cause considerable differences in shape coefficients. The specimens are therefore to be turned in the wind tunnel and measurements taken at angular increments. In the region of each shape coefficient the measurements should be reduced to approximately 1° of rotation. Comparisons are to be made with the values of similar sections given in recognised International Standards as part of the adoption and agreement procedure with the Technical Approval Authority set out in Section 4 of this document.

A2 Shape coefficients for luminaires, cameras, signs and brackets

The shape and lift coefficients for luminaires, cameras and signs may be determined from wind tunnel tests as required by BS EN 40-3-1 [Ref 19.N]. These tests have to be carried out on a full scale shape of the element in a wind tunnel sufficiently large to reduce side effects to an insignificant level. The surface condition of the specimen has to accurately represent that of the production version. Where optional attachments are to be made to the element, such as photo-electric control units, gear component extensions and suchlike, these should be included in the test specimen.

When carrying out a wind tunnel test, forces both in the direction of the airflow and in the direction normal to the airflow have to be measured, as shape and lift coefficients are required for all the increments of rotation for which the forces on an element are to be measured. All shape coefficients should be based on the projected area of the element normal to the airflow.

Forces on an element are to be measured at increments of rotation of approximately 1° between the limit of ±10° to the horizontal. BS EN 40-3-1 [Ref 19.N] requires the maximum value between ±5° to the horizontal but a more conservative value should be adopted where large increases of coefficients are obtained between 5° and 10° to the horizontal. During testing the effects of small plane rotations about the point of fixing are also to be taken into account. Where an increase in shape coefficient is obtained with a rotation within the limits of ±10° then this value has to be adopted.