Design Manual for Roads and Bridges

Highway Structures & Bridges
Design

CD 365
Portal and cantilever signs/signals gantries

(formerly BD 51/14, IAN 193/16, BE 7/04)

Revision 1

Summary
This document covers the design of portal and cantilever sign and signal gantries to Eurocodes and sets out the Overseeing Organisation's requirements.

Application by Overseeing Organisations
Any specific requirements for Overseeing Organisations alternative or supplementary to those given in this document are given in National Application Annexes to this document.

Feedback and Enquiries
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Highways England team. The email address for all enquiries and feedback is: Standards_Enquiries@highwaysengland.co.uk

This is a controlled document.

Contents

Release notes

Version	Date	Details of amendments
1	Mar 2020	Revision 1 (March 2020) Revision to update references only. Revision 0 (March 2019) CD 365 replaces BD 51/14, IAN 193/16 and BE 7/04. The full document has been rewritten to make it compliant with the new Highways England drafting rules. There are no other major revisions, including no changes to technical requirements.

Foreword

Publishing information

This document is published by Highways England.

This document supersedes BD51/14, IAN 193/16 and BE 7/04, which are withdrawn.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

There are no major technical changes to the requirements of the design of gantries since BD 51/14. The requirement to undertake a risk assessment prior to selection of the form of structure, in accordance with IAN 193/16 has been incorporated within this document. The requirement to use a specific computer model for estimating whole life safety and journey time reliability risks has been removed.

Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 24.N] apply to this document.

References in this document to BS EN documents include their UK National Annexes and all relevant Published Documents (PDs).

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 24.N].

Abbreviations and symbols

Abbreviations

Abbreviation	Definition
AADT	Average Annual Daily Traffic
AIP	Approval in Principle
ALM	Ambient Light Monitor
AMI	Advanced Motorway Indicator
ANPR	Automated Number Plate Recognition
ASI	Acceleration Severity Index
CFD	Computational Fluid Dynamics
CMU	Cable Marshalling Unit
D3M	Dual 3 Lane Motorway
DEE	Digital Enforcement Equipment
DMRB	Design Manual for Roads and Bridges
HE	High Energy Absorbing (this abbreviation is NOT Highways England)
HGV	Heavy Goods Vehicle
ITS	Intelligent Transport Systems
MCAB	Motorway Cabinet
NAA	National Application Annex
NCCI	Non-contradictory Complementary Information
PSDF	Power Spectral Density Functions
SLS	Serviceability Limit State
SM-ALR	Smart Motorway, All Lanes Running
TAA	Technical Approval Authority
THIV	Theoretical Head Impact Velocity
ULS	Ultimate Limit State

Symbols

Symbol	Definition
C	Wind factor
c_e	Wind exposure factor
c_{fx}	Force coefficient
F_7	Factor for stability of deck
F_8	Consequence factor for road bridges
F'_{wz}	Vertical downward component of the wind force
F_{dx}	Static design force in the direction normal to travel
F_{dy}	Static design force perpendicular to the direction normal to travel
F_{wx}	Horizontal component of the wind force
F_{wy}	Longitudinal wind action
F_{wz}	Vertical wind force
μ_i	Snow load shape factor

Terms and definitions

Terms

Term	Definition
$AADT_{over}$	Value of the annual average daily traffic, which includes all traffic in the stream or streams that use the part of the bridge deck structure that might collapse following failure of the support.
Adaptability risk	Risk associated with reduced future functionality of any gantry, for example because of limited load capacity or vibration characteristics.
Acceleration severity index	A non-dimensional quantity calculated from the triaxial vehicle accelerations. NOTE: The maximum value of the acceleration severity index is an assessment of the accident severity for the occupants of the impacting vehicle.
Carriageway width	In the presence of kerbs, it is the traffic running surface, which includes all traffic lanes, hard shoulders, hard strips and marker strips, between raised kerbs.In the absence of raised kerbs, it is the width between safety fences, less the amount of set-back. NOTE: The carriageway width is measured in a direction at right angles to the line of the raised kerbs, lane marks or edge marking.
Gantry	Generic term for structure supporting signs, signals, variable message signs (VMS) and other equipment. NOTE: The term 'gantry' is used for a variety of structures, including single or multiple portals, single and double cantilevers and combinations of same.
Outreach of cantilever	Length of cantilever from traffic face of support to tip.
Passively safe gantries	Gantries that are designed to yield or detach under vehicle impact in order to limit injury to the vehicle occupants.
Permanent actions (removable)	Actions resulting from elements on the structure that could be replaced/changed in the future, such as signs, signals and other equipment.
Sign	A device carrying directional or other informational message, e.g. route information at the approach to a junction.
Signal	A device that uses lights to give advisory or mandatory instructions, e.g. stop, or 30 miles/h speed restriction.
Smart motorway gantry	Gantries that are designed specifically for use on smart motorway schemes. NOTE: Smart motorway gantries are different from standard gantries insofar as they are not designed for possible reuse without modification across the motorway and all-purpose trunk roads network.
Standard gantry	Gantry structure that has been designed for possible reuse without modification across the motorway and all-purpose trunk roads network. NOTE: Passively safe gantries or gantries for smart motorway schemes are not classified as standard gantries.

Terms (continued)

Term	Definition
Support	Vertical or near-vertical structural member supporting horizontal member, sign, signal and/or associated equipment.
Theoretical head impact velocity	Velocity, expressed in km/h, at which a hypothetical point mass occupant impacts the surfaces of a hypothetical occupant compartment.
Variable message system	Sign capable of displaying a variety of text, messages and/or symbols
Vehicle restraint system	Installation to provide a level of containment for errant vehicles in order to limit damage or injury to users of the highway

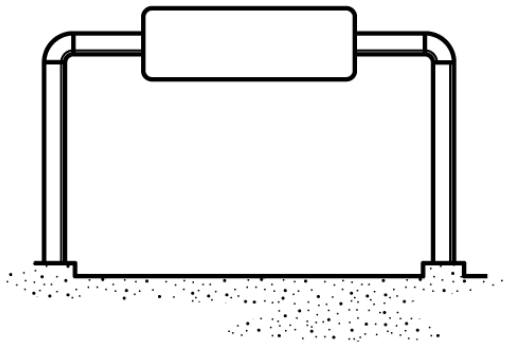
1. Scope

Aspects covered

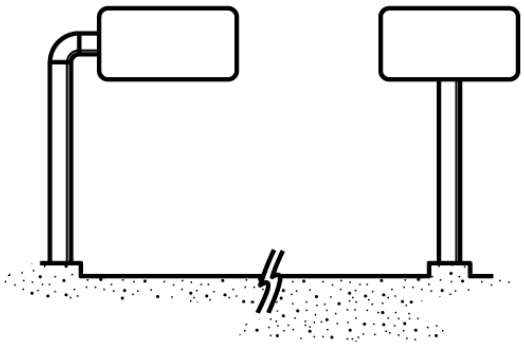
1.1 This document shall be used in designing permanent and temporary gantry structures for use on the motorway and all-purpose trunk roads, which wholly span or are partially cantilevered over the carriageway, central reserve, hard shoulder and/or hard strip for the purpose of supporting large signs and/or motorway type signals and/or message signs.

NOTE 1 Examples of gantry structures within the scope of this document are shown in Figure 1.1N1.

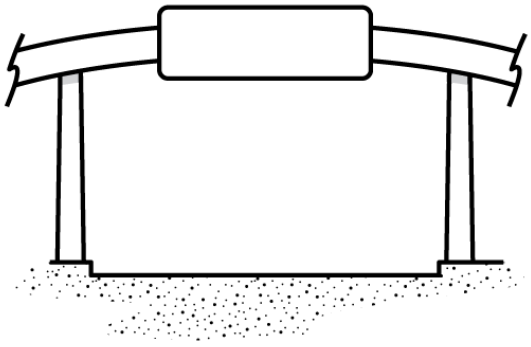
Figure 1.1N1 Examples of gantry structures within the scope of this document



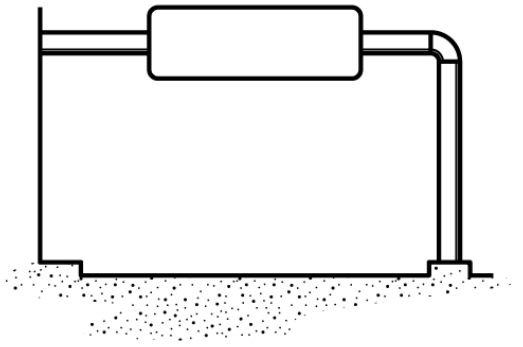
a) Spanning carriageway.



b) Cantilevered over carriageway.



c) Mounted on overbridge or tunnel portal.



d) Attached to or recessed into retaining wall.

NOTE 2 This document does not cover scheme design. Gantry positions are determined as part of the wider scheme design. This document only provides requirements for the position of the gantry where it has a direct implication on the structural design.

NOTE 3 This document does not cover cantilever or other traffic signal masts that are covered in 'Design of Minor Structures' CD 354 [Ref 4.N].

NOTE 4 This document does not cover the selection of suitable sign and signal configuration that are covered in 'Motorway Signalling' CD 146 [Ref 27.N].

Implementation

1.2 This document shall be implemented forthwith on all schemes involving the design of portal and cantilever sign and/or signal gantries, and their access structures and methods for the Overseeing Organisations' motorway and all-purpose trunk roads, according to the implementation requirements of GG 101 [Ref 24.N].

Use of GG 101

1.3 The requirements contained in GG 101 [Ref 24.N] shall be followed in respect of activities covered by this document.

2. Gantry type selection

2.1 The selection of the type of gantry to be used for a specific location/scheme shall be determined by a risk assessment and a cost benefit analysis on a whole life basis.

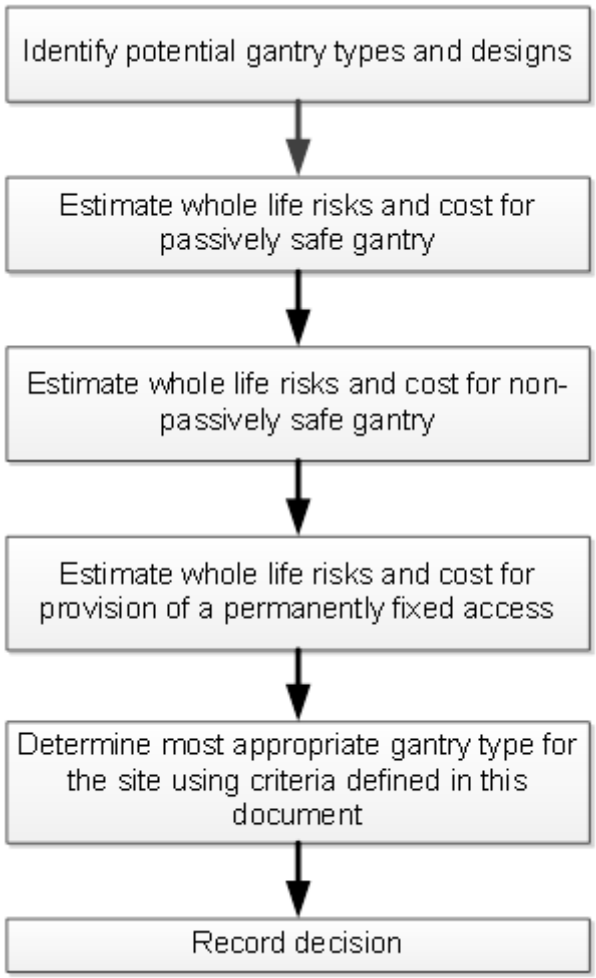
2.2 A risk assessment shall be undertaken to determine the whole-life safety and journey time reliability risks for different gantry types including passively safe and non-passively safe gantries.

2.3 The risk assessment shall include determining whether provision of permanently fixed access will be made at a site.

2.4 The risk assessment shall compare the relative whole life risks and costs associated with the use of a passively safe gantry at a site, with the whole life risks and costs associated with the use of a non-passively safe gantry at a site.

2.5 Those responsible for designs shall confirm that the selection of an optimal design solution includes all relevant factors.

Figure 2.5 Gantry selection process



NOTE Typically all relevant factors to select an optimal solution include the gantry structure and the associated technology, lighting or signing equipment as well as how inspection and maintenance activities required for these items can be integrated with other routine maintenance, maintenance renewal works or other improvement schemes.

Requirements for the risk assessment

2.6 The risk assessment shall include, as a minimum:

1) relative safety risks and journey time reliability risks of different proposed gantry types or designs;
2) risks to different user groups, such as road users, operatives and relevant third parties;
3) 'adaptability' risks associated with any constraints on future functionality arising from the proposed gantry design.

2.7 The risk assessment of the provision of gantries within a scheme shall state and report the following:

1) the inspection and maintenance requirements over the whole life of the asset including interventions and their frequency;
2) the resultant need for temporary traffic management;
3) operating regime of the carriageway, for example D3M or SM-ALR;
4) maintenance strategy including equipment restoration times in the event of failure and off-network access arrangements;
5) construction risks including ease and complexity of construction including substructure and superstructure;
6) safe taper positions and the temporary traffic management arrangements;
7) eventual demolition requirements.

2.8 When assessing the acceptability of relative safety risks of a passively safe gantry compared with a standard gantry, changes in safety risk to individual user groups as well as changes in total risk shall be included.

NOTE *In assessing the relative safety risk to different groups it is possible, for example, to have a reduced total risk for a passively safe gantry but within this to have an increased risk to a specific user group such as operatives.*

2.9 The acceptability of increase in safety risk to particular user groups shall be agreed with the Overseeing Organisation.

2.10 The acceptability of any trade-offs between increased or decreased safety risk versus journey time reliability impact and whole-life cost associated with the use of a passively safe gantry shall be agreed with the Overseeing Organisation.

Adaptability Risk

2.11 Adaptability risk shall be assessed to inform the gantry selection process.

2.12 The level of adaptability risk associated with a particular gantry design shall be assessed using the impact and likelihood ratings from Tables 2.12a and 2.12b.

Table 2.12a Impact ratings

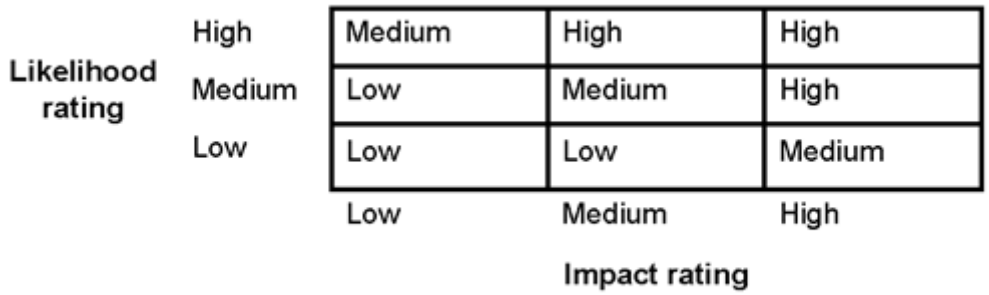
Impact rating	Description
Low	Gantry places only limited restrictions on future adaptability; can accommodate the majority of equipment that could foreseeably be required to be mounted on a gantry in the future
Medium	Gantry places some restrictions on future adaptability; can accommodate some equipment that could foreseeably be required to be mounted on a gantry in the future
High	Gantry places significant restrictions on future adaptability; can only accommodate minimal additional equipment in the future

Table 2.12b Likelihood ratings

Likelihood rating	Description
Low	Unlikely that additional equipment, not included at the design stage, will be needed in the future
Medium	Possible that additional equipment, not included at the design stage, will be needed in the future
High	Likely that additional equipment, not included at the design stage, will be needed in the future

2.13 The adaptability risk rating for a gantry shall be established from Figure 2.13.

Figure 2.13 Adaptability risk rating



Whole life costs

2.14 A cost benefit analysis shall be carried out and recorded to compare the risks identified in the risk assessment with the relative costs of the different proposed gantry types or designs on whole life basis.

2.15 The whole life cost shall include the cost of inspection and maintenance, and the traffic management associated with inspection and maintenance.

2.16 The whole life cost shall be a discounted annual equivalent cost, in pounds Sterling (GBP).

Record keeping

2.17 All the factors identified in the risk assessment shall be formally recorded.

2.18 Record of the risk assessment shall include:

1) the features and hazards present or known about at the time;
2) sources of data used to inform the risk assessment;
3) justification for the decisions made in the risk assessment.

2.19 Where required, copies of the risk assessment shall be provided to the Overseeing Organisation.

3. General design principles

Technical approval

3.1 Technical approval of the designs for construction, alteration and repositioning of portal and cantilever sign/signal gantries shall comply with the requirements of 'Technical Approval of Highway Structures', CG 300 [Ref 34.N].

NOTE *The design certification required by CG 300 [Ref 34.N] covers all structural elements and components including, but not limited to, main structural supports, foundations, sign plates, sign support frames and stiffeners, banding, clips, brackets, signal housings, clamps bolts, cabling and equipment etc.*

Design working life

3.2 The required design working life shall be 60 years for standard gantries and 30 years for smart motorway and passively safe gantries.

3.3 The minimum fatigue design life shall be the design working life plus 10 years.

3.4 In the design for wind and thermal effects, the return period shall be taken as the design working life of the gantry.

Design procedures

3.5 The design of standard gantries and smart motorway gantries shall meet the criteria set out in Sections 6 and 7 and other provisions in the NAA for the Overseeing Organisation.

3.6 The design of passively safe gantries shall meet the criteria set out in Sections 6 and 7 with design requirements for vehicle collision actions which differ from those provided for non-passively safe gantries.

NOTE 1 *Additional requirements for passively safe gantries are set out in Section 8.*

NOTE 2 *Additional requirements for gantries with permanent maintenance access are set out in Section 9.*

Design for construction

Transportation and erection

3.7 The design of the gantry shall facilitate transportation, erection and demounting with the minimum of disruption to road users.

3.8 The gantry arrangement and components shall be sufficiently robust to resist damage during transportation and erection.

3.9 Mounting systems for equipment shall enable the gantry to be transported and erected with the equipment in place.

3.10 Site welded connections shall not be used unless otherwise agreed by the TAA.

3.11 Where the gantry is not designed to be erected in one piece, the supports shall be identified and allow a phased execution procedure.

3.12 Provision for lifting the various elements of the gantry shall be provided as part of the permanent design of the gantry.

Assembly of signs and signals

3.13 The design of the gantry shall allow as much assembly of the signs and signals as practicable to be undertaken on the ground, either at the fabrication shop or close to the site, prior to erection of the main span member.

NOTE *Assembling signs and signals on the ground helps minimise temporary traffic management requirements and the risks associated with working at height for fitting out of gantries.*

Foundations

3.14 The design of the gantry foundations shall allow for construction in advance of the erection of the superstructure.

3.14.1 Templates for both position and alignment of the holding down arrangements should be used, especially when the gantry superstructure is to be erected on foundations constructed by others.

3.15 The design of the gantry foundations shall avoid disruption of the carriageway and/or minimise temporary traffic management on highways in use.

Design for maintenance

3.16 The gantry shall be designed for future maintenance, including any equipment it supports.

3.17 The gantry arrangement and components shall be sufficiently robust to resist damage during in-service maintenance.

3.17.1 Connections between structural elements of the gantry should be designed to be simple and clearly visible from the verge to enable visual inspection from a position of relative safety.

3.18 Access arrangements for gantries shall be designed to facilitate the future maintenance needs of the gantry, with the requirements for technology, lighting or signing equipment mounted on the gantry integrated with other routine maintenance, inspection programmes or other renewal programmes.

Position and dimension

3.19 All structural elements shall comply with the dimensional requirements set out in 'Cross-sections and headrooms' CD 127 [Ref 3.N], allowing for clearances and deformations defined in Section 6.

3.20 The horizontal and vertical dimensional clearances between the structure and vehicle restraint systems shall be in accordance with 'Requirements for road restraint systems' CD 377 [Ref 31.N] and 'Cross-sections and headrooms', CD 127 [Ref 3.N].

3.21 On dual carriageway roads non-passively safe portal gantries shall span both carriageways without support in the central reserve unless agreed with the TAA.

3.22 On portal type gantries, the levels at the ends of the beam shall be the same.

3.23 Gantries shall not be located less than two times their maximum height clear of any over-bridge unless the interaction between the two structures with respect to wind turbulence is included in the design.

3.24 Where the need to support signs and/or signals over the highway can be arranged to coincide with an over-bridge, or tunnel portals, that structure shall be utilised to support them, subject to technical approval by the Overseeing Organisation.

3.25 The risk of unauthorised access to signs and/or signals located on an over-bridge or tunnel portal shall be assessed and recorded to determine whether the proposal to attach signs and/or signals to an over-bridge should be approved.

NOTE *The means of attachment of signs and/or signals to the bridge structure will depend on the form of the bridge, particularly its cross section.*

3.26 Where gantries are mounted on elevated structures, the effects of the holding down arrangements of the gantry supports on the elevated structures shall be included in the design/assessment of the supporting bridge or viaduct deck.

Adaptability

3.27 Structural holding-down bolt arrangements shall be designed such that subsequent removal and replacement of the gantry structure can be readily undertaken.

3.28 The design of gantries shall assess and report the likelihood of future repositioning of equipment or signage on the gantry, or changes to actions from them, within the design life of the gantry.

3.29 The decision to make provision for future repositioning of equipment or signage on the gantry or changes to actions from them, shall be agreed at the scheme level and recorded in the 'Approval in Principle' document (AIP) prepared in accordance with 'Technical Approval of Highway Structures' CG 300 [Ref 34.N].

3.30 Where provision is made for future changes, details shall be provided on the as-constructed drawings to indicate the extent of such provision.

NOTE *A list of the items likely to be included on a gantry is given in Appendix A.*

Robustness

3.31 For standard gantries and smart motorway gantries, the design of supports shall ensure that local damage under the actions given in Section 7 does not result in the collapse of the gantry.

3.32 For passively safe gantries, the collision criteria set out in Section 8 shall be used in the design.

NOTE *In order to achieve the required resistance it can be necessary to encase or widen the support to form a concrete plinth to a height sufficient to cater for the low level collision action and/or position structural members out of the collision zone.*

Use of dissimilar metals

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

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

Mitigation of vandalism and theft

3.35 The design shall include mitigation measures to reduce vandalism and the risk of theft of components and materials.

3.36 Mitigation measures to reduce vandalism and the risk of theft of components and materials shall be included in the AIP.

Mitigation of environmental impacts

3.37 The environmental impacts of the gantry shall be minimised.

3.38 The whole environment and not just any particular element, like a gantry, in isolation, shall be evaluated in the design.

3.38.1 Aesthetics, and/or the effects on noise, air quality or wildlife/landscape should be a factor in the assessment of the environmental impacts.

4. General requirements

Protection for road users and structure

4.1 Vehicle restraint systems shall be provided in accordance with 'Requirements for road restraint systems', CD 377 [Ref 31.N].

4.2 Where gantry supports are positioned in recesses in retaining walls, the vehicle restraint system shall provide continuous protection across the recess.

4.3 Where access to the gantry support and any control equipment is specified, any breaks in the VRS shall be designed and specified in accordance with CD 377 [Ref 31.N].

Structural performance

4.4 The limiting structural deformations of the gantries shall be based on providing a stable platform for supporting the signal equipment to be provided.

Vibration limits

4.5 The gantry shall never expose equipment mounted on it to any level of vibration above 80% of the levels required by DMRB document 'Vibration, Random, Operational' TR 2130 [Ref 5.N].

Fatigue

4.6 The design working life for fatigue purposes in standard, managed motorway and passively safe gantries shall be in accordance with Section 3.

4.7 The fatigue performance of the structure shall be verified using a Miner's summation calculation.

4.8 The Miner's summation combination for all details shall give a value of less than unity.

4.9 The structure shall be assessed for fatigue life for the forces obtained from the dynamic analysis described in Section 10.

4.10 Where forms of construction are used for which there are no adequate fatigue data, approaches to fatigue verification, including testing where necessary, shall be agreed with the TAA.

4.10.1 The fatigue life of any existing gantry to be relocated should be assessed.

4.10.2 A detailed inspection of welds and particularly vulnerable details of existing gantries to be relocated may also be necessary.

4.11 Fatigue endurance of steel structures shall be checked in accordance with BS EN 1993-1-9 [Ref 11.N].

Identification

4.12 Site identification marking of gantries shall be in accordance with the requirements of the Overseeing Organisation.

Protection of steelwork

4.13 The design shall specify appropriate surface treatments and protection systems to ensure the gantry structure, its fittings and connections, and any mounting arrangements are protected against deterioration from environmental causes.

4.14 The protective systems specified shall be at least Type II, unless environmental conditions mean that a more robust approach is required to meet the Overseeing Organisation's working life requirements.

4.14.1 Where hot-dip galvanising of steelwork is used it should be in conjunction with other protective systems to achieve the required design life.

NOTE 1 It is unlikely that hot-dip galvanising of steelwork alone will deliver the required design life, due to the aggressive environment found along highways.

NOTE 2 *Weathering grades of steel are not generally suitable because of issues that can arise with regard to connections such as dissimilar metals and collection of moisture.*

Drainage

4.15 Provision shall be made for the drainage of water from the structure, including hollow sections and fixings.

4.16 All walkways, roofs of enclosures and other surfaces shall have adequate falls to allow water to run off.

4.17 Where run off can concentrate, it shall discharge clear of the carriageway and hard shoulder/strip and clear of the structure.

Fixings/connections

4.18 The design of the mounting arrangements for equipment, signs and signals shall include the possible structural interaction between any enclosure and supporting members.

4.18.1 An equipment enclosure, sign or signal may assume a contribution of structural strength/stiffness from the gantry as part of its design.

4.19 The equipment shall be mounted on the gantry structure in such a way as to limit vibration and movement and to prevent the equipment from detaching during an impact.

4.20 The mounting arrangements for items of technical equipment, signs and signals shall match the requirements of the gantry and its mounting points.

4.21 The technical equipment, signs and signals mounting arrangements shall include the capability for horizontal and vertical alignment, unless already catered for by the integral arrangement.

4.22 Fixings and connections shall be designed or specified such that they will not loosen or become detached in normal condition of use.

4.22.1 Vibration resistant fixings should be specified where possible.

4.23 In the event of the failure of fixings and/or connections, all parts of the gantry structure and attached technology, lighting or signing equipment, fixings and connections shall be designed to prevent them from falling onto the carriageway.

4.24 Gantries, fixings and connections, technical equipment, signs and signals shall be corrosion resistant, free draining and designed to ensure water or detritus does not accumulate anywhere on or in the structure.

4.25 Runoff from the gantry shall be discharged away from the gantry, any VRS and carriageway.

4.26 The tops of holding-down bolts shall be protected by plastic caps filled with an anti-corrosion compound.

Electricity, cable routes, electrical earth and lightning conduction

4.27 Where electrical plant is installed on gantry structures, provision shall be made to enable the supply to be isolated before work takes place on electrical equipment.

NOTE *It is noted that equipment for motorway communications is a permanent installation. It is therefore based on 240-volt, 50-Hz AC operation and is installed in accordance with BS 7671 Requirements for Electrical Installations BS 7671 [Ref 30.N] backed by the Electricity at Work Regulations 1989 (SI No. 635) EWR 1989 1989 [Ref 35.N].*

4.28 A structured cable management system shall be devised and incorporated into the structural design of the gantry.

4.29 The cable management system shall provide continuous protection from the ducted network in the nearside verge to a point 3.5m above adjacent ground level to protect against accidental damage, theft and vandalism.

4.30 The cable management system shall permit rapid fixing and removal of cables and include quick release joints at the gantry support/boom connections.

4.31 Where cable routes are external to the structure, they shall be positioned remote from the usual line of sight, i.e. on the down-stream face, where possible.

4.32 The minimum radius for a cable route, the entry and exit points to internal ducts and the provision of draw cords shall be in accordance with the relevant specification.

4.33 All metal components of the structure shall have electrical continuity in accordance with BS 7671 [Ref 30.N] in conjunction with the Electricity at Work Regulations. 1989 (SI No. 635) EWR 1989 1989 [Ref 35.N].

4.34 Provision shall be made to allow for the connection of any equipment fitted to the gantry and all individual components of the gantry to be earth-bonded and for the base of the structure to be connected to earth.

4.35 The earthing system described in the last clause shall be in accordance with 'Code of practice for earthing' BS 7430 [Ref 2.N] with the performance requirements of 'Requirements for Electrical Installations - IET Wiring Regulations.' BS 7671 [Ref 30.N]

NOTE *By providing electrical connection between the reinforcement in the foundations, holding down bolts and metal gantries, it can be possible to achieve adequate earth without the need for earthing rods.*

4.36 If reinforcement is employed in earthing arrangements, tests shall be made in dry conditions at each location to ensure that adequate earthing has been achieved.

4.37 A conduction path, to convey lightning strikes from all parts of the structure to earth, shall be provided in accordance with the appropriate parts of 'Protection against lightning' BS EN 62305 [Ref 28.N].

5. Appearance

General requirements for gantries

5.1 Gantries shall be designed and located, within the restrictions of the Overseeing Organisation's requirements to minimise visual impact and form part of an overall design solution that is sympathetic to both the location and landscape.

5.1.1 Gantries should be located low in the landscape, preferably in a cutting and not visible above the skyline.

5.1.2 Where gantries cannot be located low in the landscape a sympathetic appearance to the structure should be adopted.

5.2 The benefits of physical and vegetative visual barriers in mitigating the visual impact created by the gantry shall be assessed.

5.3 Material, form and colour contribute to the overall aesthetic and shall be included as part of the gantry design proposal to the TAA.

5.4 Mitigation for the visual impact of the gantry shall be provided as part of the gantry design proposal to the TAA.

NOTE 1 *In practice there are overriding functional constraints which establish the required location and size of signs and gantries in relation to road geometry and proximity to junctions.*

NOTE 2 *Requirements of the Overseeing Organisation are provided in LA 101 [Ref 23.N] and LA 117 [Ref 25.N] for locating gantries and signs in their landscape setting.*

NOTE 3 *The DMRB documents in Volumes 10 and 11 advise on the environmental assessment of highway schemes to identify, in particular, the visual impact created by the location of highways and highway features including signs and gantries, together with methods of mitigating such impact.*

5.5 Visual impacts shall be assessed and minimised in relation to:

1) the quality of landscape, urban and rural, in which the gantry is proposed, such as 'designated landscapes';
2) the extent of the visual envelope created, day and night;
3) the number of residential properties affected, day and night;

NOTE *Gantry construction can cause visual impact upon the surrounding landscape both during the day, and by any associated lighting during the hours of darkness.*

5.6 Information collected in assessing the visual impact shall be presented in the textual and environmental framework format required by LA 117 [Ref 25.N].

5.7 Assessment of visual impact caused by lighting shall be evaluated.

Form and aesthetics

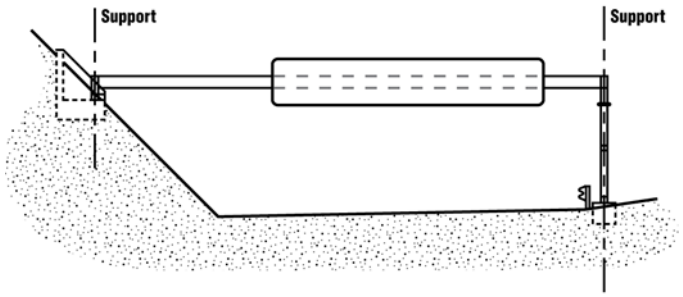
5.8 Gantries shall be designed as an integrated part of a total design solution of a road scheme, both urban and rural.

5.8.1 Satisfactory aesthetics may be achieved by including the following features in the design:

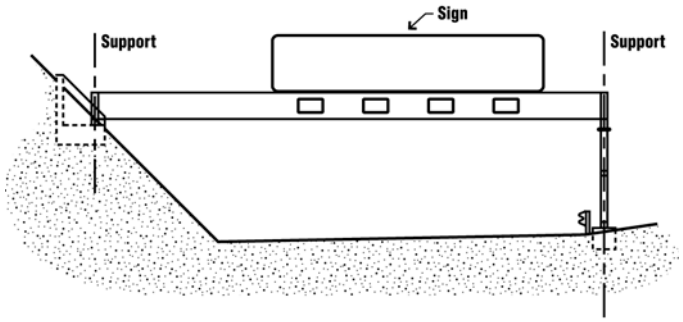
1) simplicity and unobtrusiveness;
2) visually light and uncluttered structures;
3) continuity of design with other highway elements;
4) appropriate use of colour (see also 'Colour' in this section);
5) appropriate use of materials. Modern materials can help produce gantries more appropriate to placing in the countryside and overcome the somewhat technical or mechanistic appearance of recent gantries, which are more appropriate to an urban than rural setting.

6) spanning over several carriageways/slip roads to reduce number of vertical supports;
7) spanning more than the minimum distance between vertical barriers or bunds for a more integrated appearance [see Figure 5.8.1];
8) balancing the visual impact of the need to illuminate signs against endeavouring to reduce the visual impact of lighting when viewed from outside the highway;
9) proportioning signs in relation to gantry and other highway elements;
10) omission of walkways, excessive structure, superfluous retaining walls and concrete plinths and bases, wherever possible;
11) creating an aesthetic link between different elements of the highway design including gantries, signs, fencing, other structures and the like.

Figure 5.8.1 Examples of design of gantries for a more integrated appearance



a) Without signals.



b) With signals.

Colour

5.9 The requirements for form and aesthetics of gantries shall be applied to the use of colour on gantries.

5.10 The colour of a gantry shall assist in promoting the function of communication, not compete with it.

NOTE 1 Advice on choosing the colour for a gantry is provided below:

1) Mid-to-soft grey is most appropriate for the British climate and most acceptable to the representative design bodies, especially when viewing a feature against the sky, BS 4800 [Ref 4.I] Medium Grey 18B21 and Camouflage Grey 626 are suitable BS 381C [Ref 5.I].
2) Black has been proposed as an alternative, but draws attention to itself in all but dense woodland or avenue settings.
3) Greens are frequently bright and synthetic and fail to match the complex landscape backdrop.
4) Muted grey – green has been successful in Surrey in association with colouring lighting columns.

5) *Where their use is agreed with the TAA, the silver- grey of galvanised steel or weathered aluminium frequently integrates well.*

6) *In other European Countries innovative use of colour has made a positive contribution to the highway environment and in Britain brighter colours and transparent panels have been successfully utilised on recent noise barrier designs.*

NOTE 2 *Multi-colours are not found to enhance any particular form, however, experimentation can be carried out to find suitable solutions.*

NOTE 3 *Illustrations and computer generated impressions can assist construction experimentation with colour options.*

Screening

5.11 Forward visibility requirements towards gantries shall be checked to ensure visibility is not obscured by planting.

NOTE *Often as a condition of the mitigation commitment made to adjacent residents planting has to function as a high dense screen.*

5.12 Where possible access and cables routes to gantries shall be located to avoid planting plots.

5.12.1 A procedure should be adopted that records existing cables and accesses, and mitigates damage where existing horticultural commitments have been identified and recorded.

5.13 Where the screening of gantries by vegetation requires a depth of topsoil sufficient to sustain healthy plant growth, the displacement of topsoil for the construction of gantry bases and cabling shall be fully reinstated.

5.14 Records of long-term mitigation commitments shall be established in order to ensure that maintenance regimes accord with the preservation of the environmental and aesthetic requirements of this section.

6. Limit state design

General design requirements

6.1 Gantries shall be designed in accordance with Eurocodes 'bridge parts' and the requirements of this document.

6.2 Concrete and steel gantry structures shall be designed in accordance with the relevant parts of BS EN 1992-1 [Ref 16.N] and BS EN 1993 [Ref 17.N] and in accordance with the Overseeing Organisation's requirements for the use of Eurocodes.

6.3 Aluminium gantry structures shall be designed in accordance with the relevant parts of BS EN 1999 [Ref 18.N].

6.4 When structural materials other than concrete, steel or aluminium are proposed, the design methods and criteria, performance limits and specification shall be agreed with the TAA.

Deformations

6.5 The design of gantries shall allow for deflections due to permanent and variable actions in the serviceability limit state combinations in accordance with BS EN 1990 [Ref 13.N].

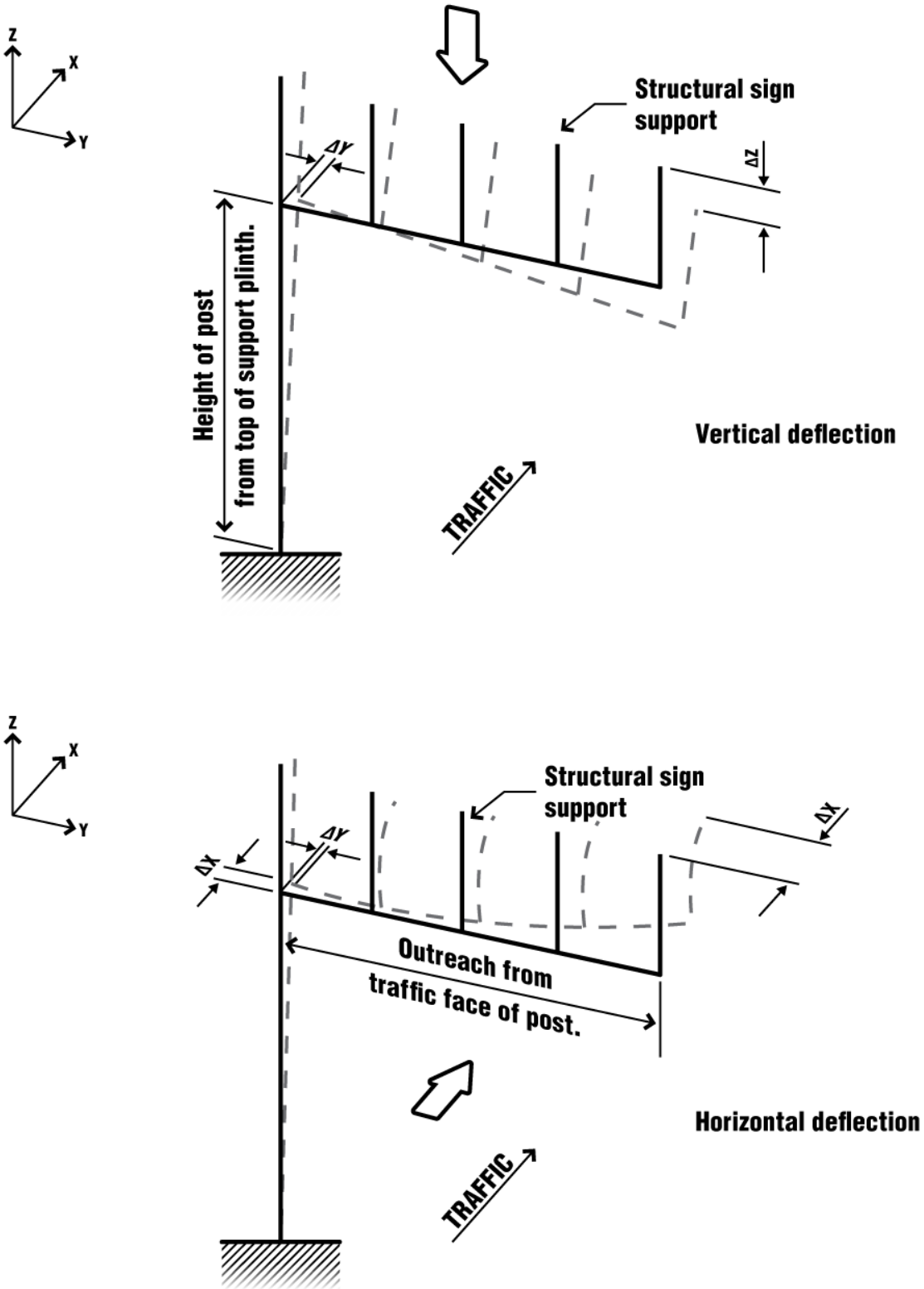
6.6 Structural deformation due to permanent actions at the centre of spans of portals or tips of cantilevers shall be counteracted by pre-camber above the chord line for portals, or the horizontal for cantilevers to avoid visible downward deformation.

6.7 Deformations in the serviceability limit state shall be limited such that they do not exceed the values given in Table 6.7 for the characteristic combination of actions. (See Figure 6.7).

Table 6.7 Limiting structural deformations of gantries

Element and position	Direction of deformation	Fixed and variable message signs and signals
Top of support of cantilever or support of portal	Horizontal (x or y)	1/300 of height
Tip of cantilever or extremity of structural sign or signal support, (see Figure 6.7)	Horizontal (x)	1/150 of outreach plus height of support and sign upright
	Vertical (z)	1/300 of outreach plus height of support
Within span of portal or extremity of structural sign or signal support	Horizontal (x)	1/200 of span plus height of support and sign or signal support
	Vertical (z)	1/300 of span plus height of support

Figure 6.7 Structural deformations of support posts and cantilevers (see Table 6.7)



6.8 The deformation at the extremities of the structural support shall be derived from the sum of the components of the effects of the actions in the supports, cantilever and sign supports.

6.9 The height of the support shall be the least vertical dimension measured from the top of any support plinth to the underside of the main horizontal structural member or signs/signal.

Fatigue

6.10 The fatigue performance of the structure shall be verified.

6.11 The fatigue life shall be assessed for the action effects obtained from wind and vehicle buffeting actions set out in Section 7 and, if appropriate, the dynamic analysis described in Section 10.

NOTE *The design working life for fatigue is set out in Section 3.*

6.12 Where forms of construction are used for which there is no adequate fatigue data, approaches to fatigue, verification, including testing where necessary, shall be agreed with the TAA.

6.13 Fatigue of steel structures shall be verified in accordance with BS EN 1993-1-9 [Ref 11.N].

Minimum thickness of metal sections

6.14 The minimum thickness of structural metal sections shall be as indicated in Table 6.14.

Table 6.14 Minimum thickness of metal sections

Steel plates and sections other than hollow sections	6mm
Steel hollow sections effectively sealed by welding, other than a small drain hole	5mm
Aluminium alloy plates and sections	4mm

Connections

6.15 All fillet welds shall have a leg length of not less than 4mm.

6.16 All fillet welds, unless contained within a closed member, shall be continuous.

Closed hollow sections

6.17 Hollow sections in all materials shall be designed to resist the ingress and retention of water or moisture by gravity flow, capillary action or condensation.

6.18 For hollow sections made out of metal, the end plate thickness shall not be less than the lesser of the following:

1) Equal to the thickness of the walls of the hollow section.
2) 8mm.

6.19 The end plates on hollow sections shall be joined by continuous structural quality welding.

6.20 Drain holes shall be provided where water could enter the hollow section in significant quantity and subsequently freezing.

6.21 Hollow sections in non-corrosive materials or galvanised steel shall be provided with drain holes at all low points.

6.22 The size of the drain hole provided in hollow sections in non-corrosive materials or galvanised steel shall be appropriate to the void being drained, but not be less than 10mm diameter.

Foundations

6.23 The design of the foundations, including holding down bolts, plinths, bases and all other structural aspects, shall be such that they have greater reserves of structural resistance than the supported gantry structure (see Section 7).

NOTE *The requirement of greater reserves of structural resistance for foundations than the supported gantry structure is to ensure that the foundations will survive an impact action intact so that a replacement support can be installed with minimum down time.*

6.24 The procedures given in BS EN 1997-1 [Ref 12.N] shall be used for the design of soil structure interaction.

6.25 The foundation shall be designed to avoid undesirable movement of the gantry due to settlements, and tilting of the foundation.

6.25.1 The adoption of recommended safe bearing resistance for the foundation design as a simplification to calculating settlements should avoid movements.

6.25.2 A separate assessment of the differential settlements and tilting of the structure should be prepared for the design of associated superstructures with built-in redundancy or cantilevers.

6.25.3 The differential settlements and tilting movements should be calculated from a displacement or consolidation analysis, and the predicted movements should be included in the overall design of the structure.

6.25.4 Reliance placed on mobilising resistance due to passive pressure acting on spread footings or pile caps particularly on the downward slopes of embankments or cuttings, filter drains or other disturbed material should be avoided.

NOTE 1 For guidance on the movement necessary to mobilise passive pressures see BS EN 1997-1 [Ref 12.N].

NOTE 2 The ultimate strength of the soil as given in BS EN 1997-1 corresponds with the following failure modes of the surrounding soil and the soil- structure interface:

1) sliding;
2) overturning;
3) bearing capacity of the foundation soil;
4) slip failure of the surrounding soil.

7. Actions

General

7.1 All actions shall be in accordance with the relevant parts of BS EN 1991 [Ref 15.N] and the Overseeing Organisation's requirements for the use of Eurocodes.

7.2 For the purpose of calculating stresses and stability, the following actions shall be calculated in accordance with the relevant Eurocode parts:

1) permanent (self-weight);
2) permanent (removable);
3) wind;
4) thermal effects;
5) snow;
6) differential settlement;
7) weight of soil;
8) accidental (vehicle collision with supports);
9) actions during execution where needed to suit proposed erection methods;
10) variable actions (imposed loading) from any walkway (refer to Section 9).

NOTE *Permanent actions (removable) include all permanent actions not forming part of the structure such as signs, equipment and other fixings attached to the gantry.*

Combination of actions

7.3 Combinations of actions shall be derived in accordance with BS EN 1990 [Ref 13.N] from applying the combination rules for footbridges.

7.4 The relevant partial factors not covered in BS EN 1990 shall be in accordance with Table 7.4.

Table 7.4 Combination of actions and partial factors

Action	Compo-nent	ULS Partial γ factors	ULS Partial γ factors (relieving)
Permanent actions (removable)	Fixed	1.2	0.95
	Removable	1.2	0
Variable actions	Thermal	1.45	0
	Wind	1.55	0
	Snow	1.5	0

7.5 Each element and the structure as a whole shall be designed to resist the effects of actions and combination of actions.

7.6 Table NA.A2.4(B) in the NA to BS EN 1990 2002 [Ref 14.N] shall be used to derive the partial factors for design values of actions in conjunction with Table 7.4, which provides values not covered by the Eurocodes relevant to gantry design.

7.7 Table NA.A2.4(A) and Table NA.A2.4(C) from the NA to BS EN 1990 2002 [Ref 14.N] shall be used directly to derive the partial factors for design values of actions.

NOTE *Using the combination rules for bridges / footbridges given by BS EN 1990 [Ref 13.N], the following applies:*

1) Snow and wind do not need to be combined with construction actions and do not need to be combined with variable actions.

2) Wind and thermal actions do not need to be applied simultaneously.

Permanent actions (removable)

7.8 The requirements of BS EN 1991-1 [Ref 7.N] on characteristic values for nominal permanent actions (removable) shall be followed.

7.9 The nominal action of a fixed sign shall not be less than 0.5kN per metre of span of gantry or outreach of cantilever

7.10 The calculated nominal permanent actions (removable) shall not be less than 1.25kN per metre of span of gantry or outreach of cantilevers.

7.11 In the case of the variable message signs, signals and associated equipment, the nominal permanent action (removable) initially assumed shall be accurately checked against the actual weights of the items to be used and, where necessary, adjustments made to the design.

NOTE The tables in Appendix A give some typical values of equipment and cabling.

Deviation of permanent actions (removable)

7.12 To determine the upper and lower characteristic values of the permanent action (removable), a deviation of the total action from the characteristic or other specified values shall be calculated.

7.13 Where the deviation of the total action from the characteristic or other specified value is determined through calculation it shall be taken equal to -20% and +25% for lower and upper characteristic values respectively.

7.14 Where the deviation of the total action from the characteristic or other specified value is determined by weighing or from data from the Overseeing Organisation's Infrastructure design guides for the various items of signal equipment, it shall be taken as equal to ±0%.

Wind action

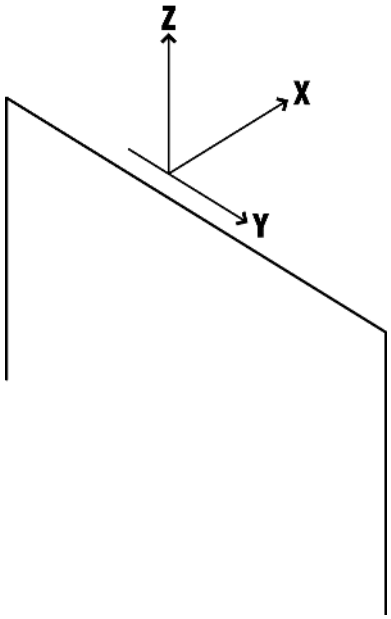
Return period

7.15 For new gantries the return period for wind effects in service shall be taken as the design life of the gantry, as set out in Section 3.

Application

7.16 The characteristic wind action in the x, y and z (see Figure 7.16) directions shall be calculated based on the requirements of BS EN 1991-1-4 [Ref 9.N] unless otherwise set out in this section.

Figure 7.16 Directions of wind actions



NOTE *Wind actions on gantries produce forces in the x, y and z directions.*

1) The x-direction is the direction parallel to the carriageway, perpendicular to the span.

2) The y-direction is the direction along the span.

3) The z-direction is the vertical direction.

7.17 The longitudinal wind action F_{wy} shall be calculated on the side elevation of the structure including any individual members not effectively shielded.

7.18 An assessment as to whether a dynamic response procedure is needed for the gantry shall be carried out in accordance with BS EN 1991-1-4 [Ref 9.N].

7.19 Where the gantry is found to be dynamically sensitive, the provisions in Section 10 of this document shall be applied.

Force coefficients

7.20 For gantries not susceptible to dynamic excitation by wind, F_{wx}, F_{wy}, F_{wz} and relevant force coefficients shall be calculated in accordance with clause 8.3 in BS EN 1991-1-4 [Ref 9.N].

Thermal effects

7.21 For new gantries the return period for thermal effects in service shall be taken as the design working life of the gantry, as set out in Section 3.

Snow action

7.22 Characteristic snow action shall be calculated in accordance with BS EN 1991-1-3 [Ref 8.N] and the recommended values set out in the national annex adopted.

7.23 The snow load shape factor, μ_i (see BS EN 1991-1-3 [Ref 8.N]) shall be taken as 0.8 for gantries.

Earth pressures

7.24 In all design situations, earth pressures generated from any retained fill shall be determined in accordance with BS EN 1997-1 [Ref 12.N].

7.25 For the ultimate strength and serviceability conditions the soil 'active' earth pressure shall be used in the design, unless otherwise agreed with the TAA.

Vehicle collision actions

Passively safe gantries

7.26 Passively safe gantries shall not be designed for the collision actions set out in 'Characteristic actions on supports' below but be designed in accordance with Section 8.

Non-passively safe gantries

7.27 When any part of the sign or structure is over the carriageway, hard shoulder or hard strip, supports shall be designed to withstand at least the vehicle collision actions in Table 7.27.

Table 7.27 Equivalent static design forces due to vehicular impact on members supporting bridges over or adjacent to roads

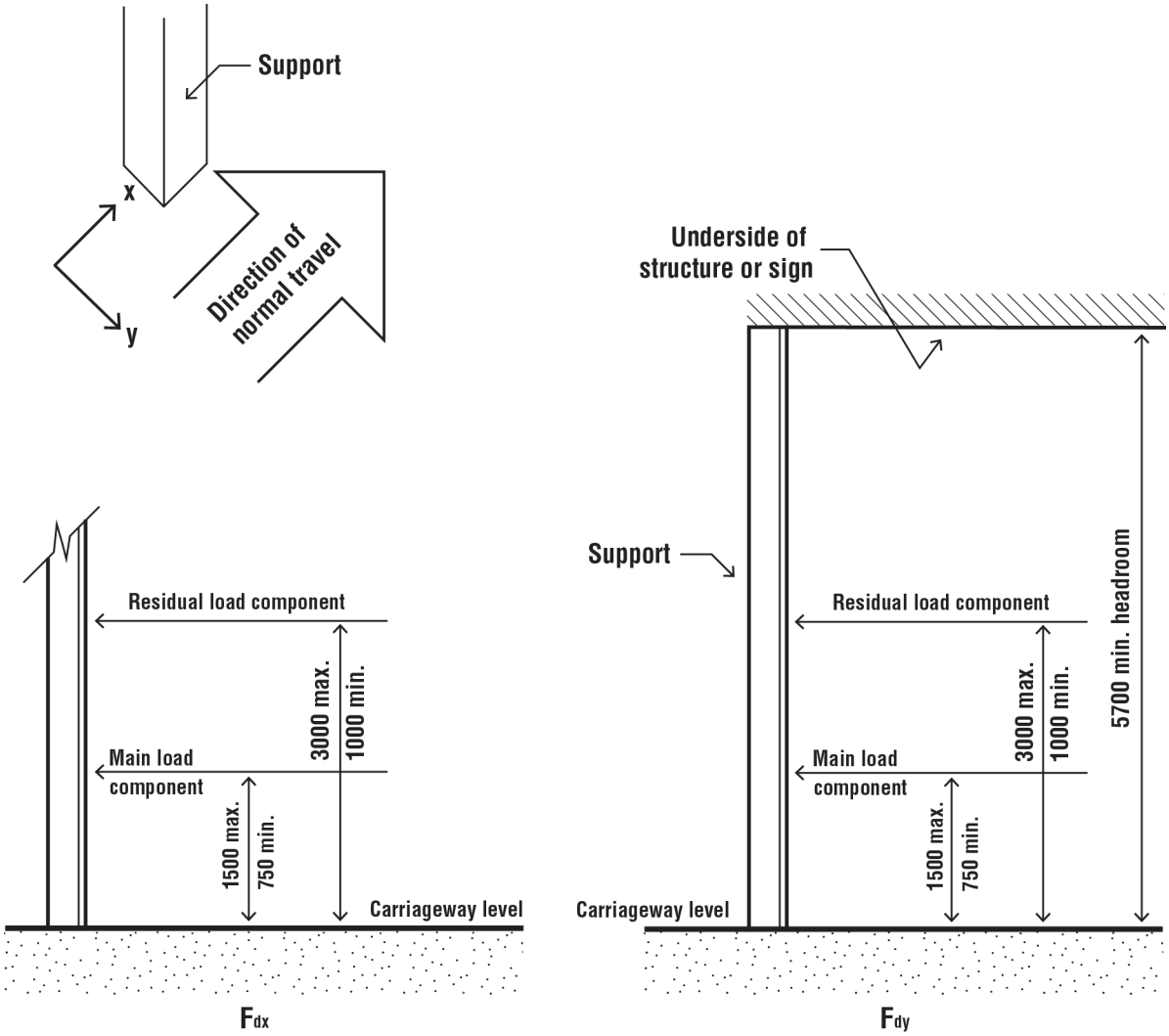
	Force F_{dx} in the direction of normal travel (kN)	**Force F_{dy} perpendicular to the direction of normal travel (kN)**	**Point of application on gantry structure support**
Sign/signal structures over motorways, trunk and principal roads			
Main action component	330	165	At the most severe point between 0.75m and 1.5m above carriageway level
Residual action component	165	85	At the most severe point between 1m and 3m above carriageway level
Sign/signal structures over other roads where speed limit ≥45 miles/h (72 km/h), for example on other rural roads			
Main action component	248	165	At the most severe point between 0.75m and 1.5m above carriageway level
Residual action component	124	85	At the most severe point between 1m and 3m above carriageway level
Sign/signal structures over other roads where speed limit <45 miles/h (72 km/h), for example on other urban roads			
Main action component	165	165	At the most severe point between 0.75m and 1.5m above carriageway level
Residual action component	85	85	At the most severe point between 1m and 3m above carriageway level

7.28 Characteristic actions on supports. A risk ranking procedure in accordance with the national annex to BS EN 1991-1-7 [Ref 6.N] shall be applied to determine the sensitivity of structure to collision.

7.28.1 For non-passively safe gantries, gantry supports in the verge should be set back from the edge of the carriageway.

7.29 Accidental collision actions on supports shall be applied in accordance with this section and including the direction and height of application are shown in Figure 7.29.

Figure 7.29 Heights of collision loadings (dimensions in millimetres)



7.30 In accordance with BS EN 1991-1-7 [Ref 6.N] main and residual actions shall be applied simultaneously, but not F_{dx} and F_{dy}.

7.31 The risk ranking factor shall be calculated in accordance with clause NA. 2.11.2.3 of the NA to BS EN 1991-1-7 [Ref 37.N].

7.32 Factor F7, deck stability factor, shall be taken as 2.0 for gantries.

7.33 For factor F8, consequence factor, $AADT_{over}$ shall be taken as 0 (except where a bridge is being used to support equipment).

7.34 Where the calculated risk ranking factor is equal to or greater than 0.5, the impact actions shall be as detailed in Table 7.27.

7.35 Where the calculated risk ranking factor is less than 0.5, the minimum robustness forces alone as set out in Table 7.35 shall be used for the design.

Table 7.35 Minimum forces to be applied for robustness of gantry supports

	Force F_{dx} in the direction of normal travel (kN)	Force F_{dy} perpendicular to the direction of normal travel (kN)	Point of application on gantry structure support
Main action component	165	165	At the most severe point between 0.75m and 1.5m above carriageway level
Residual action component	85	85	At the most severe point between 1m and 3m above carriageway level

7.36 Vehicle collision actions on supports shall be applied as part of the accidental combination of actions only.

7.37 Accidental collision actions on supports shall be applied in accordance with the principles set out in BS EN 1991-1-7 [Ref 6.N].

Accidental impact action on anchorages

7.38 For the design of anchorages for holding down bolts, plinths, bases and structural aspects of foundations, an upper and lower characteristic value of the impact action shall be determined.

7.39 The deviation between upper and lower characteristic values of the impact action shall be as follows:

1) for holding down bolts, plinths, bases and structural aspects of the foundations equal to +20% and 0%;
2) for all other structural elements, a deviation of ±0%.

NOTE *This is to ensure that holding down bolts, plinths, bases and structural aspects of the foundations have a greater reserve of strength, so that, in the event of a severe impact, they will survive and a replacement gantry support can be fitted.*

Fatigue

Fatigue actions due to high vehicle buffeting

7.40 The gantry shall be designed for buffeting actions from high-sided vehicles in accordance with DMRB 'Design of Minor Structures' CD 354 [Ref 4.N].

Fatigue actions due to wind gusting

7.41 Fatigue actions due to wind gusting shall be determined in accordance with BS EN 1991-1-4 [Ref 9.N].

7.42 The characteristic wind action shall be calculated as set out in 'wind actions' above.

7.43 The effects of wind shall be combined in a Miner's summation using the data set out in Figure B.1 of BS EN 1991-1-4 [Ref 9.N] for the full range of cycles given in this figure.

Effect of fatigue actions

7.44 The design working life for fatigue purposes shall be in accordance with Section 3.

7.45 The fatigue effects from high vehicle buffeting and wind gusting shall be combined in a Miner's summation calculation to give a value of less than unity; see Annex A [normative] 'Determination of fatigue load parameters and verification formats' in BS EN 1993-1-9 [Ref 11.N].

8. Performance and other requirements for passively safe gantries

8.1 The need for passively safe gantries shall be assessed in accordance with Section 2.

8.2 In order to ensure passively safe behaviour the area as a whole shall be assessed.

NOTE *The design of passively safe gantries assumes there are no other obstructions in the area which inhibit passively safe behaviour. This is likely to involve, as an example, moving cabinets out of the possible path of errant vehicles or using passively safe cabinets.*

8.3 Passively safe portal gantries designed according to this document shall comply with the passive safety requirements set out in this section even if the gantries are protected by road restraint systems.

NOTE *The severity of accidents for occupants of a vehicle striking a gantry is typically affected by the performance of the gantry legs under impact. These can be made in such a way that they detach or yield under vehicle impact. BS EN 12767 [Ref 26.N] covers the general design of these types of structure.*

8.3.1 Gantry structures with no performance requirements for passive safety are class 0 in accordance with BS EN 12767 [Ref 26.N] and these structures should be designed in accordance with the design rules for a standard gantry in this document.

NOTE 1 *BS EN 12767 [Ref 26.N] is applicable to three categories of passively safe support structures:*

1) high energy absorbing (HE);

2) low energy absorbing (LE);

3) non-energy absorbing (NE).

NOTE 2 *Energy absorbing gantry structures slow the vehicle considerably and thus the risk of secondary accidents with structures, trees, pedestrians or other road users can be reduced.*

NOTE 3 *Non-energy absorbing gantry structures permit the vehicle to continue after the impact with a limited reduction in speed. Non-energy absorbing gantry structures can provide a lower primary injury risk to vehicle occupants than energy absorbing gantry structures.*

NOTE 4 *Gantry structures can be either energy absorbing or non-energy absorbing depending on their design.*

NOTE 5 *BS EN 12767 [Ref 26.N] requires the boom of gantries to remain 4m (or other height depending on National Regulations) above the carriageway after impact.*

8.4 Because the UK has significant numbers of vehicles above the British Standard boom height of 4m, the minimum height of gantry booms after impact shall be 5.03m.

8.4.1 Where it is not practical to comply with the gantry boom height required by the Overseeing Organisation, such as for single span gantries, the alternative of undertaking passive safety tests on the boom may be permitted by the TAA.

Siting

8.5 A gantry leg shall not be located within 2.5m of other equipment that could present a hazard to vehicles unless the interaction of the two pieces of equipment are included in the passive safety assessment.

Equipment

8.6 Gantries shall not be used to carry equipment or cabling that is more onerous in relation to passive safety than that included in the tests described in outline in this section.

8.7 The equipment that a gantry is required to carry shall be defined in the Approval in Principle (AIP).

NOTE *An illustrative list of typical equipment and cabling requirements is provided in Appendix A. The information contained in the list is for guidance only and cannot be treated as definitive.*

8.8 If special plugs or other systems are used to avoid the cabling over-constraining the structure during the passive safety tests, systems with equivalent or better performance shall be used in the real structure.

8.9 The gantry cabling shall be designed so that whichever part of the gantry is impacted, the electrical current of whatever voltage to/from the structure will be automatically isolated from a point immediately above ground level.

General requirements for passive safety testing

8.10 Passive safety testing shall be in accordance with BS EN 12767 [Ref 26.N] and section 8 of this document including the test, site, test vehicle, calibration test and test recording.

8.11 The design of the testing regime, test absorption class and the testing itself shall be verified by an independent organisation.

8.12 Details of the proposed approach to gantry testing shall be submitted with the Approval in Principle (AIP).

Severity level

8.13 The values of the acceleration severity index (ASI) and theoretical head impact velocity (THIV) shall be calculated in accordance with BS EN 1317-1 [Ref 32.N].

NOTE *The maximum severity levels for vehicle occupants involved in an impact evolution are stated in BS EN 12767 [Ref 26.N] and evaluate two criteria; (ASI), (THIV).*

Vehicle impact speed

8.14 The gantry shall be designed for one of the vehicle speed classes listed in Table 8.14.

Table 8.14 Vehicle impact speed

Speed class	Impact speed for testing (km/h)
50	50
70	70
100	100

8.15 The speed class used shall be defined in the AIP but will normally be 100 unless the road is subject to a permanent speed limit of 80 km/h or less.

8.16 Analysis shall also be undertaken for the low speed (35 km/h) test from BS EN 12767 [Ref 26.N].

8.17 If low speed analysis indicates that this is a worst case, testing for the low speed test in BS EN 12767 [Ref 26.N] shall also be carried out with the real equipment installed.

Foundations

8.18 Foundations shall transmit the reactions from the structure safely to the supporting ground.

NOTE *Traditional gantries have typically utilised spread footings where possible, although piled foundations have also been used where ground conditions are poor or where their use proved cost effective. It is anticipated that passively safe gantries designed to this document are likely to be lighter in weight and subjected to less onerous wind actions than traditional gantries and alternative forms of foundations can be considered.*

8.19 Where alternative forms of foundations are proposed the designs shall be assessed.

8.20 The design for alternative forms of foundations shall clearly define:

1) the materials used,
2) the requirements for workmanship and,
3) the requirements for testing.

Characteristic foundation design actions

8.21 Foundations shall be designed for the following characteristic actions:

1) the applied shear force that would cause shear failure of the gantry leg;
2) the applied moment that would cause flexural failure of the gantry leg combined with a coexistent shear force determined, assuming that the applied moment is caused by a point load acting at 0.6m above ground level.

8.22 The actions above shall be combined with either zero axial load or the axial load induced by the weight of the gantry, whichever gives the most onerous effect.

8.23 The structure shall be designed to yield or fail leaving the foundation unaffected and reusable. (see clause 6.23 of this document).

8.24 Where it can be demonstrated that the foundation is significantly stiffer than the gantry, it shall not normally be necessary to replicate the foundation to be used at a specific installation in the test.

8.25 Where testing is carried out with a foundation significantly stiffer than the gantry the connection to the foundation used in the testing shall be the same as that to be used at the final installed location.

8.26 Where the type of foundation is not significantly stiffer than the gantry structure it shall be necessary to include the foundation in the testing.

Equipment on gantry during testing

8.27 The gantry shall be tested with all equipment in position.

8.28 The equipment shall include any cabling that crosses sections of the gantry predicted to yield or detach including typical underground cables and connection boxes and/or fuse units where applicable.

8.29 If it is proposed to avoid testing the gantry with all the electronics in place, the corresponding cabinets shall be ballasted to match the weight and centre of gravity of the individual items of equipment.

8.29.1 On structures that require boom tests, additional measures may be required to ensure that this does not result in major differences in the inertia or stiffness of cabinets compared with those with the real equipment installed.

8.29.2 Where otherwise similar gantries are to be used with different spans only one span may be tested provided calculations or other evidence are submitted to show that the tested span is the worst case.

8.30 If calculations and other evidence are not available to supplement the findings of the sole gantry test, or if the results are inconclusive, the longest and shortest spans shall be tested.

Two-span gantries

8.31 For 2-span gantries, separate tests for the centre and an outside leg shall be undertaken.

8.32 Where leg tests are required for a passive safety test on the boom (ref. clause 8.40) separate boom tests shall be undertaken.

Leg impact test

8.33 Impact tests shall be conducted on the legs in accordance with BS EN 12767 [Ref 26.N] and Section 8 of this document.

8.34 For multi-legged supports structures with intended installation perpendicular to the carriageway (and where the projected clear openings at the 20° impact direction between the support structure legs are not less than 1.5m at any point within the height of the vehicle) the tests shall be carried out against one leg, with the test vehicle impact point central to that leg.

8.35 Where projected clear openings between legs on multi-legged support structures are less than 1.5m at any point within the height of the vehicle, the tests shall be carried out against two legs with the test vehicle impact point aligned midway between two supports.

8.36 Where the test on a structure with two legs in one verge or central reserve is carried out against one of these legs, rather than both, an explanation shall be provided to the satisfaction of the TAA either of the choice of which one to test or of why the behaviour should be similar.

8.37 If it is not possible to provide explanation of why the behaviour of both legs should be similar, separate tests for each leg shall be undertaken.

8.38 The structure shall be deemed to pass the test provided it complies with BS EN 12767 [Ref 26.N] including the requirements for the speed class impact test for the HE1, LE1 or NE1 class and provided the boom remains attached to the leg not being tested.

8.38.1 More severe requirements (for example with an occupant safety level 2 in place of 1) may be specified by the TAA if required.

Requirements for passive safety test on boom

8.39 If the boom height over the intended carriageway position 15 minutes after the test is less than the required vertical height at any point, a passive safety test on the boom shall be undertaken in accordance with clauses 8.38 to 8.42.

8.40 Where the boom height after the test is greater than the required vertical height, a passive safety test on the boom shall be undertaken unless it is demonstrated to the satisfaction of the TAA that the boom would not fall below this height even if the leg was impacted by an HGV.

8.41 Where the required boom height after the test cannot be demonstrated by calculation, then a test shall be undertaken.

8.42 If required, the HGV leg impact test shall be undertaken with the rigid 30,000kg vehicle specified in BS EN 1317-1 [Ref 32.N].

8.43 The requirements for the HGV leg impact test shall be the same as for the car leg impact test apart from the following criteria:

8.44 Where leg tests are required for a passive safety test on the boom (ref. clause 8.40) separate boom tests shall be undertaken.

Testing of boom

8.45 If the boom height after the leg test is greater than 1m at all points above ground level, it shall be reconfigured so that the boom touches the ground at the end where the leg test was undertaken.

8.46 Where the boom height after the leg test is not greater than 1m at all points above ground level, the boom test shall be undertaken with the gantry in the condition in which it finished the leg test.

8.47 The test shall be undertaken on the same basis and with the same performance requirement as the leg test except for the following conditions.

1) The car will impact from a direction parallel to the carriageway +2°.
2) The vehicle will be aligned to impact the gantry boom at the worst case position.
3) There is no requirement for predictability.

NOTE *It is possible that the worst case position does not occur at the point where the boom touches the ground, since a more critical case could arise when the boom impacts higher on the vehicle.*

8.48 The exact position chosen as the worst case for the boom test shall be justified to the TAA.

9. Design of gantries with permanent maintenance access

9.1 Where the risk assessment in Section 2 identifies a need for permanent maintenance access then the provisions within this section shall apply.

9.2 The design shall assess and record how inspection and maintenance access is to be provided and a methodology developed and submitted as part of the Technical Approval process.

9.3 The design shall include any fixing points, hard points, handrails, ladders, etc. required on the gantry structure to facilitate this access.

General requirements

9.4 When permanent access is provided, the appropriate control of physical access by users of such a facility shall be identified.

9.5 A permanently fixed metal plate or inscription, stating the maximum number of persons and weight of equipment, in characters not less than 10mm high, shall be positioned where it can be read from the point of access.

9.6 Where a fixed walkway or platform is required to enable maintenance of signs, technology/signal equipment and/or lighting, to be carried out, the following requirements shall be met.

1) the minimum clear width of the walkway, excluding cable trays and/or working space to maintain equipment, is 0.6m;
2) on gantries where several sets of equipment could need to be maintained simultaneously, the clear width of the walkway/platform, including cable trays, is not less than 1.5m;
3) an overhead clearance of not less than 2.1m desirable, 1.5m absolute minimum, is provided;
4) wherever the headroom is less than 2.1m, risks associated with a lower than required headroom have to be considered and suitable mitigation provided. As a minimum, warning signs are provided including a notice indicating that protective head gear is to be worn. The potential for damage to the signals and other associated equipment by users of the walkway/platform is to be taken into account;
5) walkways are of open mesh type unless the requirement for a solid walkway is justified on a scheme specific basis;
6) the openings in the mesh prevent the passing of a ball 5mm in diameter;
7) the walkway surface is horizontal with nominal falls where appropriate to drain surface water;
8) the surface of all walkways on gantries have a non-slip finish;
9) the slip resistant finish has an effective life of at least ten years with a slip resistance of 65 units when new, and retain not less than 45 units throughout this period. Slip resistance will be tested using a portable skid resistance pendulum tester or equivalent.

Ladders

9.7 Where access ladders are required, they shall meet the general requirements of 'Ladders for permanent access'; Class B BS 4211 [Ref 33.N].

9.8 Where the public has pedestrian access to the highway upon which the gantry is located, the risk assessment shall include the provision of a gate across the bottom of the ladder enclosure or hinged flap with a latch capable of accepting a padlock and the lower length of the enclosure made un-climbable, such as by the provision of mesh infill round at least the lower 2 metres of the ladder enclosure and any ladder supports.

NOTE *Experience to date suggests that gantries on motorways are not at risk from unauthorised access, whereas on public highways the risk can be dependent on the locality.*

9.9 Gates or hinged flaps are a possible hindrance to authorised personnel and shall only be fitted where experience indicates they are necessary.

Mitigation of vandalism and theft

9.10 A risk assessment shall be undertaken in accordance with the Overseeing Organisation's requirements where a gantry is at risk from unauthorised entry, theft or vandalism.

9.11 Where a risk is identified, mitigation shall be put into place in the design to address this where it is recognised that gantries are generally at risk from unauthorised entry, particularly where the supports are adjacent to retaining walls, or the possibility exists that the enforcement equipment might be the target of vandalism.

9.11.1 Mitigation measures to secure gantries may include one or more of the following:

a) install gates or doors across the bottom of the safety cage on the access ladders;
b) stop the access ladder short of the ground to which it is necessary to attach a temporary ladder brought to site by the operative;
c) provide a plank or sheet of metal that can be installed and locked across the rungs of the lower part of the ladder.

9.12 The effects of any mitigation measures shall be assessed and recorded as part of the submission to the TAA.

Handrails

9.13 A safety handrail 1.1m high above the walkway or other accessible horizontal surface shall be provided round all walkway surfaces that are not protected by other means of similar height.

9.14 All edges of the walkway shall be provided with the minimum of a solid up-stand at least 150mm high in the plane of the handrail.

9.15 To prevent any items falling onto the carriageway, those parts of the walkway handrail over the carriageway and at least 1.5m beyond the back of the hard-shoulder/ strip or verge shall be infilled with either solid plate or with mesh with openings that will prevent the passing of a ball 5mm in diameter, or a combination of both.

9.16 Handrails and infill panels shall be in accordance with 'Protective barriers in and about buildings' BS 6180 [Ref 29.N].

9.17 The category shall be as defined in Table 1 of the BS 6180 [Ref 29.N].

Lifting equipment

9.18 Where lifting equipment is provided, lifting points and davits shall be provided to carry a safe working load of 100kg (1.0kN).

9.19 A permanently fixed metal plate or inscription, stating the maximum safe working load, in characters not less than 10 mm high, shall be positioned either adjacent to the hook or on the davit.

9.20 All lifting equipment shall be tested in accordance with the current requirements.

9.21 Lifting equipment shall be positioned over the back of the hard shoulder or hard strip, unless otherwise agreed.

Variable actions (imposed loading)

9.22 On gantries of the portal and cantilever types, characteristic imposed load shall consist of at least 0.5 kN per metre run of the usable length of walkway.

9.23 Cantilevers with an outreach of less than 7.5m, shall be checked for characteristic imposed load consisting of two 1.0 kN point actions acting vertically downwards spaced 0.5m apart and positioned at any point on the walkway or maintenance platform.

9.24 Walkways and maintenance platforms shall be designed for the local effects of two 1.0 kN characteristic point actions acting vertically downwards spaced at 0.5m apart and applied at any point.

9.25 Combinations of actions shall be derived in accordance with BS EN 1990 [Ref 13.N].

9.26 The relevant partial factors and combination factors not covered in BS EN 1990 [Ref 13.N] shall be in accordance with Table 9.26.

Table 9.26 Relevant partial factors and combination factors

Action	Component	ULS Partial γ factors	ULS Partial γ factors (relieving)	Combination factors		
				ψ_0 (combination)	ψ_1 (frequent)	ψ_2 (quasi-permanent)
Variable Actions	Imposed Loading	1.35	0	0.4	0.4	0

10. Dynamic analysis for a dynamically sensitive gantry

10.1 Structures shall be assessed to determine if dynamic effects are significant.

NOTE 1 Gantries that are deemed to be dynamically sensitive structures can be subject to vibration due to aerodynamic effects from environmental wind and/or vehicle buffeting (See clause 7.20).

NOTE 2 In addition to inducing forces in excess of those applied in a static analysis at the ultimate limit state, this has three other implications for design:

1) it can have significant torsional action in addition to the flexural action;

2) it can also induce significant cyclic stresses which have to be included in the analysis to avoid premature fatigue failures;

3) it can have excessive vibration effects which can either damage equipment or prevent it working effectively.

NOTE 3 For conventional steel gantries, dynamic effects become significant around spans of 20m.

NOTE 4 More flexible structures can be dynamically sensitive at spans under 20m, unless there is prior experience of similar structures indicating that dynamic analysis not needed.

10.2 Dynamic sensitivity of a gantry shall be calculated in accordance with BS EN 1991-1-4 [Ref 9.N] and PD 6688-1-4 [Ref 1.N] except where cross structure wind dynamics is the action being applied.

10.3 Basic design wind speed and factors shall be determined in accordance with Section 7 of this document.

10.4 The structure shall be analysed under the characteristic wind actions and the factors given in Section 7 applied to the effects where wind is the leading action.

NOTE Simple dynamic analyses such as those given in Section 10.12.1 below, assume that the wind action is not affected by the movement of the structure.

10.5 Structures shall be checked to ensure that they are not subject to aerodynamic effects.

10.6 Where it is proposed to use more realistic approaches, such as wind tunnel tests or CFD (computational fluid dynamics), this shall be defined in the AIP and agreed with the TAA.

10.6.1 In the absence of more realistic approaches, susceptibility to aerodynamic effects may be determined in accordance with Section 10.17.

10.7 The dynamic effects of ambient wind actions shall be applied for ULS, SLS and fatigue checks.

10.8 The dynamic effects of vehicle buffeting shall only be included in fatigue checks.

10.9 The structure shall be checked in accordance with clauses 6.1 to 6.4 for the maximum ultimate effects from the dynamic analysis.

10.10 The structure shall be checked in accordance with clauses 4.6 to 4.11 for fatigue using the forces determined from the dynamic analysis.

10.11 The maximum (unfactored) vibration of equipment from the dynamic analysis shall comply with clause 4.5.

Approach for conventional dynamic analysis

10.12 In the absence of more rigorous approaches, such as using wind tunnel tests or CFD, the following approach shall be adopted for the dynamic analysis.

10.12.1 The main dimensions of the structure may normally be determined first from a static analysis and the following approach may be used for the dynamic analysis.

1) Determine the frequencies and modes of vibration from an eigen value analysis.

2) Check if aerodynamic effects are likely to be significant using clause 10.17.

3) Generate a wind time-history using the following assumptions:
   a) An annual probability of exceedance of Q = 0.02 to calculate the probability factor (corresponding to a mean recurrence interval of 50 years).
   b) Direction factors for dynamic and fatigue analyses should be calculated from BS EN 1993-3-1 [Ref 10.N] and BS EN 1993-1-9 [Ref 11.N]. Wind pressure waves can be applied in angular sectors (e.g. twelve 30° sectors).
4) Determine local exterior pressures on the surface for an historical or simulated wind record for a critical time period. Step through the wind speed data to determine a time history of the resulting peak pressures for each pressure measurement location on the gantry surface.
5) If, in accordance with clause 10.17, aerodynamic effects are significant, modify the amplitude of the time history gust wind actions, where required, according to clause 10.18 to allow for aerodynamic characteristics of the gantry structure.
6) Check the factored envelope of the effects from this analysis for ultimate strength where wind is the leading action.
7) Use the calculated responses to derive the translational acceleration records for different locations on the gantry structure. The acceleration spectrum densities (ASD) should be calculated using Fourier transformation of the time history data.
8) The maximum (unfactored) vibration of equipment from this analysis should comply with the requirements of clause 4.5.
9) Check the stress history from the analysis for fatigue in accordance with clauses 4.6 to 4.11.

Vehicle buffeting effects

10.13 Fatigue effects from high vehicle buffeting shall be evaluated.

10.14 The gantry shall be designed for buffeting actions from high sided vehicles.

10.15 The actions on the boom structure and attachments shall be taken as given in 'Design of minor structures' CD 354 [Ref 4.N] for cantilever arms and attachments.

10.15.1 The actions on the boom may be treated as static actions.

10.16 Buffeting effects criteria shall be agreed with the TAA prior to AIP submission and included in the AIP.

Aerodynamic sensitivity

10.17 An initial assessment to BS EN 1991-1-4 [Ref 9.N] shall be undertaken to determine if the structure is likely to be sensitive (susceptibility parameter) to aerodynamic excitation.

10.17.1 This should be based on the first natural frequency determined from eigen value analysis.

10.18 If the structure is found to be sensitive, an aerodynamic assessment shall be carried out.

10.18.1 The following approach may be used for an aerodynamic assessment:

1) Determine turbulence intensity in accordance with BS EN 1991-1-4 [Ref 9.N].
2) Determine a comprehensive set of aerodynamic parameters for the structure using a suitably (i.e. aerodynamically) accurate code calculation, instruments and/or CFD simulation. These parameters include: the static coefficients (lift, moment, drag etc.). These quantities are to be used in the analytical simulation.
3) Using a detailed numerical (generally finite element) dynamic model of the structure, determine a set of eigen values and eigen vectors and a corresponding set of generalised inertias. Generally, this includes at least 15 to 20 modes, but in some cases more can be required.
4) Develop an analytical framework and computational aids for synthesising the above data. Evaluate the interaction of multiple modes for very sensitive gantry structures.
5) Using the results of this analysis, modify the actions used in clause 10.12.1 point 5 (approach for conventional dynamic analysis).

6) For long-span gantry structures with bluff type sections in smooth flow, examine the divergent vibration called galloping.
7) In turbulent flow, evaluate the divergent amplitude vibration (which can turn out to be less divergent but more random).
8) Evaluate the aerodynamic forces acting on the typical cross section (i.e. circular, rectangular) in smooth and turbulent flow in order to examine the turbulence effects on galloping stability.
9) For flexible long-span gantries, calculate the Power Spectral Density Functions (PSDFs) of the fluctuating lift, at rest, to examine the effect of wind.
10) Evaluate the turbulence effects (which can broaden the peaks of the PSDF of the lift).
11) For portal gantries susceptible to aerodynamic effects, it can be necessary to evaluate the unsteady lift forces which can be measured by the forced oscillation method.
12) Evaluate the vortex-induced vibrations (which can also take place in long-span gantry structures at wind speeds considerably lower than their design wind speed) for the stability of gantry structure.
13) Carry out an accurate calculation for the amplitude of vortex-induced vibrations for the design of long-span gantry structures.
14) Study the mechanism and countermeasures of the vortex-induced vibrations in the design.
15) Examine the vortex-induced vibrations of vertical bending mode for flexible portal gantries in smooth flow.
16) In turbulent flow, the reduction of the amplitude of the vortex-induced vibrations can be evaluated. An example of the application of the approach to bridge structures is given in Davenport, A.G. 1962, "Buffeting of a suspension bridge by storm winds", Proc. ASCE, Vol. 88 [Ref 1.I].
17) Define an approach in the AIP and agree with the TAA, where the effects of galloping and vortex induced vibrations are found to be significant and specialist expertise is likely to be required.
18) Define assumed values in the AIP and agree with the TAA, where the analysis is also sensitive to the assumed damping.

11. Equipment and cabling

General

11.1 The equipment that a gantry is required to carry shall be defined on a project-specific basis.

NOTE This section outlines the typical equipment, signs and cabling that can be included on a gantry.

Overloading of information

11.2 The amount of information provided on a sign shall be limited to minimise overloading of information.

Separation of functions

11.3 The functions of displaying signs and signals on gantries shall be separated.

11.4 When a design to accommodate both sign and signal functions is required for reasons of limited space and economic considerations, this shall be agreed with the TAA without the need for a departure from standards.

11.4.1 Dedicated structures to support signs alone should be used to reduce overcrowding of information and visual impact of the gantry.

NOTE By placing the beam member at the centre of the sign area, torsional actions on the structure can be reduced.

11.4.2 Dedicated structures to support signals alone should be used to reduce information and visual intrusion of the gantry structure.

11.4.3 Gantries carrying both signs and signals should be avoided in order to minimise information on signs and to simplify structural requirements.

Directional signs

11.5 The layout of the sign must be in accordance with 'The Traffic Signs Regulations and General Directions' TSRGD 2016 [Ref 36.N].

Illumination of signs

11.6 Motorway gantries shall be lit.

11.6.1 The light spill beneath signs for non-access gantries should be evaluated in the lighting design as their open nature on non-access gantries can create a problem in this regard.

External lighting

11.7 Luminaires shall be positioned to achieve the luminance required by BS EN 12899-1 2007 [Ref 19.N] across the whole area of the sign face.

11.7.1 Positioning of luminaires should fulfil maintenance requirements for the luminaires and for other equipment mounted on the gantries.

Internal lighting

11.8 Where internal illumination is envisaged, a suitable light source giving sufficient light to evenly illuminate the area of the sign face shall be provided.

Variable message signs

11.9 Where variable message signs (VMSs) are required, gantry designs shall allow for their mounting and for their associated control equipment, together with their subsequent removal for maintenance and replacement.

Maintenance of signs

11.10 Inspection and maintenance of traffic signs shall be carried out in accordance with CS 125 [Ref 22.N].

11.11 Traffic signs shall be cleaned in accordance with the DMRB Traffic Signals and Control Equipment documents (mainly document CS 125 [Ref 22.N].

NOTE *In industrial areas, annual cleaning is preferred to prolong the life of the sign.*

11.12 Bulk replacement of lamps for illuminated signs shall be evaluated to minimise the out of course maintenance visits.

11.13 Rotating prism VMSs shall be maintained on the same basis as scheduled maintenance of signals.

NOTE *Rotating prism VMSs have a high maintenance need.*

11.14 Installation of road luminaires with IP65-rating enclosures shall be evaluated to reduce the need for cleaning to the same intervals as lamp changing.

Mounting of signs

11.15 Signs shall be mounted at a small inclination to the vertical where this would improve visibility.

11.16 The structural member to which the sign is to be attached shall be flush-faced and suitable for use with bands or clamps to fasten the signs.

11.17 Projecting bolt heads and cover plates, that prevent the sign from being fixed in one plane, shall be avoided.

11.18 The design of the sign support members shall be such that subsequent resigning to the required sizes can be implemented without major disruption to the main members of the gantry.

11.19 The sign support members shall be readily capable of being removed and replaced to suit revised sign configurations.

11.20 Where signs are to be mounted on the top of a beam or girder and a light screen independent of the sign panel is to be provided, the screen shall have a horizontal straight top edge after allowing for any pre-camber and/or deflection under self-weight.

11.21 The sign support members shall be plumb in elevation.

11.21.1 Header rails should be used to achieve plumb sign support members.

Motorway signals

11.22 Motorway signals shall comply CS 125 [Ref 22.N], and the provisions within CD 146 [Ref 27.N], CD 127 [Ref 3.N], CD 122 [Ref 20.N], CD 109 [Ref 21.N].

NOTE *Descriptions of the different types of signals and design guidance for their implementation is given in CD 146 [Ref 27.N].*

Closed circuit television cameras

11.23 Where it is required to locate closed circuit television (CCTV) cameras on gantry structures, the position of the camera shall be such that a clear, unimpeded view of the motorway is provided.

NOTE *Where fixed cameras are used, the field of view will depend on the coverage of other cameras within the overall CCTV scheme.*

11.24 A CCTV mast shall be incorporated on the gantry if an evaluation determines this would be beneficial.

11.25 Allowance shall be made for CCTV camera maintenance.

NOTE *Where CCTV cameras are fixed at higher level on gantry structures including provision for winching down would reduce the risks associated with using mobile access platforms.*

Signal control equipment

11.26 Signal control equipment shall be mounted so that it can be readily accessed for maintenance from the maintenance walkway or a mobile access platform.

11.26.1 For maintenance, operational and safety reasons signal control equipment should remain on the gantry structure, close to the signals themselves.

NOTE *Signal control equipment includes equipment for power distribution, communications links and signal drivers.*

Mounting of signal equipment

11.27 The design of lane signal mountings shall be able to accommodate all types of existing equipment without the need for major modifications.

11.28 The design shall assess and record the benefits of making provision for the addition of unspecified additional equipment at a later date without the need for structural check and preferably need for interference with any structural element.

NOTE *Equipment plates with a matrix of holes or a proprietary racking system could be considered.*

11.29 Where gantries have a combined function the design shall ensure that the sign face, including the junction number and distance marker, can be viewed without visual obstruction and that information over-loading will not occur.

Power distribution

11.30 If a gantry walkway is provided, power sockets along the walkway shall be provided for use by maintenance personnel if an evaluation finds power sockets would be beneficial.

NOTE *Typically these would be used for test equipment, power tools and lifting hoists.*

Third party equipment

11.31 The presence of equipment provided and installed by a third party, usually for vehicle detection, shall only be permitted when there is no practical alternative.

11.32 The duplication of any third-party equipment on gantries shall be avoided.

Ground level installations

11.33 Electrical cabinets shall be located so as to be unobtrusive and integrated with the landscape design where possible.

NOTE *Where signals are installed on gantries or lighting is provided, electrical cabinets are usually required adjacent to the gantry.*

11.34 Ducts for electric supply and communication cables shall be provided from the cabinet to the base of the superstructure and cable routes along the highway.

Access to gantries

11.35 A hard standing area at the base of the gantry ladder and between the ladder, cabinet and point of entry from the highway shall be installed, together with steps and hand-railing as appropriate.

11.36 Where practical, provision shall be made in the vicinity of the gantry for a car or light van to drive off the highway clear of other road users.

NOTE *The provision of an adjacent vehicle lay-by behind a gap in any safety fencing for the use of maintenance staff would reduce the risk from vehicle collision while stopped on the hard shoulder.*

12. 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 1.N	BSI. PD 6688-1-4, 'Background information to the National Annex to BS EN 1991-1-4 and additional guidance'
Ref 2.N	BSI. BS 7430, 'Code of practice for protective earthing of electrical installations'
Ref 3.N	Highways England. CD 127, 'Cross-sections and headrooms'
Ref 4.N	Highways England. CD 354, 'Design of minor structures'
Ref 5.N	Highways Agency. TR 2130, 'Environmental Tests for Motorway Communications Equipment and Portable and Permanent Road Traffic Control Equipment, 5.2 Vibration, Random, Operational'
Ref 6.N	BSI. BS EN 1991-1-7, 'Eurocode 1 - Actions on structures - Part 1-7 General actions - Accidental actions'
Ref 7.N	BSI. BS EN 1991-1, 'Eurocode 1- Actions on Structures'
Ref 8.N	BSI. BS EN 1991-1-3, 'Eurocode 1: Actions on structures. General actions - Snow loads'
Ref 9.N	BSI. BS EN 1991-1-4, 'Eurocode 1: Actions on structures. Part 1-4: General actions – Wind actions'
Ref 10.N	BSI. BS EN 1993-3-1, 'Eurocode 3 - Design in steel structures - Towers, masts and chmineys - towers and masts'
Ref 11.N	BSI. BS EN 1993-1-9, 'Eurocode 3. Design of steel structures. Fatigue.'
Ref 12.N	BSI. BS EN 1997-1, 'Eurocode 7: Geotechnical design - Part 1: General rules'
Ref 13.N	BSI. BS EN 1990, 'Eurocode: Basis of structural design'
Ref 14.N	BSI. NA to BS EN 1990, 'Eurocode: Basis of structural design' , 2002
Ref 15.N	BSI. BS EN 1991, 'Eurocode 1: Actions on structures'
Ref 16.N	BSI. BS EN 1992-1, 'Eurocode 2: Design of concrete structures'
Ref 17.N	BSI. BS EN 1993 , 'Eurocode 3: Design of steel structures'
Ref 18.N	BSI. BS EN 1999 , 'Eurocode 9: Design of Aluminium Structures'
Ref 19.N	BSI. BS EN 12899-1, 'Fixed, vertical road traffic signs. Fixed signs' , 2007
Ref 20.N	Highways England. CD 122, 'Geometric design of grade separated junctions'
Ref 21.N	Highways England. CD 109, 'Highway link design'
Ref 22.N	Highways England. CS 125, 'Inspection of traffic signs'
Ref 23.N	Highways England. LA 101, 'Introduction to environmental assessment'
Ref 24.N	Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges'
Ref 25.N	Highways England. LA 117, 'Landscape design'
Ref 26.N	BSI. BS EN 12767, 'Passive safety of support structures for road equipment. Requirements, classification and test methods.'
Ref 27.N	Highways England. CD 146, 'Positioning of signalling and advance direction signs'

Ref 28.N	BSI. BS EN 62305, 'Protection against lightning'
Ref 29.N	BSI. BS 6180, 'Protective barriers in and around buildings'
Ref 30.N	BSI. BS 7671, 'Requirements for Electrical Installations, IET Regulations'
Ref 31.N	Highways England. CD 377, 'Requirements for road restraint systems'
Ref 32.N	BSI. BS EN 1317-1, 'Road restraint systems. Terminology and general criteria for test methods.'
Ref 33.N	BSI. BS 4211, 'Specification for permanently fixed ladders; Class B'
Ref 34.N	Highways England. CG 300, 'Technical approval of highway structures'
Ref 35.N	gov.uk. EWR 1989, 'The Electricity at Work Regulations 1989 (SI 1989/635) (as amended) (the Regulations)' , 1989
Ref 36.N	The Stationery Office. TSRGD 2016, 'The Traffic Signs Regulations and General Directions 2016'
Ref 37.N	BSI. NA to BS EN 1991-1-7, 'UK National Annex to Eurocode 1 - Actions on structures - Part 1-7 General actions - Accidental actions'

13. Informative references

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

Ref 1.I	American Society of Civil Engineers (ASCE). Davenport, AG. Proc. ASCE, Vol. 88, 'Buffering of a suspension bridge by storm winds, Proc. ASCE, Vol. 88'
Ref 2.I	Highways England. MCHW Series 1500, 'Manual of contract documents for highways works, Volume 1 Specification for Highways works - Series 1500: Motorway Communications'
Ref 3.I	Highways England. TD 131, 'Roadside technology and communications'
Ref 4.I	BSI. BS 4800, 'Schedule of paint colours for building purposes'
Ref 5.I	BSI. BS 381C, 'Specification for colours for identification, codes and special purposes'

Appendix A. Typical equipment and cabling

Typical equipment and cabling requirements for passively safe gantries are given in Table A.1 and A.2 respectively.

Tables A.1 and A.2 are provided to assist in developing testing regimes to demonstrate the ability of gantries to satisfy passive safety requirements relevant to a range of schemes. It is emphasised that Tables A.1 and A.2 contain typical requirements for guidance alone. They are based on recent experience and practice and should not be treated as definitive. Reference should be made to TD 131 [Ref 3.I] and MCHW Series 1500 [Ref 2.I].

Table A.1 Typical equipment for passive gantries

Equipment	Maximum size (mm)	Typical weight (kg)	Cable entry position	Quantity per gantry
Advanced Motorway Indicator (AMI)	1840 wide 1500 high 350 deep	150	Rear	1 per lane, including hard shoulder, front facing, mounted above lane centreline
Advanced Motorway Indicator (AMI) – enforcement type	1840 wide 1500 high 350 deep	200	Rear	1 per lane, including hard shoulder, front facing, mounted above lane centreline
Digital Enforcement Equipment (DEE) camera head unit	1000 wide 550 high 510 deep	50	Side	1 per lane, including hard shoulder, rear facing, mounted above lane centreline
DEE flash unit	365 wide 325 high 460 deep	20	TBC	1 per DEE camera head unit, rear facing, offset from camera head unit
Variable Message Sign (2x12)[1]	4410 wide 1755 high 500 deep	420	Rear	1 (design to consider most onerous possible location)
Variable Message Sign (2x16)[1]	7790 wide 2390 high 500 deep	870	Rear	1 (design to consider most onerous possible location)
Automated Number Plate Recognition (ANPR) Camera	400 wide 275 high 100 deep	8	Rear	1 per lane, including hard shoulder, front face, above lane centreline
ITS beacon	600 wide 200 high 100 deep	5	Rear	1 per lane, including hard shoulder, front face, above lane centreline
Lane traffic detector	250 wide 275 high 600 deep	5	Rear	1 per lane, including hard shoulder, front face, above lane centreline
Fixed CCTV camera	250 wide 275 high 600 deep	25	Underside of camera housing	2 (design to consider most onerous possible locations)

[1] These signals will not be installed together on a gantry

Table A.2 Typical cabling requirements

From/To	Type	No. & diam. (mm)	Weight (kg/m)	Min. bend radius (mm)
Bottom of gantry support to message sign	2-pair signal	1 x 10	0.11	75
MCAB to Message Sign	4mm^2 3-core	1 x 11	0.25	30
Bottom of gantry support to CMU	RS485 (quad)	1 x 10	0.1	30
CMU to AMI	30-way	1 x 20	0.4	120
MCAB to AMI	4mm^2 3-core	1 x 11	0.25	30
Roadside cabinet to DEE	Fibre optic	2 x 10	0.15	50
CMU to DEE	14-way	1 x 13	0.26	100
MCAB to DEE	4mm^2 3-core	1 x 11	0.25	30
MCAB to DEE flash unit	4mm^2 3-core	1 x 11	0.25	30
DEE flash unit to DEE	2-way	1 x 8	0.08	30
Bottom of gantry support to ANPR camera	Composite	1 x 10	0.52	90
MCAB to ANPR camera	4mm^2 3-core	1 x 11	0.25	30
Bottom of gantry support to ITS beacon	Quad	1 x 10	0.52	90
MCAB to ITS beacon	4mm^2 3-core	1 x 11	0.25	30
Bottom of gantry support to lane traffic detector	Quad	1 x 10	0.52	90
MCAB to lane traffic detector	4mm^2 3-core	1 x 11	0.25	30
Bottom of gantry support to CCTV camera	Composite	1 x 13.5	0.11	150
Bottom of gantry support to MCAB	4mm^2 3 core – armoured	10 x 15.8	0.52	96
Bottom of gantry support to ALM processor unit	RS485 (quad)	1 x 10	0.1	30
ALM processor unit to ALM sensor head	8-core	1 x 10	0.15	30

Appendix B. Table of gantry features

This table may be useful for the designer to assist in schemes requiring the provision of gantries.

Table B.1 Gantry features

Feature	Requirement	Clause reference
Gantry type	Carry out risk assessment to determine if a passively safe or non- passively safe gantry will be utilised	2.1 - 2.5
Maintenance Access	Carry out risk assessment to determine appropriate provision.Walkway / MEWP/ Other	2.1 - 2.5 & Section 9
Function	Support signs/signals/other equipment	1.1
Span arrangement	Cantilever/single portal/twin portal/other	
Spans	Specify individual/range (m)	
Over span	Yes/No	5.8
Location	Specify/wind speed for design	7.16
Signs	None/specify No ht x w (m)	3.28, 11.5
Illumination of signs	Specify type: none/external/internal/LED	11.6 - 11.8
Retroreflective sheeting	Specify type, none/type	
Variable message sign	None/rotating prism/other	11.9
Signals	None/No & position of MS/EMS/EMI/CMI	11.22
CCTV	None/location	11.23 - 11.25
Mounting for signal control equipment	None/location & method	11.27, 11.29
Power distribution	None/location	11.30
Lifting facilities	None/location	9.16 - 9.19
Other parties equipment	None/specify	11.31
Ground works for control/power cabinets/ lay by	None/provision	11.33 - 11.36
Design working life	No. of years	TAA for Overseeing Organisation
Flexibility in future use	Capable of being re-configured and/or re-positioned.	11.15 - 11.19, 11.27
Use of over-bridge	No/details	3.24 - 3.26
On elevated structures	No/details	
Colour of structure	Specify	5.8, 5.9
Restraint systems	Yes/No/Dependent on set out	4.11 - 4.13
Other	Specify any other requirement	