VOLUME 2 **HIGHWAYS STRUCTURES: DESIGN (SUBSTRUCTURES AND SPECIAL STRUCTURES), MATERIALS**

SECTION 2 **SPECIAL STRUCTURES**

PART 4

BD 51/14

PORTAL AND CANTILEVER SIGN/SIGNAL GANTRIES

SUMMARY

This standard sets out the design criteria and considerations for portal and cantilever sign and/or signal gantries for use over highways. It updates and expands upon BD51/98, which it replaces.

INSTRUCTIONS FOR USE

1. Remove Contents pages from Volume 2 and insert new Contents pages for Volume 2 dated May 2014.
2. Remove BD51/98 from Volume 2, Section 2 which is superseded by this Standard and archive as appropriate.
3. Insert BD51/14 into Volume 2, Section 2.
4. Archive this sheet as appropriate.

Note: A quarterly index with a full set of Volume Contents Pages is available separately from The Stationery Office Ltd

THE HIGHWAYS AGENCY

TRANSPORT SCOTLAND

LLYWODRAETH CYMRU
WELSH GOVERNMENT

THE DEPARTMENT FOR REGIONAL DEVELOPMENT
NORTHERN IRELAND

BD 51/14
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Part 4

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Volume 2 home page

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SECTION 2 SPECIAL STRUCTURES

PART 4

BD 51/14

PORTAL AND CANTILEVER SIGN/SIGNAL GANTRIES

Contents

1. INTRODUCTION

Background

1.1. This Standard supersedes BD51/98, IAN85/07 and IAN86/07. The main changes are:

a) Compliance with Eurocodes and removal of references to superseded structural design standards;

b) Incorporating requirements from Interim Advice Notes IAN 85 and IAN 86;

c) Restriction of scope to structural design only i.e. scheme design is not covered in this Standard;

d) Removal of detailed itemisation of gantry equipment provision.

Scope

1.2. This Standard covers the design of Portal and Cantilever Sign and Signal Gantries (see Annex A Figure 1) and sets out their structural design requirements in accordance with the Overseeing Organisation's requirements for the use of Eurocodes.

1.3. It is intended for use in designing permanent and temporary structures which wholly span or are partially cantilevered over the carriageway, hard shoulder and/or hard strip for the purpose of supporting large signs and/ or motorway type signals and/or message signs, such as, but not exclusively, the examples shown in Annex A Figure 1, but excluding cantilever or other traffic signal masts which are covered in BD94 "Design of Minor Structures" (DMRB 2.2.2.1).

1.4. This Standard specifies criteria and advice for the structural design of sign and signal gantries of portal and cantilever types for use on trunk roads including motorways (and all purpose roads in Northern Ireland), where any part of the sign or motorway signal and their supporting structure is mounted over the carriageway, central reserve, hard shoulder and/or hard strip. They may be constructed of steel, aluminium, concrete or composite metal and concrete. Other materials may also be considered in accordance with clause 4.4.

1.5. The selection of suitable sign and signal configurations is outside the scope of this standard.

1.6. Scheme design is not covered by this document. It is assumed that the gantry positions are determined as part of the scheme design. This Standard only considers the position of the gantry where it has a direct implication on the structural design.

1.7. **Mandatory Sections**

> Sections of this Standard containing mandatory requirements are identified by being contained in boxes. These requirements must be complied with or a prior agreement to a Departure from Standard must be obtained from the Overseeing Organisation. The text outside boxes contains advice and explanation, which is commended to users for consideration.

Mutual Recognition

1.8. The requirements and guidance on this document are given on the basis that the construction and/or maintenance of sign and signal gantries will be carried out using the Specification for Highway Works (MCHW Vol.1). However, products conforming to equivalent standards and specifications of other member states of the European Union and tests undertaken in other member states may be acceptable in accordance with the terms of the 104 and 105 Series of Clauses of that Specification.

Devolved Administration Issues

1.9. Not applicable.

Implementation

1.10. This Standard must be used forthwith on all projects for the assessment, design, construction, operation and maintenance of motorway and all-purpose trunk roads (and all roads in Northern Ireland) except where procurement of works has reached a stage at which, in the opinion of the Overseeing Organisation, its use would result in significant additional expense or delay progress (in which case the decision must be recorded in accordance with the procedure required by the Overseeing Organisation).

Definitions and Abbreviations

1.11. Specific definitions applicable for this Standard are given below.

Carriageway

For the purposes of this Standard, the carriageway width is taken to be 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. The carriageway width should be measured in a direction at right angles to the line of the raised kerbs, lane marks or edge marking.

Eurocodes

For the purpose of this Standard, Eurocodes should be taken to include the UK National Annexes and relevant requirements of associated Published Documents.

Gantry

Generic term for structure supporting signs, signals, Variable Message Signs (VMS) and other equipment. Gantry includes single or multiple portals, single and double cantilevers and combinations of same.

Managed Motorway Gantry

Managed motorway gantries are those that are designed specifically for use on Managed Motorway Schemes. These gantries have not been designed for possible re-use without modification across the network.

Outreach of Cantilever

Length of cantilever from traffic face of support to tip.

Passively Safe Gantries

Passively safe gantries are those that are designed to yield or detach under vehicle impact in order to limit injury to the vehicle occupants.

Published Documents

For the purpose of this Standard, Published Documents contain non- contradictory complementary information (NCCI) to assist in the application of Eurocode Principles.

Sign

A device carrying directional or other informational message, e.g. route information at the approach to a junction.

Signal

A device which uses lights to give advisory or mandatory instructions, e.g. stop, or 30 mph speed restriction.

Standard Gantry

Typical gantry structure that has been designed for possible re-use without modification across the network. It does not include passively safe gantries or gantries for managed motorway schemes.

Supports

Vertical or near-vertical structural member supporting horizontal member, sign, signal and/or associated equipment.

Variable Message Sign (VMS)

Sign capable of displaying a variety of text, messages and/or symbols.

Vehicle Restraint System (VRS)

Installation to provide a level of containment for errant vehicles in order to limit damage or injury to users of the highway.

1.12 References in this Standard to BS EN documents include their UK National Annexes.

Feedback

1.13 Any comments or feedback regarding the technical content and suggestions to improve this document should be directed to the Standards_Feedback&enquiries@ highways.gsi.gov.uk mailbox or the KPGI Team at Highways Agency Woodlands, Bedford, MK41 7LW.

2 GANTRY TYPE SELECTION AND DESIGN PROCEDURES

2.1. The designer must carry out a risk assessment in accordance with Annex B and whole-life costing analysis to determine the type of gantry most appropriate to the site.

Design Procedures

2.2. The design procedures will be dependent on the type of gantry selected. The two types of gantries are set out below.

2.3. Standard and Managed Motorway Gantry: The design criteria are set out in chapters 4 and 5 with the design working life given in clause 3.2.

2.4. Passively Safe Gantry: The design criteria are set out in chapters 4 and 5 (except clause 5.27) with the design working life given in clause 3.2. Additional requirements as set out in chapter 7 for passively safe gantries.

3. GENERAL DESIGN PRINCIPLES

Technical Approval

3.1. Technical Approval (TA) of the designs for construction, alteration and re-positioning of sign/signal portal and cantilever gantries must comply with the requirements of BD 2 (DMRB 1.1.1).

Design Working Life

3.2. The required design working life for standard, managed motorway and passively safe gantries is 30 years. For Transport Scotland and Northern Ireland the required design working life is 60 years.

3.3. In the design for wind and thermal effects, the return period for these effects must be taken as the design working life of the gantry. In the design for fatigue, the design working life must be based on the design working life plus 10 years.

Design for Maintenance

3.4. The design of the gantry must consider its future maintenance. This must be considered in accordance with the Technical Approval requirements in accordance with BD 2.

3.5. The positioning of items requiring inspection and maintenance, such as bolted connections, junction boxes, CCTV cameras etc. should take account of their security and how they are accessed.

Structural Layout

3.6. All elements must comply with the dimensional requirements set out in TD 27 (DMRB 6.1.2) for cross sections and headroom. This must allow for deflections due to variable actions (permanent, imposed, wind, snow and thermal) in the serviceability limit state combinations. On portal type gantries, the levels at the ends of the beam must be the same.

3.7. On dual carriageway roads consideration must be given to provide non-passively safe portal gantries spanning both carriageways without support in the central reserve.

3.8. Gantries must 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 considered in the design.

Signs and/or Signals supported on structures

3.9. When the need to support signs and/or signals over the highway can be arranged to coincide with an over-bridge, or possibly a tunnel portal, consideration must be given to utilising that structure to support them.

3.10. The means of attachment to the bridge structure will depend on the form of the bridge, particularly its cross section.

3.11. Before agreeing such a solution, an assessment of the risk of unauthorised access must be carried out to determine whether the proposal to attach signs and/or signals to an over-bridge should be approved.

Construction on Site

3.12. To minimise disruption on site due to gantry construction, as much of the gantry structure as possible should be constructed off site. Foundations should be constructed in advance of the erection of the superstructure and should aim to avoid disruption of the carriageway surfacing and/or minimise traffic management on highways in use. 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.

3.13. To minimise traffic management requirements for fitting out of gantries, as much assembly of the signs and signals as practicable must be undertaken on the ground, either at the fabrication shop or close to the site, prior to erection of the main span member.

3.14. Where possible, connections should be simple and clearly visible from the verge to enable visual inspection from a position of relative safety.

Adaptability

3.15. Structural holding down bolt arrangements must be designed such that subsequent removal and replacement of the gantry structure may be readily undertaken.

3.16. The design of the gantry structure, and the connections between support and foundation, and if applicable, support and main horizontal beam, must facilitate rapid and simple installation and removal in order to keep traffic disruption due to traffic management to a minimum.

3.17. The designer must consider whether to allow in the design for the likely future repositioning of, or changes to actions from, equipment or signage on the gantry, taking into account the probability of this within the design life of the gantry. The decision to make such provision must generally be agreed at the scheme level and recorded in the Approval in Principle. Where provision is made for future changes, appropriate detail must be provided on the as-constructed drawings to indicate the extent of such provision.

3.18. The above design considerations provide the user with the opportunity to pick those features for immediate and possible future use needed on the scheme under consideration. A list of the items that might be included is given in Annex G. By this means many of the necessary requirements can be described and new designs submitted for approval can be evaluated against these requirements.

Robustness

3.19. The gantry arrangement and components must be sufficiently robust to resist damage during transportation, erection and in-service/maintenance. Mounting systems for equipment must enable the gantry to be transported and erected with the equipment in place.

Use of dissimilar metals

3.20. Where dissimilar metals are to be used, the connections must be designed to avoid the risk of galvanic corrosion. The electrical bonding of all metal components must be maintained.

Gantries on Elevated Structures

3.21. Where gantries are mounted on elevated structures, the effects of the holding down arrangements of the gantry supports on the elevated structures must be considered in the design of the supporting bridge or viaduct deck.

Supports

3.22. For standard gantries and managed motorway gantries, the design of supports must ensure that local damage under the actions given in chapter 5 does not result in the collapse of the gantry. For passively safe gantries, the collision criteria are set out in chapter 7.

Mitigation of Vandalism and Theft

3.23. The design should include mitigation measures to reduce vandalism and the risk of theft of components and materials. Mitigation measures must be included in the AIP.

3.24. Where practicable, the arrangement or detailing of the supports should be such as to prevent them being used as a means of ready access to the superstructure, particularly at gantries located close to areas of habitation. Any measures used to prevent such access to the superstructure should be included in the passive safety testing arrangement – see chapter 7.

Environmental

3.25. The environmental impacts of the gantry must be minimised as far as reasonably practicable.

Access

3.26. Gantries designed or constructed using this standard must not be provided with a fixed means of access for inspection and maintenance. (England only)

3.27. In Scotland, Wales and Northern Ireland the additional design criteria for fixed access provided in Annex F must be considered.

4. LIMIT STATE DESIGN

General Design Requirements

4.1. Eurocodes bridge parts must be used for the design of gantries. This Standard provides complementary requirements that address aspects not covered.

4.2. Concrete and steel gantry structures must be designed in accordance with the relevant parts of BS EN 1992 and 1993 respectively and in accordance with the Overseeing Organisation's requirements for the use of Eurocodes.

4.3. Aluminium gantry structures must be designed in accordance with the relevant parts of BS EN 1999.

4.4. When structural materials other than those stated in 4.2 and 4.3 are proposed, the design methods and specification must be agreed with the TAA. The design criteria and limits to be adopted for such materials must also be agreed, before their use is approved for the construction of gantries.

Deformations

4.5. Structural deformation due to permanent actions (self weight and removable) at the centre of spans of portals or tips of cantilevers must be counteracted by pre-camber above the chord line for portals, or the horizontal for cantilevers to avoid visible downward deformation.

4.6. Deformations in the serviceability limit state must be limited such that they do not exceed the values given in Table 4.1 for the Characteristic combination of actions. (See Annex A Figure 6).

4.7. The deformation at the extremities of the structural support must be derived from the sum of the components of the effects of the actions in the supports, cantilever and sign supports. The height of the support must be measured from the top of any support plinth to the underside of the main horizontal beam or cantilever.

Table 4.1 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 Annex A Figure 6)	Horizontal (x)	1/150 of outreach plus heights 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 heights of support and sign or signal support
	Vertical (z)	1/300 of span plus height of support

Minimum Thickness of Metal Sections

4.8. The minimum thickness of structural metal sections must be as follows:

i. Steel plates and sections other than hollow sections 6mm

ii. Steel hollow sections effectively sealed by welding, other than a small drain hole 5mm

iii. Aluminium alloy plates and sections 4mm

Connections

4.9. All fillet welds must have a leg length of not less than 4mm. All fillet welds, unless contained within a closed member, must be continuous.

Closed Hollow Section Requirements

4.10. Hollow sections in all materials must be designed to resist the ingress and retention of water or moisture by gravity flow, capillary action or condensation. For hollow sections made out of metal, the end plates must be of thickness not less than the lesser of the following:

i. Equal to the thickness of the walls of the hollow section

ii. 8mm

4.11. The end plates must be joined by continuous structural quality welding. Should there be a possibility of water entering in significant quantity and subsequently freezing, then drain holes must be provided. Hollow sections in non-corrosive materials or galvanised steel must be provided with drain holes at all low points and the size of the hole must be appropriate to the void being drained, but must not be less than 10mm diameter.

Fatigue

4.12. The design working life for fatigue is set out in clause 3.3. The fatigue performance of the structure must be verified and the fatigue life assessed for the action effects obtained from wind and vehicle buffeting actions set out in clauses 5.36-5.38 and, if appropriate, the dynamic analysis described in Annex E.

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

4.14. Fatigue of steel structures must be verified in accordance with BS EN 1993-1-9.

Foundations

4.15. The design of the foundations, including holding down bolts, plinths, bases and all other structural aspects, must be such that they have greater reserves of structural resistance than the supported gantry structure (see clause 5.35). This requirement is to ensure that the foundations will survive an impact action intact so that a replacement support can be installed with minimum down time.

4.16. The procedures given in BS EN 1997-1 must be used for the design of soil structure stability.

4.17. Ultimate Strength of Soil.

i) This condition corresponds with the following failure modes of the surrounding soil and the soil-structure interface:

a) Sliding

b) Overturning

c) Bearing capacity of the foundation soil

d) Slip failure of the surrounding soil

4.18 Serviceability Condition of Soil

The adoption of recommended safe bearing resistance for the foundation design as a simplification to calculating settlements should avoid undesirable soil movements due to settlements and tilting of the foundation. Nevertheless a separate assessment of the differential settlements and tilting of the structure is still necessary for the design of associated superstructures with in-built redundancy or cantilevers. Such movements can be calculated from a displacement or consolidation analysis. The predicted movements must be taken into account in the overall design of the structure.

4.19 Caution is necessary if reliance is 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. For guidance on the movement necessary to mobilise passive pressures see BS EN 1997 and PD 6694-1.

5. ACTIONS

Actions to be considered

5.1. All actions must be in accordance with the relevant parts of BS EN 1991, its National Annex and where necessary Published Documents in accordance with the Overseeing Organisation's requirements for the use of Eurocodes.

5.2. For the purpose of calculating stresses and stability, the following actions must be calculated in accordance with the relevant Eurocode. The differentiation between the two permanent actions is not covered in Eurocodes.

i. Permanent (self-weight)

ii. Permanent (removable)

iii. Wind

iv. Thermal effects

v Snow

vi Differential settlement

vii Weight of soil

viii Accidental (vehicle collision with supports)

ix Variable actions/imposed loading (in Scotland, Wales and Northern Ireland only) – refer to Annex F

5.3. Additional actions during execution in accordance with BS EN 1991-1-6 must be included as necessary to suit proposed erection methods.

Application of actions

5.4. Each element and the structure as a whole must be considered under the effects of actions in each combination as given in Table 5.1. This is intended to provide information not covered in Table NA.A2.4(B) in the NA to BS EN 1990 and to provide clarification on application. Table NA.A2.4(A) and Table NA.A2.4(C) should be used directly.

General Combination of Actions

5.5. Combinations of actions are to be derived in accordance with BS EN 1990 and Table NA.A2.1 in the NA to BS EN 1990. The relevant partial factors not covered in BS EN 1990 must be in accordance with Table 5.1.

Table 5.1

Action	Component	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

Notes:

Combination rules are set out in Annex A2 of BS EN 1990. The combination rules for footbridges are to be applied. Based on this, the following need not be considered simultaneously:
Snow and wind do not need to be combined with construction actions and do not need to be combined with variable actions. Wind and thermal do not need to be considered simultaneously.

Permanent Actions (removable)

5.6. Permanent actions (removable) include all permanent actions not forming part of the structure. This includes signs, equipment and other fixings attached to the gantry.

5.7. Characteristic values for nominal permanent actions (removable) may be based on the densities of the materials given in BS 648 and BS EN 1991-1-1:2002. Information provided in BS EN 1991-1-1:2002 must take precedence over that provided in BS 648.

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

5.9. In the case of the variable message signs, signals and associated equipment, the nominal permanent action (removable) initially assumed must in all cases be accurately checked with the actual weights of the items to be used and, where necessary, adjustments must be made (Table C1 gives some typical values). The calculated nominal permanent actions (removable) must not be less than 1.25 kN per metre of span of gantry or outreach of cantilevers.

Adverse Effects of Permanent Actions (removable)

5.10. 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 should be taken into account. This deviation should be taken equal to + 25 % and – 20 % if it is obtained through calculation and ±0% if it is determined by weighing or from data from the Overseeing Organisation's Infrastructure Design Guides for the various items of signal equipment.

Earth Pressures

5.11. In all design situations, earth pressures generated from any retained fill must be determined in accordance with BS EN 1997-1.

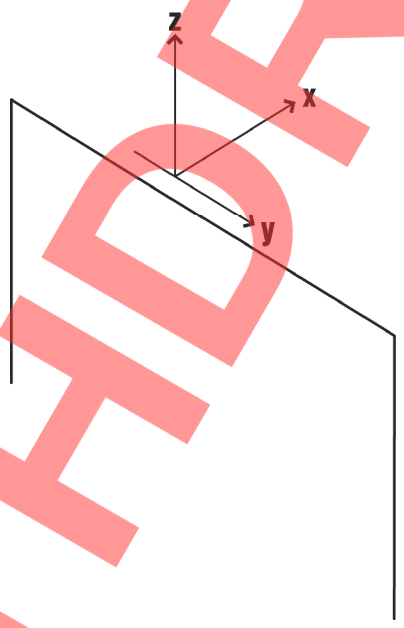
5.12. For the ultimate strength and serviceability conditions the soil 'active' earth pressure must be used in the design, unless otherwise agreed with the TAA.

Environmental Effects

5.13. For new gantries the return period for wind and thermal effects in service must be taken as the design life of the gantry, as specified in clause 3.3.

Application of Wind Action

5.14. Wind actions on gantries produce forces in the *x*, *y* and *z* directions. The *x*-direction is the direction parallel to the carriageway, perpendicular to the span. The *y*-direction is the direction along the span and the *z*-direction is the vertical direction.



5.15 The characteristic wind action in the *x*, *y* and *z* directions are to be calculated based on the requirements set out in Chapter 8 of BS EN 1991-1-4 unless otherwise set out below.

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

5.17. Where there is an impervious horizontal surface abutting the lower edge of a vertical sign face or other impervious face, a vertical downward component of the wind force F'_{wz} acts concurrently with the horizontal one, F_{wx} blowing into the '*L*' as shown in Annex A Figure 3.

5.18. The characteristic vertical wind action F'_{wz} should be taken as acting at the centroid of the appropriate area and must be derived from: $F'_{wz} = 2qA_4$ x modification factor as given in Table 5.2 where A_4 is the solid area of the horizontal surface on the windward side of the vertical solid face. The force F_{wz} in accordance with BS EN 1991-1-4 should be considered together with F'_{wz} if it produces an adverse effect.

Dynamic Sensitivity of gantry

5.19. Clause 8.3.2 in BS EN 1991-1-4:2005 assumes that the dynamic response procedure is not required. This assumption should be verified in accordance with BS EN 1991-1-4. If the gantry is found to be dynamically sensitive, the provisions in Annex E of this standard must be applied.

Wind Action Combinations

5.20. Combinations of F_{wx}, F_{wy}, F_{wz} should be as required by BS EN 1991-1-4 Chapter 8.

Force Coefficients

5.21. For gantries not susceptible to dynamic excitation by wind, F_{wx}, F_{wy}, F_{wz} are to be calculated in accordance with clause 8.3 in BS EN 1991-1-4:2005. The wind factor C for the various gantry components should be calculated as follows:

$C = c_e c_{f,x}$

$c_{f,x}$ is the force coefficient

c_e is obtained from clause 4.5 of BS EN 1991-1-4:2005.

5.22. The force coefficient should be calculated in accordance with BS EN 1991-1-4, unless otherwise specified below.

5.23. For parts of gantries with lattice structures, the force coefficient should be calculated based on clause 7.11 in BS EN 1991-1-4:2005.

5.24. The following force coefficients, $c_{f,x}$ should be taken for flat surfaces, such as sign faces, in directions both parallel and normal to the sign:

Rectangles: 2.2 x modification factor as given in Table 5.2

Circles: 1.15

Table 5.2 Modification factor of drag coefficients for rectangular plates

max dimension / min dimension	Factor
∞	1.00
20	0.75
17	0.70
10	0.64
8	0.63
4	0.59
2	0.57
1	0.55

Snow Action

5.25. Characteristic snow action is to be calculated in accordance with BS EN 1991-1-3. The recommended values set out in the National Annex should be adopted. μ_i must be taken as 0.8 for gantries.

Vehicle Collision Actions for passively safe gantries

5.26. Passively safe gantries must not be designed for the collision actions set out in clauses 5.28 -5.35 but be designed in accordance with Chapter 7.

Vehicle Collision Actions for non-passively safe gantries

5.27. When any part of the sign or structure is over the carriageway, hard shoulder or hard strip, supports must be designed to withstand at least the vehicle collision actions in Table 5.4.

Characteristic Actions on Supports

5.28. For non-passively safe gantries, gantry supports in the verge should wherever possible be set back from the edge of the carriageway. A risk ranking procedure in accordance with NA to BS EN 1991-1-7 should be applied to determine the sensitivity of structure to collision.

5.29. Accidental impact actions are given below and their direction and height of application are shown in Annex A Figure 4. In accordance with BS EN 1991-1-7, main and residual actions must be applied simultaneously but F_{dx} and F_{dy} must not be applied simultaneously.

5.30. The risk ranking factor must be calculated in accordance with clause NA. 2.11.2.3 of the NA to BS EN 1991-1-7:2006. Factor F_7 for deck stability must be taken as 2.0 for gantries. For factor F_8 for consequence factor, $AADT_{over}$ must be taken as 0 (except where a bridge is being used to support equipment).

5.31. If the risk ranking factor calculated in clause 5.30 is equal to or greater than 0.5, the impact actions are to be as detailed in Table 5.3.

Table 5.3 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 sign/signal 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 ≥45mph (72kph): e.g. 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 <45mph (72kph): e.g. 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

5.32. If the risk ranking factor calculated in clause 5.30 is less than 0.5, the minimum robustness forces alone as set out in Table 5.4 should be used for the design.

Table 5.4 Minimum forces for Robustness on Supports to Sign/Signal Structures

	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 sign/signal structure support
Main action component	**165**	**165**	At the most severe point between 0.75 m and 1.5 m above carriageway level
Residual action component	**85**	**85**	At the most severe point between 1 m and 3 m above carriageway level

5.33. Vehicle collision actions on supports must be applied as part of the accidental combination only.

5.34. Accidental actions are to be applied in accordance with the principles set out in BS EN 1991-1-7.

5.35. 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 must be considered. This deviation should be taken equal to + 20 % and – 0 %. For all other structural elements, a deviation of ±0% is to be considered. This is to ensure that these elements 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

5.36. The gantry must be designed for buffeting actions from high sided vehicles in accordance with the recommendations provided in BD 94 "The design of Minor Structures" (DMRB 2.2.1).

5.37. Fatigue actions due to wind gusting must be determined in accordance with BS EN 1991-1-4. The characteristic wind action is to be calculated as set out in clause 5.15. The effects of wind must be combined in a Miner's summation using the data set out in Figure B.1 of BS EN 1991-1-4 for the full range of cycles considered in this figure.

5.38. For new gantries, the design working life for fatigue purposes must be in accordance with clause 3.3. The fatigue effects from high vehicle buffeting and wind gusting must be combined in a Miner's summation calculation to give a value of less than unity; see BS EN 1993-1-9, Annex A.

6. GENERAL REQUIREMENTS

Structural Layout

6.1. The horizontal dimensional clearances between the structure and vehicle restraint systems must be in accordance with TD 19 (DMRB 2.2.8) and TD 27 (DMRB 6.1.2).

Fixings/Connections

6.2. All fixings, including those for equipment, as far as reasonably practicable, must be securely attached to the structure using vibration resistant fixings.

6.3. All parts of the gantry structure and attached items and fixings must be prevented from falling onto the carriageway.

6.4. The design of the mounting arrangements for signs and signals must take account of the possible structural interaction between the enclosure and supporting members.

6.5. The equipment must 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.

6.6. Some, but not all, items of equipment are supplied with a full or partial mounting arrangement. The design of these mounting arrangements must be tailored to match the requirement of the gantry and its mounting points. For details of these integral mountings, reference should be made to the current specifications which can be obtained from Overseeing Organisation. (For England the plans registry)

6.7. The element of the equipment mounting included in the gantry design must provide the capability for any horizontal and vertical alignment necessary for the particular piece of equipment, not already catered for by the integral arrangement.

6.8. The area of the holding down arrangements must be designed to be free draining and corrosion resistant. The tops of holding down bolts must be protected by plastic caps filled with an anti-corrosion compound.

Erection/Demounting

6.9. Site welded connections must not be used unless otherwise agreed with the TAA.

6.10. The design of the gantry must facilitate erection and demounting with the minimum of disruption to road users.

6.11. Where the gantry is not designed to be erected in one piece, the supports must be self-stable to allow a phased execution procedure.

6.12. Provision for lifting the various elements of the gantry must be provided as part of the permanent design of the gantry.

Protection for Road Users and Structure

6.13. Vehicle restraint systems must be provided at gantry supports in accordance with TD19 (DMRB 2.2.8). Details of the vehicle restraint system must be agreed with the TAA.

6.14. Where gantry supports are positioned in recesses in retaining walls, provision must be made to give continuity to vehicle restraint across the recess and afford access, if required, to the gantry support and any control equipment. Possible means of achieving this are shown in Annex A Figure 2.

Protection of Steelwork

6.15. The gantry structure must be protected against deterioration from environmental causes with appropriate protection systems. These systems must be designed to minimise major maintenance requirements during the design working life of the structure as defined in clause 3.2.

6.16. Steel structures must be protected by a Type II protective system in accordance with Specification for Highway Works Series 1900.

6.17. It is unlikely that hot-dip galvanising of steelwork alone will deliver the specified design life, due to the aggressive environment found along highways, and it should be used in conjunction with other protective systems to achieve the required design life. Weathering grades of steel are not generally considered suitable because of issues that may arise with regard to connections (e.g. dissimilar metals, collection of moisture).

Supports

6.18. In order to achieve the required resistance, it may 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.

Drainage

6.19. Provision must be made for the drainage of water from the structure and fixings. All walkways, roofs of enclosures and other surfaces must have adequate falls to allow water to run off. Where run off can concentrate, it must discharge clear of the carriageway and hard shoulder/strip and clear of the structure.

6.20. Provision must be made to drain hollow sections, see clause 4.11.

Identification

6.21. In England and Wales the structure site identification marking of gantries must be in accordance with Departmental Standard BD 45 (DMRB 3.1.1). In Scotland Transport Scotland must be consulted. In Northern Ireland Road Service Traffic Information and Control Centre must be consulted. The following information is to be included:

i. Name and location of the manufacturer;

ii. Year of manufacture;

iii A unique serial number for each element;

iv All up self weight of member plus attached equipment but excluding the weight of any variable message sign.

The characters must not be less than 10mm high nor more than 20mm high.

Electricity, Cable Routes, Electrical Earth and Lightening Conduction

6.22. Where electrical plant is installed on gantry structures, provision must be made to enable the supply to be isolated before work takes place on electrical equipment. It is noted that equipment for motorway communications is a permanent installation. It is therefore based on 240 volts and is installed in accordance with BS 7671 Requirements for electrical installations.

6.23. A structured cable management system must be devised and incorporated into the structural design of the gantry. It must 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. The system must permit rapid fixing and removal of cables and must include quick release joints at the gantry support/boom connections. Where cable routes are external to the structure, they must be positioned remote from the usual line of sight, i.e. on the down-stream face, where possible.

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

6.25. All metal components of the structure must have electrical continuity in accordance with BS 7671. Provision must 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. The earthing system must be in accordance with BS 7430 Code of practice for earthing.

6.26. By providing electrical connection between the reinforcement in the foundations, holding down bolts and metal gantries, it may be possible to achieve adequate earth without the need for earthing rods. Tests must be made in dry conditions at each location to ensure that this has been achieved.

6.27. A conduction path, to convey lightning strikes from all parts of the structure to earth, must be provided in accordance with the appropriate parts of BS EN 62305.

7. PERFORMANCE AND OTHER REQUIREMENTS FOR PASSIVELY SAFE GANTRIES

Background

7.1. The design of passively safe gantries assumes there are no other obstructions in the area which inhibit passively safe behaviour. In order to ensure passively safe behaviour it is necessary to consider the area as a whole. This is likely to involve, for example, either moving cabinets out of the possible path of errant vehicles or using passively safe cabinets.

7.2. The need for passively safe gantries must be assessed in accordance with Annex B. Passively safe portal gantries designed to this standard must comply with the passive safety requirements set out here even if they are protected by Road Restraint Systems.

7.3. 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 covers the general design of these types of structure and this standard refers to it and gives more specific requirements for gantries.

7.4. Gantry structures with no performance requirements for passive safety are class 0 in accordance with BS EN 12767 and these structures should be designed in accordance with the design rules for a standard gantry.

7.5. BS EN 12767 considers three categories of passively safe support structures:

i) high energy absorbing (HE);

ii) low energy absorbing (LE);

iii) non-energy absorbing (NE).

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.

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

It is envisaged that the gantry structures could be either energy absorbing or non-energy absorbing depending on their design.

7.6. BS EN 12767 requires the boom of gantries to remain 4m (or other height depending on National Regulations) above the carriageway. Because the UK has significant numbers of vehicles, including coaches, above this height, it has been increased to 5.03m in this Standard (5.7m for Scotland). However, as it might not be practical to comply with this for all cases, particularly for single span gantries, the alternative of undertaking passive safety tests on the boom will be permitted. The general requirements for passive safety testing, details of the leg test, criteria for avoiding the requirement for the boom test and requirements for the boom test are given in this Chapter.

Siting

7.7. A gantry leg must 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 is considered in the passive safety assessment.

Equipment

7.8. The equipment that a gantry is required to carry must be defined in the Approval in Principle (AIP). An illustrative list of typical equipment and cabling requirements is provided in Annex C. The information contained in Annex C is for guidance only and should not be treated as definitive.

7.9. Gantries must not be used to carry equipment or cabling that is more onerous in relation to passive safety than that considered in the tests described in outline below.

7.10. 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 must be used in the real structure.

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

General Requirements for Passive Safety Testing

7.12. The passive safety testing must be in accordance with BS EN 12767 and chapter 7 of this document. In particular the Test, Site, Test Vehicle, Calibration Test and Test Recording must be in accordance with BS EN 12767.

7.13. The design of the testing regime, test absorption class and the testing itself must be verified by an independent organisation. Details of the proposed approach must be submitted with the AIP.

Severity Level

7.14. The maximum severity levels for vehicle occupants involved in an impact evolution are stated in BS EN 12767 and consider two criteria; acceleration Severity Index, and Theoretical Head Impact Velocity, descriptions of which are as follows:

Acceleration severity index (ASI)

This value is calculated from the triaxial vehicle accelerations. The maximum ASI value is considered to be an assessment of the accident severity for the occupants of the impacting vehicle. ASI is a non-dimensional quantity and is calculated in accordance with BS EN 1317-1.

Theoretical head impact velocity (THIV)

Velocity, expressed in km/h, at which a hypothetical "point mass" occupant impacts the surfaces of a hypothetical occupant compartment. THIV is calculated in accordance with BS EN 1317-1.

Vehicle Impact Speed

7.15. The gantry must be designed for one of the vehicle speed classes listed in Table 7.1. The speed class used must be defined in the AIP but must normally be 100km/h unless the road is subject to a permanent speed limit of 80km/h or less. Analysis must also be undertaken for the low speed (35km/h) test from BS EN 12767. If this indicates that this is a worst case, testing for the low speed test in BS EN 12767 must also be carried out with the real equipment installed.

Table 7.1 Vehicle Impact Speed

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

Foundations

7.16. Foundations are required to transmit the reactions from the structure safely to the supporting ground. 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 Standard are likely to be lighter in weight and subjected to less onerous wind actions than traditional gantries, and alternative forms of foundations such as helical screw type piles should be considered. The specification for such foundations must clearly define the materials used, and the requirements for workmanship and testing.

Characteristic Foundation Design Actions

7.17. Foundations must be designed for the following characteristic actions:

i) The applied shear force that would cause shear failure of the gantry leg;

ii) 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.

These actions should be combined with either zero axial load or the axial load induced by the weight of the gantry, whichever gives the most onerous effect.

7.18. The structure must be designed to yield or fail leaving the foundation unaffected and reusable (see 4.15). Where it can be demonstrated that the foundation is significantly stiffer than the gantry, it will not normally be necessary to replicate the foundation to be used at a specific installation in the test. However, the connection to the foundation used in the testing must be the same as that to be used at the final installed location. Where the type of foundation is not significantly stiffer than the gantry structure it will be necessary to include the foundation in the testing. Justification for the testing approach must be submitted with the AIP.

Equipment on Gantry in Test

7.19. The gantry must be tested with all equipment in position. This must 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. If it is proposed to avoid testing the gantry with all the electronics in place, the corresponding cabinets must be ballasted to match the weight and centre of gravity of the individual items of equipment. 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.

Test Gantry

7.20. Where otherwise similar gantries are to be used with different spans, it will be acceptable to test only one span provided calculations or other evidence are submitted to show that the tested span is the worst case. If this is not done, or if the results are inconclusive, the longest and shortest spans must be tested.

Two Span Gantries

7.21. For two span gantries, separate tests for the centre and an outside leg must be undertaken. Where required in accordance with 7.27 separate boom tests must be undertaken.

Leg Impact test

7.22. Impact tests must be conducted on the legs in accordance with BS EN 12767, its National Annex and Chapter 7 of this document.

7.23. 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 must be carried out against one leg with the test vehicle impact point central to that leg. Where the same projected clear openings between legs are less than 1.5 m at any point within the height of the vehicle, the tests must be carried out against two legs with the test vehicle impact point aligned midway between two supports.

7.24. Where, in accordance with 7.23, the test on a structure with two legs in one verge or central reserve is done against one of these legs, rather than both, an explanation either of the choice of which one to test or of why the behaviour should be similar must be provided to the satisfaction of the TAA. If this is not possible, separate tests for each leg must be undertaken.

7.25. The structure must be deemed to pass provided it complies with BS EN 12767 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. More severe requirements (e.g. occupant safety level 2 in place of 1) may be specified by the TAA if required. Where low speed tests are required in accordance with 7.15, the low speed test criteria from BS EN 12767 apply.

Requirements for passive safety test on boom

7.26. If the boom height over the intended carriageway position 15 minutes after the test is less than 5.03m (5.7m for Scotland) at any point, a passive safety test on the boom must be undertaken in accordance with 7.29 to 7.31.

7.27. If the boom height after the test is greater than 5.03m (5.7m for Scotland), a passive safety test on the boom will still be required 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. If this cannot be done by calculation, a test must be undertaken.

7.28. If required, the HGV leg impact test must be undertaken with the rigid 30000kg vehicle specified in BS EN 1317. The test must be similar to that for the car except:

i) The speed must be 65km/hr, or the speed used in the car test if lower;

ii) No instrumentation for ASI or THIV is required;

iii) The "1.5m at any point within the height of the vehicle" in 7.23 must be changed to "2.5m at any point within the height of the vehicle";

iv) A pass will only require that the boom stays a minimum of 5.03m (5.7m for Scotland) above the carriageway.

Testing of boom

7.29. Unless 7.30 applies the boom test must be undertaken with the gantry in the condition it finished the leg test.

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

7.31. The test must be undertaken on the same basis and with the same performance requirement as the leg test except:

i) The car must impact from a direction parallel to the carriageway ± 2°;

ii) The vehicle must be aligned to impact the gantry boom at the worst case position. Account must be taken of the possibility that this position may not occur at the point where the boom touches the ground as a more critical case could arise when the boom impacts higher on the vehicle. The exact position chosen as the worst case must be justified to the TAA;

iii) There is no requirement for predictability.

Structural Performance

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

Vibration Limits

7.33. The gantry must never expose equipment mounted on it to any level of vibration above 80% of the levels required by TR 2130 (Vibration, Random, Operational) Sections 5.2 to 5.4 with Section 5.3 amended to replace "BS EN 60068-2-6 Test Fc" with "BS EN 60068-2-64 Test Fh".

Fatigue

7.34. The design working life for fatigue purposes must be taken as set out in clause 3.3. The fatigue performance of the structure must be verified using a Miner's summation calculation. The Miner's summation combination for all details should give a value of less than unity.

7.35. The structure must be assessed for fatigue life for the forces obtained from the dynamic analysis described in Annex E.

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

7.37. The designer should assess the fatigue life of any existing gantry to be relocated. A detailed inspection of welds and particularly vulnerable details may also be necessary.

7.38. Fatigue endurance of steel structures must be checked in accordance with BS EN 1993-1-9.

8 NOTIFICATION

8.1 This document was notified in draft to the European Commission in accordance with Directive 98/34/EC, as amended by Directive 98/48/EC.

9 NORMATIVE REFERENCES

BD 2/12 Technical approval of highway structures (DMRB 1.1.1)

BD 94/07 The design of Minor Structures (DMRB 2.2.1)

BD 45/93 Identification marking of highway structures (DMRB 3.1.1)

TD 27/05 Cross-sections and headroom (DMRB 6.1.1)

BSI Publications: British Standards Institution, London

BS EN 1990, 1991, 1992, 1993, 1997, 1999 Eurocodes, various parts and dates

BS 648: 1964 Schedule of weights of building materials

BS EN 12767 Passive safety of support structures for road equipment

BS EN 12899-1:2007. Fixed, vertical road traffic signs. Fixed signs

BS 4211:2005 + A1:2008: Specification for permanently fixed ladders

BS 381C Colours for Identification, Coding and Special Purposes

BS 4800 Schedule of paint colours for building purposes

BS 6180 Protective barriers in and about building

BS EN 60068 Environmental testing

BS EN 62305 various parts

BS EN: 1317-1:2010. Road restraint systems. Terminology and general criteria for test methods

BS 7430 Code of practice for earthing

BS 7671 Requirements for electrical installations. IET Wiring Regulations

TR 2130 Environmental Tests for Motorway Communications Equipment and Portable and Permanent Road Traffic Control Equipment

10 INFORMATIVE REFERENCES

BD51/98 Portal and Cantilever Sign/Signal Gantries (DMRB 2.2.4)

TD 19/06 Requirements for Road Restraint Systems (DMRB 2.2.8)

TD 46/05 Motorway signalling (DMRB 9.1.1)

TA 74/97 Motorway signalling, (DMRB 9.3)

IAN85/07 Design of Passively Safe Portal Signal Gantries

IAN86/07 Amendments to Design Requirements for Portal and Cantilever Sign/Signal Gantries

Specification for Highway Works (MCHW Vol.1)

TRH 1239 National Motorways Communications System Installation Drawings, Highways Agency et al

Davenport, A.G. 1962, "Buffeting of a suspension bridge by storm winds", Proc. ASCE, Vol.88, ST3Traffic Signs Manual, SO:

Chapter 1 – Introduction, 2nd Edition, 1982

Chapter 11 – Illumination of signs, 1967

Chapter 12 – Sign maintenance, 1968

Chapter 13 – Sign construction and mounting, 1968

The design and use of directional informatory signs, Local Transport Note 1/94, Department of Transport, SO, July 1994

Directional informatory signs interim design notes, Local Transport Note 2/94, Department of Transport, SO, 1994

The Traffic Signs Regulations and General Directions, HMSO, 1994

Road lighting and the environment, Department of Transport, 1993

Road Note 27. Instructions for using the portable ski resistance tester, TRRL Institution of Electrical Engineers: Regulations for electrical installations

Construction (Design and Management) Regulations, 2007

Health and Safety at Work Act, 1974

Eurocomp Draft design code/background information, Issue 4, 1994

11 ENQUIRIES

All technical enquiries or comments on this Standard should be sent in writing as appropriate to:

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Director of Engineering
The Department for Regional Development
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Clarence Court
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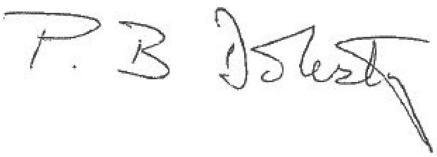
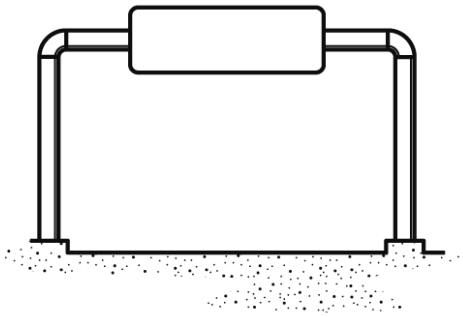


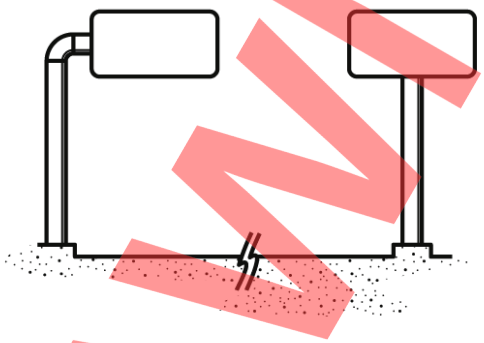
P B Doherty
Director of Engineering

ANNEX A: Sign Structure Figures

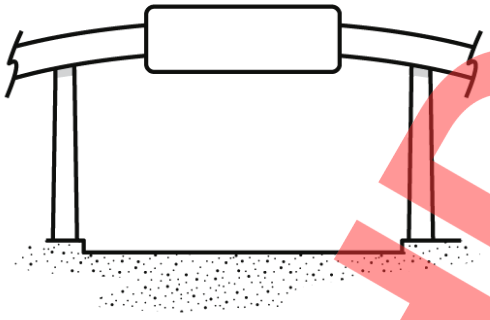
Figure 1 Examples of Sign Structures within the Scope of this Standard



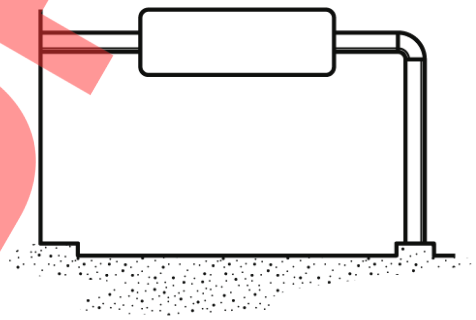
a) Spanning carriageway.



b) Cantilevered over carriageway.



c) Mounted on overbridge or tunnel portal.



d) Attached to or recessed into retaining wall.

Note
For definition of carriageway see Clause 1.11.

Figure 2 Recesses for gantry supports in retaining walls

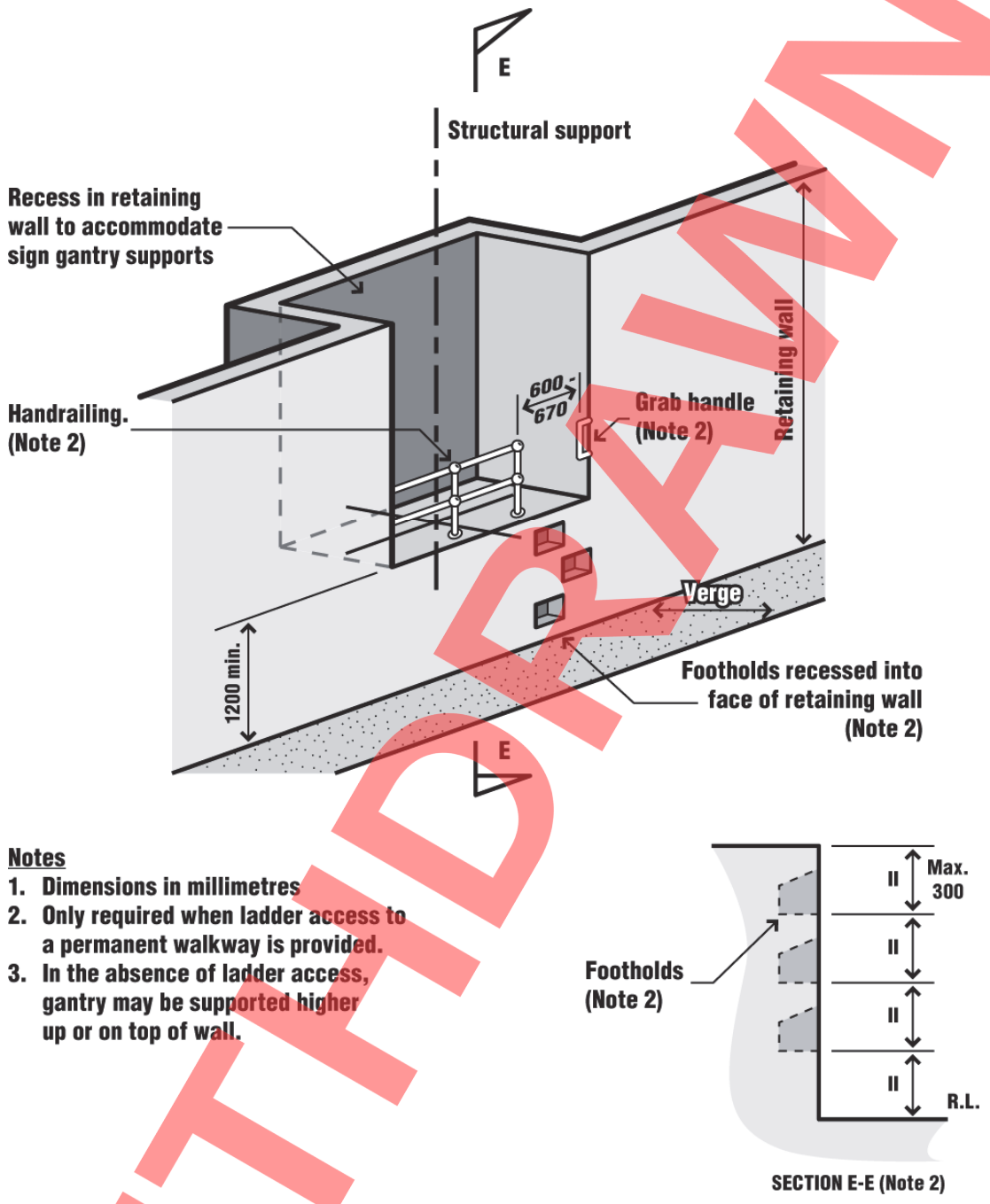
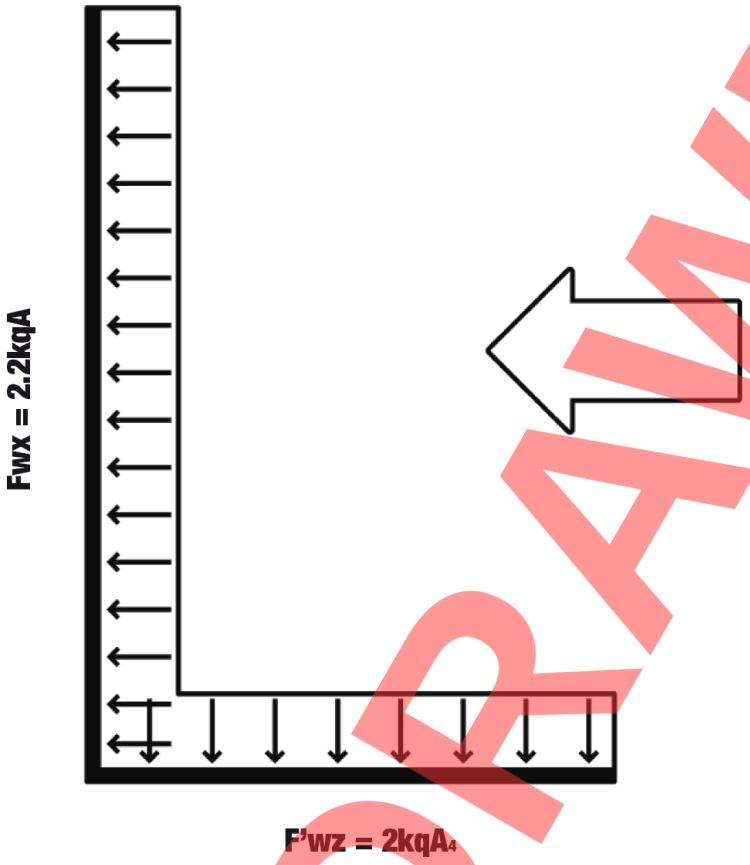
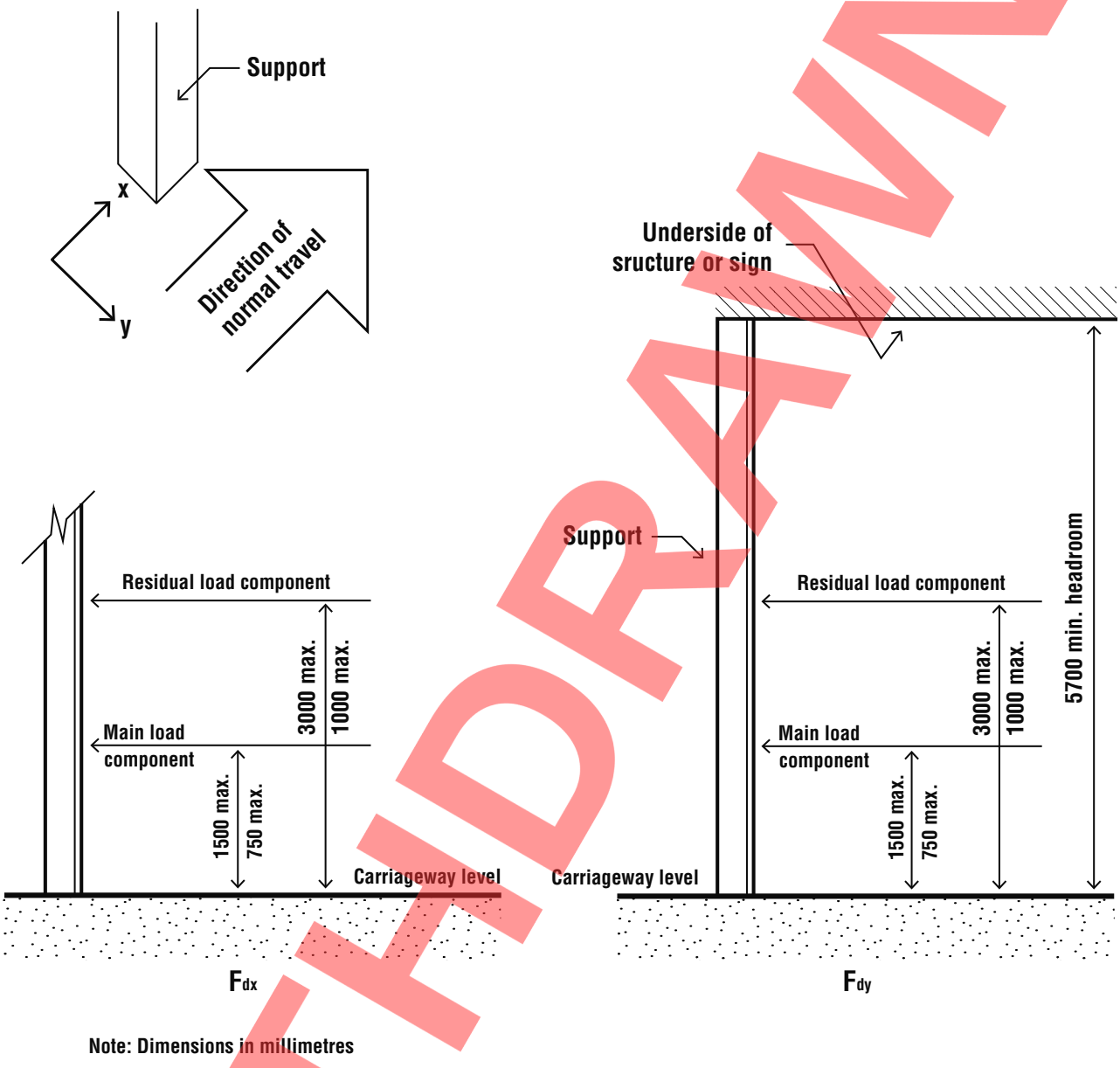


Figure 3 Wind loading on L shaped cross sections



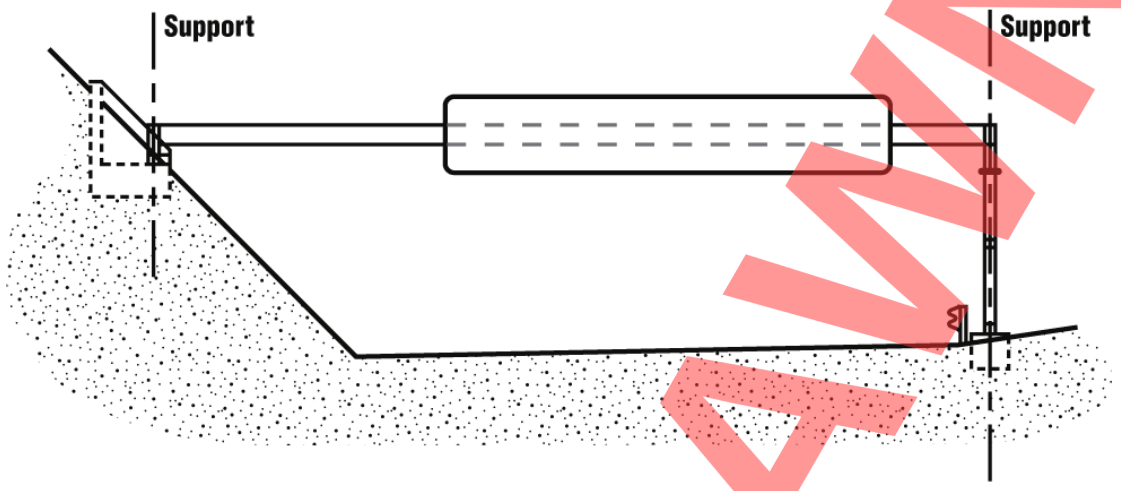
Where k = modification factor as given in Table 5.2

Figure 4 Heights of collision actions

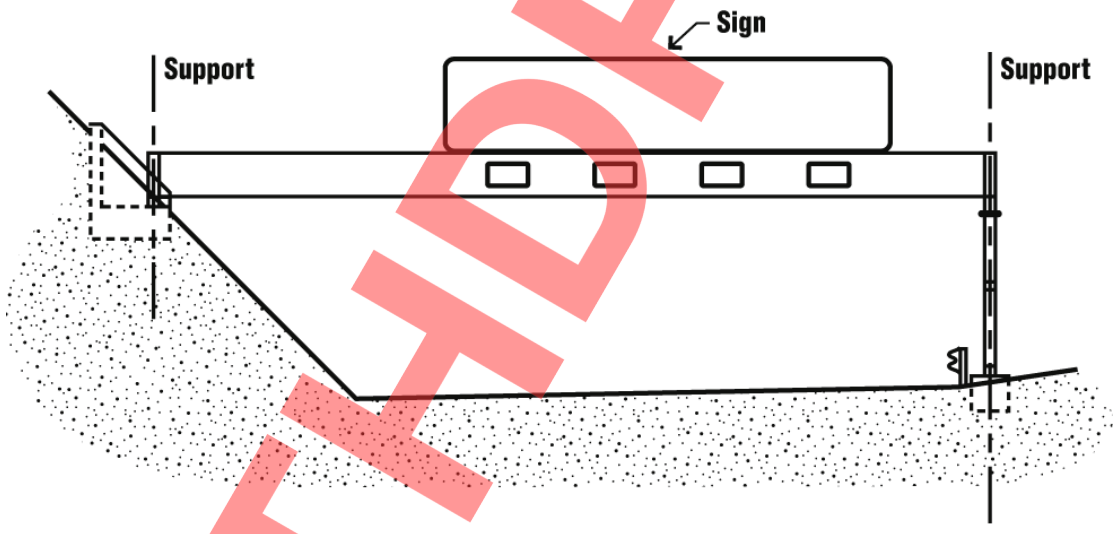


Note: Dimensions in millimetres

Figure 5 Form and Aesthetics – see clause D.10 (g)

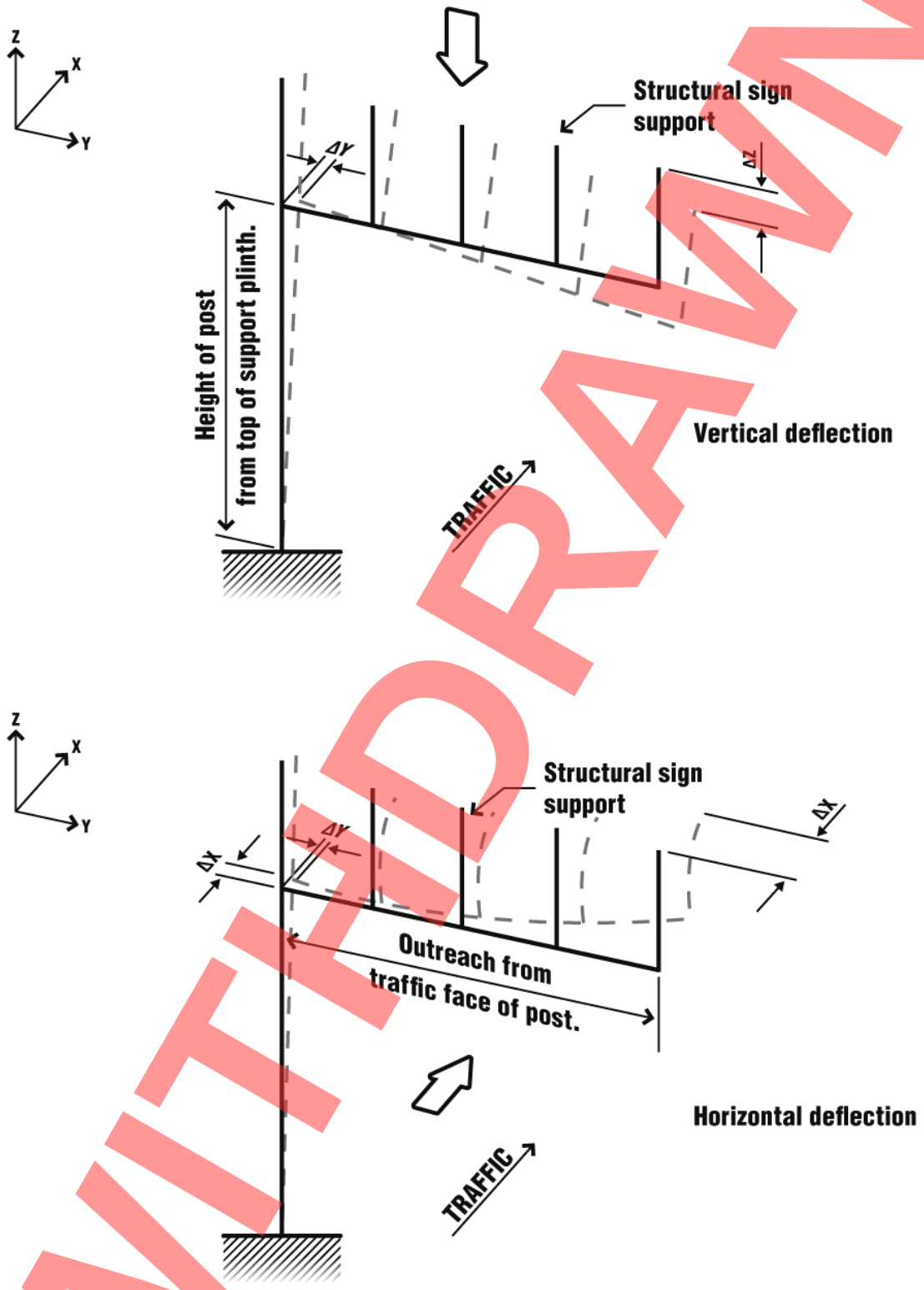


a) Without signals.



b) With signals.

Figure 6 Structural deformations of support posts and cantilevers (see Table 4.1)



ANNEX B: Risk Assessment and Cost Benefit Analysis for Passively Safe and Non-Passively Safe Gantries

Purpose of Risk Assessment and Cost Benefit Analysis

A risk assessment and cost benefit analysis is required to inform the decision whether or not a passively safe gantry is appropriate for use at a particular site. (See clauses 2.1 and 7.2)

B1 Scope

B1.1 The risk assessment must take account of:

i) Relative safety and journey time reliability risks of different proposed gantry types or designs;

ii) Road user, operative and third party risks;

iii) 'Adaptability' risks associated with any constraints on future functionality arising from the proposed gantry design.

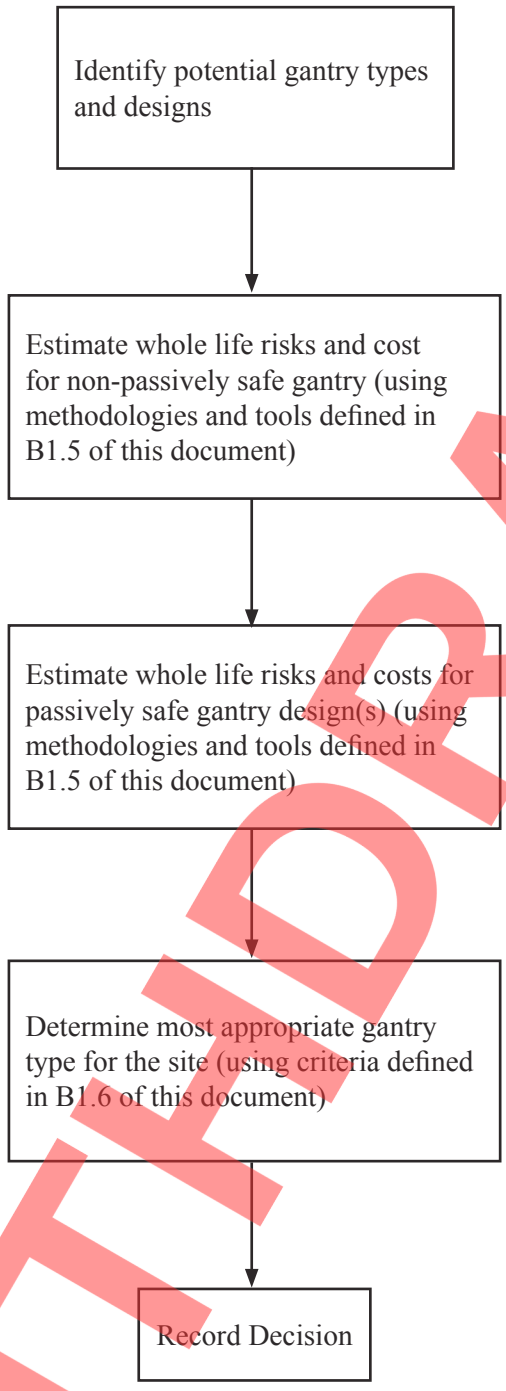
B1.2 The cost benefit analysis must then compare these risks with the relative costs of the different proposed gantry types or designs. Risks and costs must be considered on a whole life basis.

Process

B1.3 The minimum requirement must be to 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.

B1.4 Figure B.1 shows the gantry assessment process.

Figure B.1 Gantry Assessment Process



Methodologies and Tools for Estimating Whole-life Risks and Costs

B1.5 Whole life safety and Journey Time Reliability risks, as well as whole life costs for different gantry types must be estimated using the computer model available at www.dft.gov.uk/ha/standards/tech_info/psgrm/index.htm.

B1.6 The choice of gantry type must also consider Adaptability risk. This is the risk associated with reduced future functionality of any gantry e.g. because of limited load capacity or vibration characteristics. The level of Adaptability risk associated with a particular gantry design must be assessed as follows using the impact and likelihood ratings from Tables B.1 and B.2:

Table B.1 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 B.2 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

The Adaptability Risk Rating for a gantry is then:

Likelihood rating	Impact Rating: Low	Impact Rating: Medium	Impact Rating: High
High	Medium	High	High
Medium	Low	Medium	High
Low	Low	Low	Medium

Impact Rating

"Go – no go" Decision Criteria

B1.7 The final decision whether to use a passively safe gantry for a particular site must be informed by consideration of the relative whole life risks and costs of this type of gantry compared with a standard gantry.

B1.8 When assessing the acceptability of relative safety risks of a passively safe gantry compared with a standard gantry, designers need to consider changes in safety risk to individual user groups as well as changes in total risk. For example, it is possible to have a reduced total risk for a passively safe gantry but within this to have an increased risk to operatives. The acceptability of this type of increase in safety risk must be agreed with the Overseeing Organisation.

B1.9 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 must be agreed with the Overseeing Organisation.

Record Keeping

B1.10 Designers must formally record all the factors considered in the risk assessment. This will include:

i) the features and hazards present or known about at the time;

ii) sources of data used to inform the risk assessment;

iii) justification for the decisions made in the risk assessment.

B2 Introduction

B2.1 In early 2006, the Highways Agency commissioned work to develop a Performance Standard for a new type of low cost, passively safe gantry. This included a requirement for the Standard to include a risk assessment process for designers to use to decide whether or not a passively safe gantry is suitable for a particular site.

B2.2 It was originally intended that the risk assessment should comprise two tools; a high level flowchart/ decision tree that would identify those sites where a passively safe gantry definitely should or should not be used and a computer-based model to be used in those cases where the risks associated with the use of a passively safe gantry were less clear-cut.

B2.3 Sensitivity analyses conducted using the computer-based model did not identify any clear-cut cases where a passively safe gantry either definitely should or should not be used; the Performance Standard therefore requires the computer model to be used in all cases.

B2.4 This document is part of the material written to support the model. It describes how the model is constructed, the assumptions and data that underpin it and the results that it generates.

B3 Background

Purpose of the model

B3.1 The purpose of the model is to quantify the relative risks associated with a Passively Safe Gantry, compared with a Standard gantry. Risks considered by the model are:

i. Safety

ii. Journey Time Reliability (JTR)

The model also calculates the Whole Life Costs for different gantry designs.

Assumptions

B3.2 Assumptions behind the model are:

i. The scheme specification defines the required gantry and signal locations

ii. The design decision is whether to use passively safe or standard gantry design

iii. The baseline is the standard gantry design – the model then compares the benefits/disbenefits of a passively safe gantry relative to a standard design

iv. The model can accommodate baseline BD51 gantry designs without a walkway providing access for maintenance, or standard gantry designs with a walkway providing access for maintenance. The default model assumption is that the standard gantry will be designed without a walkway

v. All gantry designs will be required to carry the same signal technology i.e. signals are the same for the passively safe and standard gantry options

Data

B3.3 The model is populated with a set of default generic data. Where possible, this has been derived from available network level data. However, for some parameters directly relevant data could not be found. In these cases, data has been estimated either from:

i. The knowledge and experience of the team responsible for building the model

ii. Discussions with relevant experts

iii. Modelling

B4 Overview of the model

B4.1 The model is built in Excel. There are 4 worksheets in the model; these are:

i. Summary

ii. EventTrees

iii. JTR&Cost

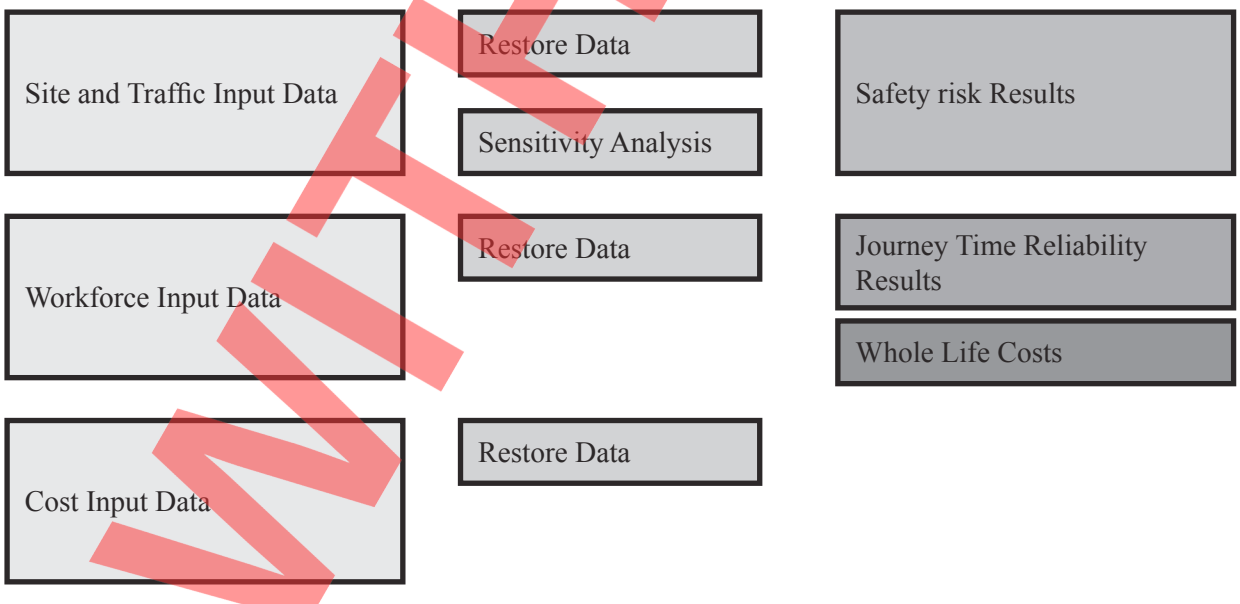
iv. GenericData

Summary data sheet

B4.2 The 'Summary' data sheet collects input data for the model; it also presents results for the different risk types considered by the model.

B4.3 Figure B.2 shows the general layout of the Summary data sheet. The content and functionality of the different sections of the Summary sheet are discussed in more detail in subsequent sections of this User Guide.

Figure B.2 General layout of summary data sheet



EventTrees data sheet

B4.4 The EventTrees data sheet holds event trees for calculating safety risk and frequency of walkway-related incidents.

B4.5 Users are not required to do anything with this sheet. It shows the detail of the safety risk calculation to inform sensitivity analyses and the understanding of what is driving safety risk.

JTR&Cost data sheet

B4.6 The JTR&Cost sheet calculates the Journey Time Reliability (JTR) impacts of different gantry types; it also calculates their whole life costs.

B4.7 Users are not required to do anything with this sheet. It draws data from the 'Summary' and 'GenericData' sheets to perform calculations. The sheet then shows the detail of the JTR and WLC calculations to inform sensitivity analyses and the understanding of what is driving journey time reliability impact and whole life costs.

GenericData data sheet

B4.8 The GenericData sheet holds several types of data:

i. Conditional probability data for safety risk event trees

ii. Other frequency data for safety risk event trees

iii. Consequence data for safety and Journey Time Reliability

Data on this sheet can be changed if designers feel the default data is not appropriate for their site or design.

Hazards included in the model

B4.9 Table B.3 describes the hazards and related event trees included within the model:

Table B.3 Model hazards and related event trees

User	Hazard	Event Tree
Occupant(s) of errant vehicle	Operative and/or TM vehicle hit in TM (construction)	Operative hit behind protective barrier during construction
	Gantry support	Gantry support hit by errant vehicle
	Road Restraint System	
	Operative and/or TM vehicle hit in TM (operation)	Operative and/or TM vehicle in TM
Other road users	Collapse of gantry onto the carriageway following impact	Other road users hit accident debris
	Debris from vehicle impact	
	Items dropped on the carriageway (operatives)	Operative on walkway/platform
	Items dropped/thrown onto the carriageway (unauthorised access)	Unauthorised access by third party
	Items fall off gantry (as a result of unobserved deterioration/defects)	Object falls off gantry
Operatives	Installing and removing TM (construction)	Operative hit crossing carriageway during construction
	Working adjacent to live carriageway (construction)	Operative hit behind protective barrier during construction
	Working at height (construction)	Operative falls from height during construction
	Installing and removing Traffic Management (Operation)	Operative hit crossing carriageway + Operative and/or TM vehicle hit in TM
	Working at height on gantry walkway (Operation)	Operative on walkway/platform
	Working at height on mobile platform (Operation)	Operative hit crossing carriageway + Operative and/or TM vehicle hit in TM
	Working adjacent to live traffic (operation)	Operative accident caused by errant vehicle
3rd Parties	Fall from height (unauthorised access)	Unauthorised access by third party

B5 Description of input data

B5.1 This section describes the input data required by the model.

B5.2 Data can be input via yellow cells within the 'Summary' and 'GenericData' sheets. These cells are populated initially with default data, taken from network average data/estimates. However, data in these cells can be changed to reflect uncertainties/variability in data values for local sites or schemes.

B5.3 To help determine whether the default data is appropriate, each yellow cell has a 'comment' attached to it which gives the basis for the default data value. 'Comments' can be viewed by positioning the cursor over the cell.

Site and traffic input data

B5.4 Table B.4 describes the site and traffic input data parameters. Site and traffic data is input via the 'Summary' data sheet.

Table B.4 Site and traffic data parameters

Parameter	Description
Standard gantry design to include a walkway?	Select 'yes' or 'no' from the drop-down menu to set the baseline standard gantry design that the PSG will be compared with
Length of site within hitting distance of gantry support	Length of carriageway in advance of gantry over which it is considered feasible that an errant vehicle could reach a gantry support
Length of barrier in relation to above site length	Length of barrier to be provided at the site within the 'length of site within hitting distance'. Note this length cannot be greater than the 'length of site within hitting distance'.
Type of barrier	Select from 'None', 'N2', 'H1' or 'H4a'
Average frequency that vehicles leave carriageway	Average frequency of errant vehicles at the site expressed as the number of vehicles per 1km site length per year
Average frequency of unauthorised access to gantry (with or without a walkway)	Number of times per 10 year period per gantry that expect someone to attempt to climb a gantry (enter zero if not an 'at risk' site)
Time between General Inspection	Number of years between General Inspections of the gantry structure

Table B.4 Site and traffic data parameters (continued)

Parameter	Description
Time between Principal Inspection	Number of years between Principal Inspections of the gantry structure
Time between re-painting for Standard gantries (steel construction)	Number of years between re-painting for steel gantries
Mean time between critical structural defects on a gantry	Mean number of years before an object falls into the carriageway if a critical defect that is present on the gantry is not detected
Average traffic mix passing through site	Average mix of cars, LGVs, buses/coaches and HGVs

Workforce input data

B5.5 Table B.5 describes the workforce data parameters. Workforce data is input via the 'Summary' data sheet.

Table B.5 Workforce data parameters

Parameter		Description
Working adjacent to live carriageway, during construction	Duration of TM	Input duration of TM to allow construction work adjacent to the live carriageway
	Day, night or 24h?	Select 'day', 'night' or '24h' for whether the TM is in place during day (only), night (only) or 24 hours
	Hard shoulder closed?	Select 'yes' or 'no' for whether TM to allow construction work adjacent to the live carriageway involves closure of the hard shoulder
	No. of carriageway lanes closed	Select '0', '1', '2' or '3' for number of carriageway lanes closed to allow construction work adjacent to the live carriageway
	Duration of work	Input number of hours workforce are present adjacent to the live carriageway during construction
	No. of times operative required to cross live carriageway	Input number of 'operative crossings' required to install advance warning signs for construction TM (e.g. 2 operatives required to make 3 crossings per sign for 6 advance warning signs = 2 x 3 x 6 = 36)
	No. of operatives	Input average number of operatives working adjacent to the live carriageway at any time during construction
Working at height installing boom, during construction	Duration of closure	Input duration of road closure to allow installation of the gantry boom
	Day, night or 24h?	Select 'day', 'night' or '24h' for whether installation of the gantry occurs during the day, at night or over a 24 hour period
	No. of operatives	Input number of operatives working at height during installation of the gantry boom

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Table B.5 Workforce data parameters (continued)

Parameter		Description
Working adjacent to live carriageway, normal operation	General Inspections per year	Value calculated from input 'Time between General Inspection'
	Other events per year	Input number of times per year 'other' work is expected to be required adjacent to the live carriageway during normal operation. Number to include visits to any equipment mounted adjacent to the gantry e.g. fixed CCTV cameras and communications cabinets
	Total no. of events per year	Value calculated from number of General Inspections per year, plus number of 'other' events per year
	Average duration of TM	Input average duration of any TM required to allow work adjacent to the live carriageway during normal operation
	Day, night or 24h?	Select 'day', 'night' or '24h' for whether average work event (and therefore TM) occurs during the day, at night or at any time over a 24 hour period
	Hard shoulder closed?	Select 'yes' or 'no' for whether average TM to allow work adjacent to the live carriageway during normal operation involves closure of the hard shoulder
	No. of carriageway lanes closed	Select '0', '1', '2' or '3' for average number of carriageway lanes closed per work event to allow work adjacent to the live carriageway during normal operation
	Average duration of work	Input average number of hours per work event that workforce are present adjacent to the live carriageway during normal operation
	Average no. of times operative required to cross live carriageway	Input average number of 'operative crossings' required to install advance warning signs for TM per work event

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Table B.5 Workforce data parameters (continued)

Parameter		Description
Working adjacent to live carriageway, normal operation (continued)	Average no. of operatives	Input average number of operatives working adjacent to the live carriageway per work event
Working at height on Standard Gantry Walkway, normal operation	Principal Inspections per year	Value calculated from input 'Time between Principal Inspection'
	Other events per year	Input number of times per year 'other' work is expected to be required from the gantry walkway. Number to include routine inspection and maintenance of signals and other gantry-mounted equipment, plus reactive repairs of signals and other gantry-mounted equipment
	Total no. of events per year	Value calculated from number of Principal Inspections per year, plus number of 'other' events per year
	Day, night or 24h?	Select 'day', 'night' or '24h' for whether average work event occurs during the day, at night or at any time over a 24 hour period
	Average duration of work	Input average number of hours per work event that workforce are present on the gantry walkway during normal operation
	No. of operatives	Input average number of operatives working adjacent to the live carriageway per event
Working at height on mobile platform with TM, normal operation	Principal Inspections per year	Value calculated from input 'Time between Principal Inspection'

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Table B.5 Workforce data parameters (continued)

Parameter		Description
Working at height on mobile platform with TM, normal operation (continued)	Other events per year	Input number of times per year 'other' work is expected to be required from a mobile platform during normal operation. Number to include routine inspection and maintenance of signals and other gantry-mounted equipment, plus reactive repairs of signals and other gantry-mounted equipment.
	Total no. of events per year	Value calculated from number of Principal Inspections per year, plus number of 'other' events per year
	Average duration of TM	Input average duration of any TM required to allow working at height on a mobile platform during normal operation
	Day, night or 24h?	Select 'day', 'night' or '24h' for whether average work event (and therefore TM) occurs during the day, at night or at any time over a 24 hour period
	Hard shoulder closed?	Select 'yes' or 'no' for whether average TM to allow work from a mobile platform during normal operation involves closure of the hard shoulder
	No. of carriageway lanes closed	Select '0', '1', '2' or '3' for average number of carriageway lanes closed per work event to allow work from a mobile platform during normal operation
	Average duration of work	Input average number of hours per work event that workforce are on or around a mobile platform, (i.e. working with TM on a live carriageway) during normal operation
	Average no. of times operative required to cross live carriageway	Input average number of 'operative crossings' required to install advance warning signs for TM per work event
	Average no. of operatives	Input average number of operatives working on or around a mobile platform (i.e. working with TM on a live carriageway) per work event

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Table B.5 Workforce data parameters (continued)

Parameter		Description
Standard gantry re-painting	Events per year	Value calculated from input 'Time between re-painting for Standard gantries'
	Average duration of TM	Input average duration of any TM required to allow re-painting work during normal operation
	Day, night or 24hr?	Select 'day', 'night' or '24h' for whether average work event (and therefore TM) occurs during the day, at night or at any time over a 24 hour period
	Hard shoulder closed?	Select 'yes' or 'no' for whether average TM to allow re-painting work during normal operation involves closure of the hard shoulder
	No. of carriageway lanes closed	Input average number of carriageway lanes closed per work event to allow work associated with repainting during normal operation
	Average duration of work	Input average number of hours per work event that workforce are working adjacent to a live carriageway during normal operation
	Average no. of times operative required to cross live carriageway	Input average number of 'operative crossings' required to install advance warning signs for TM per work event
	Average no. of operatives	Input average number of operatives working on re-painting and adjacent to the live carriageway per work event per work event

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Cost input data

B5.6 Table B.6 describes the cost data parameters. Cost data is input via the 'Summary' data sheet.

Table B.6 Cost data parameters

Parameter		Description
Construction cost, in first year	Design	Cost of gantry design (including any changes in design effort for signalling/other gantry-mounted equipment or communications cabinets to accommodate differences between gantry types)
	Foundations	Cost of foundations (including any modifications/changes to requirements to accommodate differences between gantry types)
	Fabrication & Erection	Cost of gantry fabrication and erection (including the cost of any changes to signalling/other gantry-mounted equipment to accommodate differences between gantry types)
	Barriers	Cost of barriers for different gantry types
Working adjacent to live carriageway, normal operation	Fixed cost	Average fixed cost per work event for working adjacent to live carriageway e.g. cost of TM vehicle/Impact Protection Vehicle
	Labour cost	Average cost per man per hour for work adjacent to live carriageway (including TM crew and operatives performing required work)
Working at height on Standard gantry walkway, normal operation	Fixed cost	Average fixed cost per work event for working at height on Standard gantry walkway
	Labour cost	Average cost per man per hour for working at height on Standard gantry walkway
Working at height on mobile platform with TM, normal operation	Fixed cost	Average fixed cost per work event for working at height on mobile platform e.g. cost of TM vehicle, Impact Protection Vehicle, mobile platform, lorry-mounted crane
	Labour cost	Average cost per man per hour for work adjacent to live carriageway (including TM crew and operatives performing required work)
Standard gantry re-painting	Preliminaries	Cost of preliminary works to prepare structure for re-painting
	Works	Cost of repainting
	Contingency	Contingency allowance for re-painting preliminaries and works
Reference time period for WLC calculation, in years		Enter gantry design working life or functional life (depending on basis being used for WLC calculation) in years

Generic data

B5.7 Generic data are held on the 'GenericData' data sheet. It is not expected that users will need to change default values for generic model data. Default values for the generic data are shown in Section B5.9.

Sensitivity analysis

B5.8 The Site and Traffic section of the 'Summary' data sheet includes scroll bars for sensitivity analysis. Moving these bars left or right increases or decreases the values for the relevant parameters. Effects of any changes made on model outputs are shown instantly in the results section.

Restore data

B5.9 The data input areas of the model include buttons that run macros, as follows:

Restore default site data. Loads in a default set of Site input data (the data displayed in Figure B.3).

Figure B.3 Default site and traffic input data

Site and Traffic Input Data

Standard gantry design to include a walkway?		no
Length of site within hitting distance of gantry leg, in metres	Passively Safe	50
	Standard	50
Length of barrier in relation to above site length, in metres (enter zero if no barrier present)	Passively Safe	0
	Standard	30
Type of barrier	Passively Safe	none
	Standard	H1
Average frequency that vehicles leave carriageway (no. of vehicles per 1km site length per year)		1.0
Average frequency of unauthorised access to gantry (with or without a walkway) (no. of events per 10 year period per gantry, enter zero if not an at risk site)	Passively Safe	0.0
	Standard	0.0
Time between General Inspections, in years	Passively Safe	2
	Standard	2
Time between Principal Inspections, in years	Passively Safe	6
	Standard	6
Time between re-painting for Standard gantries (steel construction), in years		15
Mean time between critical structural defects on a gantry, in years (Mean no. of years before object falls into carriageway if not detected)	Passively Safe	10.0
	Standard	10.0
Average traffic mix passing through site	Car	81%
	LGV	12%
	Bus / Coach	1%
	HGV	6%

Restore default workforce data. Loads in a default set of Workforce input data (the data displayed in Figure B.4).

Figure B.4 Default workforce input data

Workforce Input Data	Passively Safe	Std. no walkway	Std. with walkway
Working adjacent to live carriageway, during construction			
Duration of TM, in hours	350	1350	1350
Day, night or 24h?	24h	24h	24h
Hard shoulder closed?	yes	yes	yes
No. of carriageway lanes closed	0	0	0
Duration of work, in hours	115	450	450
No. of times operative required to cross live carriageway	30	30	30
No. of operatives	10	10	10
Working at height installing boom (carriageway closed), during construction			
Duration of closure, in hours	0.5	0.5	0.5
Day, night or 24h?	night	night	night
No. of operatives	2	2	2
Working adjacent to live carriageway (routine I&M), normal operation			
General Inspections per year (calculated from above)	0.5	0.5	0.5
Other events per year	2.5	2.5	2
Total no. of events per year	3	3	2.5
Average duration of TM, in hours	0	0	0
Day, night or 24h?	day	day	day
Hard shoulder closed?	no	no	no
No. of carriageway lanes closed	0	0	0
Average duration of work, in hours	1	1	1
Average no. of times operative required to cross live carriageway, per event	2	0	0
Average no. of operatives	1	1	1
Working at height on Standard gantry walkway, normal operation			
Principal Inspections per year (calculated from above)			0.17
Other events per year			5
Total no. of events per year			5.17
Day, night or 24h?			day
Average duration of work, in hours			1
No. of operatives			1
Working at height on mobile platform with TM, normal operation			
Principal Inspections per year (calculated from above)	0.17	0.17	0.00
Other events per year	5.5	5.5	0.5
Total no. of events per year	5.67	5.67	0.50
Average duration of TM, in hours	7	7	7
Day, night or 24h?	night	night	night
Hard shoulder closed?	yes	yes	yes
No. of carriageway lanes closed	2	2	2
Average duration of work, in hours	3	3	4
Average no. of times operative required to cross live carriageway, per event	30	30	30
Average no. of operatives	3	3	3
Standard gantry (steel construction) re-painting			
Events per year (calculated from above)		0.07	0.07
Average duration of TM, in hours		42	42
Day, night or 24h?		night	night
Hard shoulder closed?		yes	yes
No. of carriageway lanes closed		3.33	3.33
Average duration of work, in hours		42	42
Average no. of times operative required to cross live carriageway, per event		30	30
Average no. of operatives		8	8

Restore default cost data. Loads in a default set of Cost input data (the data displayed in Figure B.5).

Figure B.5 Default cost input data

Cost Input Data	Passively Safe	Std. no walkway	Std. with walkway
Construction cost, in first year			
Design	£ 10,000	£ 10,000	£ 10,000
Foundations	£ 10,000	£ 40,000	£ 40,000
Fabrication & Erection	£ 35,000	£ 44,000	£ 54,000
Barriers	£ -	£ 70,000	£ 70,000
Working adjacent to live carriageway (routine I&M), normal operation			
Fixed cost, £ per event	£ 10	£ 10	£ 10
Labour cost, £ per man hour	£ 30	£ 30	£ 30
Working at height on Standard gantry walkway, normal operation			
Fixed cost, £ per event			£ 10
Labour cost, £ per man hour			£ 30
Working at height on mobile platform with TM, normal operation			
Fixed cost, £ per event	£ 100	£ 100	£ 100
Labour cost, £ per man hour	£ 30	£ 30	£ 30
Standard gantry (steel construction) re-painting, per event			
Preliminaries		£ 16,000	£ 16,000
Works		£ 55,000	£ 55,000
Contingency		£ 9,000	£ 9,000
Reference time period for WLC calculation, in years	30	30	30

Restore default conditional probabilities. Loads in a default set of conditional probability data (see Figures B.6a & B.6b).

Figure B.6a Default conditional probability data

Conditional probability data

Conditional probability that barrier fails to contain impact from		none	N2	H1	H4a
	Car	100%	5%	1%	0.01%
	LGV	100%	90%	5%	0.10%
	Bus / Coach	100%	99%	50%	1.00%
	HGV	100%	100%	90%	20.00%

Conditional probability that hit gantry leg, given that no/missed barrier	Passive	Standard
	10%	10%
Conditional probability that hit gantry leg, given that breached barrier	Passive	Standard
	0.0%	20.0%

Conditional probability that significant debris lands in carriageway, given that barrier (only) hit by		none	N2	H1	H4a
	Car	0%	10%	10%	10%
	LGV	0%	10%	10%	10%
	Bus / Coach	0%	10%	10%	10%
	HGV	0%	10%	10%	10%

Conditional probability that gantry collapses across carriageway, given no/missed barrier and gantry leg hit by		Passive	Standard
	Car	10%	0%
	LGV	10%	0%
	Bus,/ Coach	10%	1%
	HGV	10%	5%

Conditional probability that significant debris lands in carriageway, given no/missed barrier and gantry leg hit, but gantry does not collapse		Passive	Standard
	Car	10%	20%
	LGV	10%	20%
	Bus / Coach	10%	20%
	HGV	10%	20%

Conditional probability that gantry collapses across carriageway, given barrier breached and gantry leg hit by		Passive	Standard
	Car	2%	0%
	LGV	2%	0%
	Bus / Coach	2%	0%
	HGV	2%	1%

Conditional probability that significant debris lands in carriageway, given barrier breached and gantry leg hit, but gantry does not collapse		none	N2	H1	H4a
	Car	0%	10%	10%	10%
	LGV	0%	10%	10%	10%
	Bus / Coach	0%	10%	10%	10%
	HGV	0%	10%	10%	10%

Conditional probability that lead vehicles hit debris in carriageway under normal traffic conditions (assumed to scale with volume)	10%
Conditional probability that lead vehicles hit collapsed gantry under normal traffic conditions (assumed to scale with volume)	50%

Conditional probability that following vehicles brake & rear end shunt under normal traffic conditions (assumed to scale with volume)	Brake	Rear end shunt
	40%	10%
Conditional probability that following vehicles swerve & side impact under normal traffic conditions (assumed to scale with volume)	Swerve	Side impact
	50%	20%

Conditional probability that third party falls into carriageway from gantry, given that gantry has been climbed	Passive	Std no walkway	Std with walkway
	20%	20%	20%
Conditional probability that third party drops object into carriageway, given that gantry has been climbed	Passive	Std no walkway	Std with walkway
	50%	50%	50%

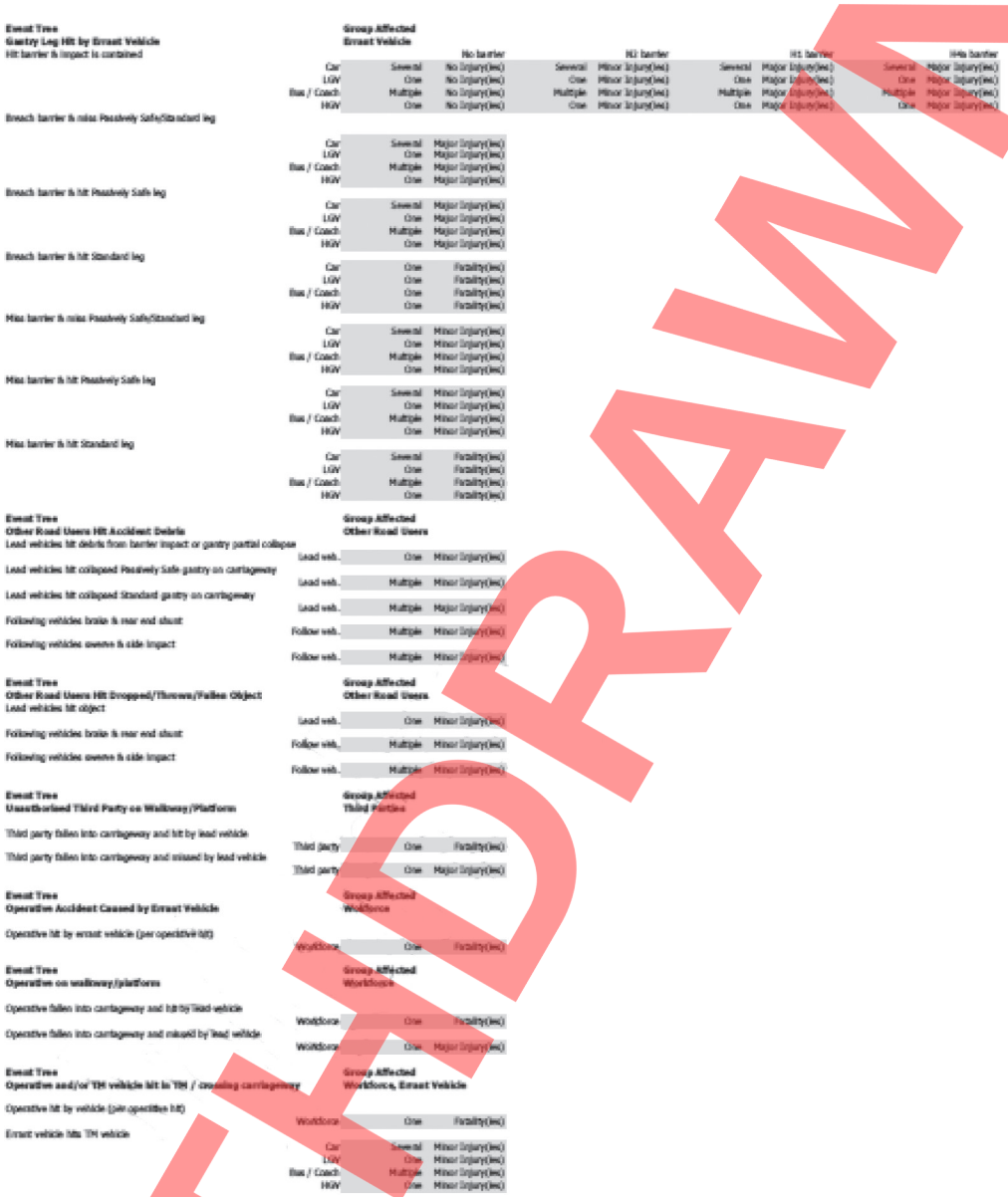
Conditional probability that third party is hit by lead vehicle, given that has fallen into carriageway from gantry	50%

Figure B.6b Default conditional probability data (Continued)

Working adjacent to live carriageway, errant vehicle rate factor for day, night, or 24h working	day	night	24h
	1.4	0.16	1.0
Conditional probability that operative(s) working adjacent to carriageway when errant vehicle leaves carriageway	Passive	Standard	
	0.034%	0.034%	
Conditional probability that operative(s) hit, given that errant vehicle missed barrier	Passive	Standard	
	10%	10%	
Conditional probability that operative(s) hit, given that errant vehicle breached barrier	Passive	Standard	
	0.0%	14.3%	
Working on Standard walkway, errant vehicle rate factor for day, night, or 24h working	day	night	24h
	1.4	0.16	1.0
Working on mobile platform, errant vehicle rate factor for day, night, or 24h working	day	night	24h
	1.4	0.16	1.0
Conditional probability that operative falls into carriageway from walkway or platform	walkway	platform	
	0.000916%	0.0366%	
Conditional probability that operative drops significant object into carriageway from walkway or platform	walkway	platform	
	0.0073%	0.0018%	
Conditional probability that operative is hit by lead vehicle, given that has fallen into carriageway from walkway or platform	walkway	platform	
	50%	10%	
Conditional probability that General Inspection misses any critical defects present, per inspection performed			
	20%		
Conditional probability that Principal Inspection misses any critical defects present, per inspection performed from walkway or platform	walkway	platform	
	5%	10%	
Conditional probability that cursory inspection misses any critical defects present, per inspection performed from walkway or platform	walkway	platform	
	25%	50%	
Conditional probability that operatives and/or TM vehicle present in TM when errant vehicle leaves carriageway	Passive	Standard	
Working adjacent to live carriageway	0.00%	0.00%	
Platform	0.19%	0.23%	
Conditional probability that operatives hit, given that errant vehicle breaches TM whilst operatives present	Passive	Standard	
Working adjacent to live carriageway	10.0%	10.0%	
Platform	30.0%	30.0%	
Conditional probability that TM vehicle hit, given that errant vehicle breaches TM whilst operatives present	Passive	Standard	
Working adjacent to live carriageway	12.0%	12.0%	
Platform	12.0%	12.0%	
Conditional probability that operative hit when crossing carriageway, per carriageway crossing			
	0.00002%		
Working adjacent to live carriageway during construction, errant vehicle rate factor for day, night, or 24h working	day	night	24h
	1.4	0.16	1.0
Conditional probability that operatives hit, given that errant vehicle breaches barrier during construction	Passive	Standard	
	100.0%	100.0%	

Restore default consequences data. Loads in a default set of consequences data (see Figure B.7a & B.7b).

Figure B.7a Default consequence



Volume 2 home page

Figure B.7b Default consequence data (Continued)

Emergency TM consequence data

		Duration of TM, in hours	Hard shoulder closed?	No. of c.way lanes closed
Initial clearance of barrier impact				
	Passively Safe	0.5	yes	2
	Standard	0.5	yes	2
Emergency roadworks to repair barrier				
	Passively Safe	3	yes	1
	Standard	3	yes	1
Removal of accident debris from carriageway				
	Passively Safe	0.5	no	2
	Standard	0.5	no	2
Removal of collapsed gantry from carriageway				
	Passively Safe	4	yes	3
	Standard	4	yes	3
Removal of dropped/thrown objects from carriageway				
	Passively Safe	0.5	no	2
	Standard	0.5	no	2

B6 Model outputs and results

B6.1 Outputs from the model are:

i. Safety risk of different gantry designs (in units of Fatalities and Weighted Injuries/year)

ii. Journey Time Reliability impacts of different gantry designs (in units of Lost Lane Hours)

iii. Whole Life Costs of different gantry designs (as a discounted annual equivalent cost, in £)

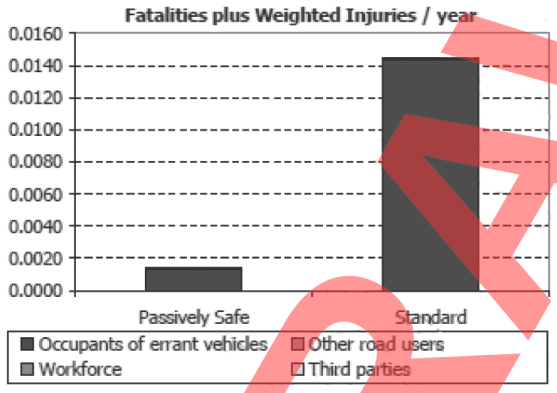
The following sub-sections describe the outputs and results produced by the model in more detail.

Safety risk results

B6.2 Figure B.8 shows the format of the safety risk results, comparing a passively safe gantry with a standard gantry without walkway access:

Figure B.8 Safety risk results

Safety Risk: Fatalities + Weighted Injuries/ yr	Passively Safe	Standard
Occupants of errant vehicles	1.36E-03	1.44E-02
Other road users	3.04E-05	1.38E-05
Workforce	7.56E-05	7.59E-05
Third parties	0.00E+00	0.00E+00
Total	**1.46E-03**	**1.45E-02**
Safety Risk for Passively Safe relative to Standard design	**-90%**	**Green**
Workforce risk during construction	*1.29E-04*	*2.68E-04*



B6.3 Differences in safety risk between passively safe and standard gantries are presented in units of 'Fatalities and Weighted Injuries/year'. Differences in safety risk are provided for:

i. Workforce

ii. Road users

iii. Unauthorised Third Parties

iv. Total

B6.4 The model shows the % difference in safety risk between Passively Safe and Standard gantries.

i. If a Passively Safe gantry is >20% safer than a Standard gantry then Passively Safe gantry risk is rated as 'Green'.

ii. If a Passively Safe gantry is >20% less safe than a Standard gantry then Passively Safe gantry risk rated as 'Red'.

iii. For cases where Passively Safe gantry risk is within +/- 20% of Standard gantry risk then Passively Safety gantry risk is rated as 'Amber'.

B6.5 The workforce safety risk associated with construction is also presented for Passively Safe and Standard gantries.

B6.6 Safety risk results are also summarised in a graph that updates automatically as input data is changed.

Journey time reliability results

B6.7 Figure B.9 shows the format of the Journey Time Reliability results:

Figure B.9 Journey time reliability results

Journey Time Reliability: Lane Hours Lost / year	Passively Safe	Standard
Carriageway, day	0.01	0.11
Carriageway, night	79.33	88.67
Hard shoulder, day	0.00	0.09
Hard shoulder, night	39.67	42.48
Total	**119.01**	**131.35**
Lane hours lost during construction	*352.00*	*1,352.00*

B6.8 Journey Time Reliability impact is calculated in terms of 'lane hours lost' i.e. number of hours that lanes are closed because of planned or emergency Traffic Management associated with inspection, maintenance or repair of different gantry designs.

B6.9 Lane hours lost are provided for:

i. Carriageway, day

ii. Carriageway, night

iii. Hard shoulder, day

iv. Hard shoulder, night

v. Total

The total lane hours lost during construction are also provided for different gantry designs.

Whole-life cost results

B6.10 Figure B.10 shows the format of the Whole Life Cost results (where 'I&M' is 'Inspection & Maintenance'):

Figure B.10 Whole-life cost results

Whole life cost for construction and routine I&M activities:	Passively Safe	Standard
Discounted annual equivalent cost	£3,192	£8,417

B6.11 The model calculates a discounted annual equivalent cost for different gantry designs. For each gantry, this is the total Present Value cost over the lifecycle, divided by the cycle duration. Within this, the model assumes a discount rate of 3.5%.

ANNEX C: Typical Equipment and Cabling

General

C.1 This Annex outlines the typical equipment, signs and cabling that may be included on a gantry.

C.2 The equipment that a gantry is required to carry should be defined on a project specific basis.

Overloading of Information

C.3 The amount of information provided on a sign must be limited in accordance with appropriate design guidance, such as Local Transport Note No 1/94, to a maximum of six destinations or their equivalent, unless otherwise agreed as a departure from standards by the TAA.

Separation of Functions

C.4 The functions of displaying signs and signals on gantries must be separated, except in Scotland, and Northern Ireland, and designs for each function developed. When a design to accommodate both functions is required for reasons of limited space and economic considerations, this must be agreed as a departure from standards by the TAA.

Sign Alone Gantries

C.5 To reduce overcrowding of information and visual impact of the gantry structure, dedicated structures to support signs alone, must be considered. By placing the beam member at the centre of the sign area, torsional actions on the structure can be reduced.

Signal Alone Gantries

C.6 To reduce information and visual intrusion of the gantry structure, dedicated structures to support signals alone must be considered. Depending upon the eventual requirements, these might also be suitable for motorway tolling equipment.

Combined Sign and Signal Gantries

C.7 To minimise information on signs and simplify structural requirements, it is desirable to avoid gantries carrying both signs and signals. However, in Scotland and Northern Ireland and where operational requirements call for both signs and signals, and subject to satisfying [C.5], designs to support both may be used.

Directional Signs

C.8 The layout of the sign must be in accordance with The Traffic Signs Regulations and General Directions.

Size of Sign to be Allowed for

C.9 The size of sign to be allowed for in design depends on sign face design. The basis of design of sign layouts is given in Local Transport Notes 1 and 2/94 *The Design and Use of Directional Informatory Signs* and *Directional Informatory Signs Interim Design Notes* respectively. The size of the panel is influenced by:

i) The 'x' height adopted;

ii) The number of destinations;

iii) The layout, such as spacing, and the need for arrows and panelling of destinations where appropriate.

The 'x' height is by far the greatest influence and needs to be such that the sign is legible to the driver for sufficient time to be able to read and act upon the message as he approaches. This is governed by the approach speed of the vehicle and hence the siting distance.

C.10 The sign must be visible from the maximum distance at which it can be read, depending on vehicle speed and the letter 'x' height as defined by Local Transport Note 1/94, and the minimum distance given by a maximum upward angle of view by the driver of 10 degrees from the line of travel.

Illumination of Signs

C.11 Generally, motorway gantries are required to be lit. Lighting designers should consider light spill beneath signs for non-access gantries as their open nature can create a problem in this area.

External Lighting

C.12 Luminaires must be positioned to achieve the luminance required by BS EN 12899, Part 1 across the whole area of the sign face. Positioning of luminaires should take account of maintenance requirements for the luminaires and for other equipment mounted on the gantries.

Internal Lighting

C.13 Where internal illumination is envisaged, a suitable light source giving sufficient light to evenly illuminate the area of the sign face must be provided.

Variable Message Signs

C.14 Where required, gantry designs must allow for the mounting of variable message signs and their associated control equipment, together with their subsequent removal for maintenance and replacement.

Maintenance of Signs

C.15 Traffic signs need to be cleaned in accordance with the Traffic Engineering and Control (TD and TA) requirements. Cleaning is required and at intervals not exceeding three years. In industrial areas, annual cleaning is preferred to prolong the life of the sign. Consideration must be given to the bulk replacement of lamps for illuminated signs to minimise the out of course maintenance visits. Rotating prism variable message signs have a high maintenance requirement and must be considered in the same manner as signals. Consideration must be given to specifying road luminaires to IP65 enclosure rating to reduce the need for cleaning to the same intervals as lamp changing.

Mounting of Signs

C.16 Where appropriate, signs must be mounted at a small inclination to the vertical to improve visibility. The structural member to which the sign is to be attached must be flush faced and suitable for use with bands or clamps to fasten the signs. Projecting bolt heads and cover plates, that prevent the sign from

being fixed in one plane, must be avoided. The design of the sign support members must be such that subsequent resigning can be implemented, possibly to a different sign size, without major disruption to the main members of the gantry. The sign support members must be readily capable of removal and replacement to suit revised sign configurations.

C.17 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 must have a horizontal straight top edge after allowing for any pre-camber and/or deflection under self weight. The sign support members must be plumb in elevation. To achieve the latter, header rails are advisable.

Motorway Signals

C.18 The other main purpose of gantry structures is to support motorway signals over the carriageway. TD 46 (DMRB 9.1.1) describes the different types of motorway signals available and gives the criteria to be satisfied for their provision. Descriptions of the different types of signals and design guidance for their implementation is given in TA 74 (DMRB 9.4.3)

Closed Circuit Television Cameras

C.19 Where it is required to locate closed circuit television (CCTV) cameras on gantry structures, the position of the camera must be such that a clear, unimpeded view of the motorway is provided. Where fixed cameras are used, the field of view will depend on the coverage of other cameras within the overall CCTV scheme.

C.20 Where required, consideration must be given to making provision for the incorporation of such a mast on the gantry structure. Allowance for maintenance will be required and this will include for the camera to be winched down.

Signal Control Equipment

C.21 Signal control equipment is currently mounted on gantries. This includes equipment for power distribution, communications links and signal drivers. For maintenance, operational and safety reasons such equipment will remain on the gantry structure, close to the signals themselves. Equipment must be mounted so that they can be readily accessed for maintenance from a mobile access platform.

Mounting of Signal Equipment

C.22 The design of lane signal mountings must be such that they can accommodate all types of existing equipment – AMI and MS without the need for major modifications.

C.23 Consideration must be given in the design of the gantry to allow for the addition of unspecified equipment at a later date without the need for structural checks and preferably without the need for interference with any structural element. Equipment plates with a matrix of holes or a proprietary racking system could be considered.

C.24 On combined function gantries the design must 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

C.25 If a walkway is provided, consideration must be given to the provision of power sockets along the walkway for use by maintenance personnel. Typically these would be used for test equipment, power tools, lifting hoist etc.

Third Party Equipment

C.26 The presence of equipment provided and installed by a third party, usually for vehicle detection, must only be permitted when there is no practical alternative. Efforts must be made to limit the duplication of any such equipment.

Ground Works

C.27 Where signals are installed on gantries or lighting is provided, electrical cabinets are usually required adjacent to the gantry. Ducts for electric supply and communication cables must be provided from the cabinet to the base of the superstructure and cable routes along the highway. Electrical cabinets must be located so as to be unobtrusive and integrated with the landscape design where possible. Examples of cabinets and duct routes for use on Motorway Signal Mark 2 schemes at gantry sites are shown on Drawing No MCX 0582 and 0811 of TRH 1239 National Motorway Control Systems, Installation Drawings.

C.28 A hard standing at the base of the gantry ladder and between the ladder, cabinet and point of entry from the highway must be included, with steps and hand railing as appropriate. Where practical, provision must be made in the vicinity for a car or light van to drive off the highway clear of other road users. Where space permits, 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.

Passively Safe Gantries

C.29 Typical equipment and cabling requirements for passively safe gantries are given in Table C.1 and C.2 respectively.

C.30 Tables C.1 and C.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 C.1 and C.2 contain typical requirements for guidance alone. They are based on recent experience and practice and should not be treated as definitive.

Table C.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 C.2 Typical Cabling Requirements

From/To	Type	No. & Dia. (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	4mm² 3 core	1 x 11	0.25	30
Bottom of gantry support to CMU	RS485 (quad)	1 x 10	0.10	30
CMU to AMI	30 way	1 x 20	0.40	120
MCAB to AMI	4mm² 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	4mm² 3 core	1 x 11	0.25	30
MCAB to DEE Flash Unit	4mm² 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	4mm² 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	4mm² 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	4mm² 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	4mm² 3 core – Armored	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

ANNEX D: Appearance

General

D.1 The overall appearance is an important consideration for gantries. The gantry design must be submitted by the designer to the TAA for England, or to the Overseeing Organisation for Scotland, Wales and Northern Ireland, for approval of its appearance at the time of approval in principle. The designer should consult with the TAA prior to formal AIP submission to establish outline agreement.

D.2 When considering the environmental and aesthetic aspects related to the location and detailed design of sign gantries, the designer should ensure that visual impact and appearance are given full attention to that of the function. The designer should take into account the following clauses in considering the visual impact and appearance of sign gantries.

Environmental and Aesthetic Considerations

Context

D.3 When locating gantries and signs in their general landscape setting to accord with current European Community legislation in the preparation of Environmental Statements, designers must consider the environmental advice embodied in DMRB, Volumes 10 and 11. These volumes 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.

D.4 Visual impact must be assessed by a combination of the degree to which the feature is prominent in the view, and the quality of the landscape, urban and rural, in which the feature is located. Visual impact will be caused upon the surrounding landscape by gantry construction both during the day, and by any associated lighting during the hours of darkness. These impacts must be assessed and minimised in relation to:

a) The quality of landscape in which the gantry is proposed. (Designated Landscapes, etc.).

b) The extent of the visual envelope created, day and night.

c) The number of residential properties affected, day and night.

Information collected under a), b) and c) above must be presented for assessment in the textual and environmental framework format required in DMRB, Volume 11.

D.5 Further assessment of visual impact caused by lighting should be considered in conjunction with the Department of Transport publication *Road Lighting and the Environment*.

D.6 As a general guide, gantries must be located low in the landscape, preferably in cutting and not visible above the skyline.

D.7 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. Although the most effective mitigation is the initial choice of location for a gantry, where standards dictate this is not possible, developing a sympathetic appearance to the structure is the best solution to adopt, accompanied by consideration of physical and vegetative visual barriers which can assist in mitigating the visual impact created.

Form and Aesthetics

D.8 Gantries must not be perceived as an isolated or "bolt on" element in the design of a road scheme but must be considered an integrated part of a total design solution. Ideally a theme of design should be established which runs through the separate elements of highway development including structures, gantries, signs, fencing, noise barriers and lighting, lending visual sympathy between elements and establishing a continuity to the overall proposal.

D.9 Recent gantries have a somewhat "technical or mechanistic" appearance more appropriate to an urban than a rural setting, but using modern materials it should be possible to produce a gantry-more appropriate to placing in the countryside.

D.10 More satisfactory aesthetics will be achieved, if the gantry design includes the following features:

a) Simplicity and unobtrusiveness.

b) Visually light and uncluttered structures.

c) Continuity of design with other highway elements.

d) Innovative design. Appropriate choice between "technical" and "organic" appearance to gantry design in urban and rural settings.

e) Appropriate use of colour (see also below "Colour").

f) Spanning over several carriageways/slip roads to reduce number of vertical supports.

g) Spanning more than the mere minimum distance between vertical barriers or bunds for a more integrated appearance, [see Annex A, Figure 5].

h) 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.

i) Proportioning signs in relation to gantry and other highway elements.

j) Creating a "sense of place" with individual designs or sculptural forms. For example, at the beginning of a motorway as it leaves a city; this transition point could be emphasised by a unique design, however, such a feature may be more appropriate for a bridge.

k) Lateral thought and innovation. This is required in conceiving original gantry design, by a combined team of engineers and architects/ landscape architects.

l) Omission of walkways, excessive structure, superfluous retaining walls and concrete plinths and bases, wherever possible.

Colour

D.11 The same aesthetic criteria must be applied to the use of colour on gantries and signs as is indicated for form, with the added caution that the colour of a gantry must assist in promoting the function of communication, not compete with it.

D.12 Research suggests that 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 Medium Grey 18B21 and BS 381C Camouflage Grey 626 are suitable. Black has been proposed as an alternative, but draws attention to itself in all but dense woodland or avenue settings. Greens are frequently bright and synthetic and fail to match the complex landscape backdrop. Muted grey – green has been successful in Surrey in association with colouring lighting columns. Where their use is agreed with the TAA, the silver-grey of galvanised steel or weathered aluminium frequently integrates well.

D.13 Generally multi-colours are not found to enhance any particular form, however, designers should not be discouraged from experimentation. 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. Illustrations and computer generated impressions will assist construction experimentation with colour options.

Detail

D.14 The visual impact caused by the provision of gantries and signs may be mitigated by the selection of a suitable form of either a vertical barrier, earth bund, dense tree and shrub planting or a combination of these three elements.

D.15 There is frequently a shortage of space within the highway land take, particularly where motorway widening has taken place. Where required sufficient space must be made available to establish sustainable screen vegetation and allow for good horticultural practice.

D.16 Assessment must be made of the necessary access from the highway to maintain horticultural plots which have the function of screening gantries and signs, with reasonable ease. Access through barriers, bunds and fences has traditionally been spaced at 200m ensuring none of the landscape maintenance is placed further than 100m from an access from the highway.

D.17 Forward visibility requirements towards gantries must be checked to ensure no conflict with planting which has to function as a high dense screen, often as a condition of the mitigation commitment made to adjacent residents.

D.18 Where possible access and cables routes to gantries must be located to avoid essential planting plots. It is recommended that a procedure be adopted that records existing cables and accesses and mitigates damage where existing horticultural commitments have been identified and recorded.

D.19 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 must be fully reinstated.

D.20 Records of long term mitigation commitments must be established in order to ensure that maintenance regimes accord with the preservation of these undertakings.

D.21 Notwithstanding the requirements of D.1 to D.20, gantries designed in accordance with this standard must possess continuity of structural form within a scheme, with the aim of minimising overall visual impact. This is irrespective of whether the gantry spans one or more carriageways or slip roads, or carries signal equipment and/or fixed static signs.

ANNEX E: DYNAMIC ANALYSIS FOR A DYNAMICALLY SENSITIVE GANTRY

Introduction

E.1 Gantries that are deemed to be dynamically sensitive structures may be subject to vibration due to aerodynamic effects from environmental wind and/or vehicle buffeting. (See clause 5.19). In addition to inducing forces in excess of those considered in a static analysis at the ultimate limit state, this has three other implications for design. Firstly, it can have significant torsional action in addition to the flexural action. Secondly, it can also induce significant cyclic stresses which have to be considered to avoid premature fatigue failures. Thirdly, it can have excessive vibration effects which can either damage equipment or prevent it working effectively.

E.2 Structures must be assessed to determine if dynamic effects are significant.

E.3 For conventional steel gantries, the span where these effects become significant has been found to be around 20m. However, it may be shorter for more flexible structures, unless there is prior experience of similar structures indicating it is not needed. Dynamic sensitivity of a gantry is to be calculated in accordance with BS EN 1991-1-4 and PD 6688-1-4 except where cross structure wind dynamics is the action being considered.

E.4 Basic design wind speed and factors must be determined in accordance with Chapter 5 of this Standard.

E.5 The structure must be analysed under the characteristic wind actions and the factors given in Chapter 5 applied to the effects where wind is the leading action.

E.6 Simple dynamic analyses such as those given in E.13 to E.22 assume that the wind action is not affected by the movement of the structure. In addition, structures must be checked to ensure that they are not subject to aerodynamic effects.

E.7 In the absence of more realistic approaches, such as using wind tunnel tests or CFD (computational fluid dynamics) susceptibility to aerodynamic effects may be determined in accordance with E.24. Where it is proposed to use these more realistic approaches, this must be defined in the AIP and agreed with the TAA.

E.8 The dynamic effects of ambient wind actions must be considered for ULS, SLS and Fatigue checks. However, vehicle buffeting need only be considered for fatigue.

E.9 The structure must be checked in accordance with 4.1 to 4.4 for the maximum ultimate effects from the dynamic analysis.

E.10 The structure must be checked in accordance with 7.34 to 7.38 for fatigue using the forces determined from the dynamic analysis.

E.11 The maximum (unfactored) vibration of equipment from this analysis must comply with the requirements of 7.33.

E.12 In the absence of more rigorous approaches, such as using wind tunnel tests or CFD, the following approach may be adopted for the dynamic analysis.

Conventional Dynamic Analysis

E.13 The main dimensions of the structure will normally be determined first from a static analysis and the following approach may be used for the dynamic analysis.

E.14 Determine the frequencies and modes of vibration from an eigen value analysis.

E.15 Check if aerodynamic effects are likely to be significant using E.24.

E.16 Generate a wind time-history using the following assumptions:

i. An annual probability of exceedance of Q = 0.02 to calculate the probability factor (corresponding to a mean recurrence interval of 50 years).

ii. Direction factors for dynamic and fatigue analyses should be calculated from BS EN 1993-3-1 and the National Annex. Wind pressure waves can be considered in angular sectors (e.g. twelve 30° sectors).

E.17 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.

E.18 If, in accordance with clause E.24, aerodynamic effects are significant, modify the amplitude of the time history gust wind actions, where required, according to E.25 to E.29 (and E.30 to E.34 when applicable) to account for aerodynamic characteristics of the gantry structure.

E.19 Check the factored envelope of the effects from this analysis for ultimate strength where wind is the leading action.

E.20 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.

E.21 The maximum (unfactored) vibration of equipment from this analysis should comply with the requirements of 7.33.

E.22 Check the stress history from the analysis for fatigue in accordance with 7.34 to 7.38.

Vehicle Buffeting Effects

E.23 Fatigue effects from high vehicle buffeting must be considered. The gantry must be designed for buffeting actions from high sided vehicles. The actions on the boom structure and attachments must be taken as given in BD94 (DMRB 2.2.1) for cantilever arms and attachments. They may be treated as static actions. Criteria must be agreed with the TAA prior to AIP submission and included in the AIP.

Aerodynamic Sensitivity

E.24 An initial assessment to BS EN 1991-1-4 should be undertaken to determine if the structure is likely to be sensitive (susceptibility parameter) to aerodynamic excitation. This will be based on the first natural frequency determined from eigen value analysis. If the structure is found to be sensitive, an aerodynamic assessment is required and the following approach may be used.

E.25 Determine turbulence intensity in accordance with BS EN 1991-1-4.

E.26 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 then used in the analytical simulation.

E.27 Using a detailed numerical (generally finite element) dynamic model of the structure, determine a set of eigenvalues and eigenvectors and a corresponding set of generalised inertias. Generally, this will include at least 15 to 20 modes, but in some cases more may be required.

E.28 Develop an analytical framework and computational aids for synthesising the above data. The interaction of multiple modes should be considered for very sensitive gantry structures.

E.29 Using the results of this analysis, modify the actions used in E.18.

E.30 For long-span gantry structures with bluff type sections in smooth flow, divergent vibration called galloping should also be examined. In turbulent flow, the divergent amplitude vibration, which may turn out to be less divergent but more random, should also be considered. The aerodynamic forces acting on the typical cross section (i.e. circular, rectangular) should be considered in smooth and turbulent flow in order to examine the turbulence effects on galloping stability.

E.31 For flexible long-span gantries, the Power Spectral Density Functions (PSDFs) of the fluctuating lift, at rest, should be calculated to examine the effect of wind. The turbulence effects which may broaden the peaks of the PSDF of the lift should also be considered. For portal gantries susceptible to aerodynamic effects, it may be necessary to take into account the unsteady lift forces which can be measured by the forced oscillation method.

E.32 The vortex-induced vibrations which may also take place in long-span gantry structures at wind speeds considerably lower than their design wind speed should be considered for the stability of gantry structure. An accurate calculation for the amplitude of vortex-induced vibrations should be carried out for the design of long-span gantry structures. The mechanism and countermeasures of the vortex-induced vibrations should be studied in the design.

E.33 The vortex-induced vibrations of vertical bending mode should be examined for flexible portal gantries in smooth flow. In turbulent flow, the reduction of the amplitude of the vortex-induced vibrations can be considered. 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, ST3.

E.34 Where the effects considered in E.30 and E.33 are significant, specialist expertise is likely to be required and the approach used should be defined in the AIP and agreed with the TAA. The analysis is also sensitive to the assumed damping. Assumed values should be defined in the AIP and agreed with the TAA.

ANNEX F: Design of Gantries with Permanent Maintenance Access

Introduction

F.1 Except for Scotland, Wales and Northern Ireland, gantries should generally not be designed with permanent access. However, exceptions may be considered where the gantry provides the only safe means of access to equipment isolated between carriageways or in other exceptional circumstances.

F.2 In these exceptional circumstances, the designer must consider how inspection and maintenance access is to be provided and a methodology developed and submitted as part of the TA process. The design must include any fixing points, hard points, etc. required on the gantry structure to facilitate this access.

F.3 The additional design requirements for gantries with fixed access are set out in this Annex.

General Requirements

F.4 When permanent access is provided, consideration must be given to the appropriate control of users of such a facility. The potential for damage to the signals and their associated equipment by users must be addressed.

F.5 Where a fixed walkway or platform is required to enable maintenance of signs, signal equipment and/or lighting, to be carried out, the following requirements must be met:

i. The minimum clear width of the walkway, excluding cable trays and/or working space to maintain equipment, must be 0.6m. On gantries where several sets of equipment may need to be maintained simultaneously, the clear width of the walkway/platform including cable trays must be not less than 1.5m.

ii. An overhead clearance of not less than 2.1m desirable, 1.5m absolute minimum, must be provided. Wherever the headroom is less than 2.1m, secured protective head gear must be worn by all operatives mounting the gantry and a notice must be provided indicating that protective head gear must be worn.

iii. The walkway surface must be nominally horizontal. Solid walkways must be sufficiently inclined to drain surface water.

iv. Unless over a horizontal structural member or within an enclosure, walkways should preferably be of the open mesh type with the minimum possible solidity compatible with openings which will prevent the passing of a ball 5mm in diameter.

v. The surface of all walkways on gantries must have a non-slip finish. The surfacing of solid walkways, when new, must have a slip resistant finish which has a slip resistance against rubber, leather or composite sole material of not less than 65 units under wet conditions or equivalent. The slip resistant finish must have an effective life of at least ten years and must retain a slip resistance of not less than 45 units under wet conditions or equivalent throughout this period. The slip resistance of solid surfacings should be checked by the portable skid resistance pendulum tester developed by the Transport Research Laboratory or equivalent. A suitable in situ finish on solid surfaces may be obtained by over sprinkling the surface with calcined bauxite flints with a particle size in the range of 0.17 to 0.50mm or other materials with an equivalent performance.

vi. Access facilities must be designed so as to discourage the use of cable trays as walkways.

vii. In Scotland, Wales and Northern Ireland, fixed walkways and platforms may be enclosed as agreed with the approval and maintaining authorities.

F.6 Whilst open mesh walkways may reduce the vertical effects of wind actions, there is still the risk of small objects falling onto the carriageway below; in addition it is uncomfortable to work on. Therefore situations where solid walkways are preferred may arise. The selection of whether an open mesh or solid walkway is to be provided should be made on a scheme specific basis with the designer justifying the selection.

Mitigation of Vandalism and Theft

F.7 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, a risk assessment must be undertaken. Where necessary gantries must be fitted with doors across the bottom of the safety enclosure to the ladder to prevent access to all but the very determined. In Scotland, Wales and Northern Ireland doors must be fitted across all access ladders to prevent illegal entry.

F.8 The methods adopted to secure gantries include one or more of the following:

i. Install gates or doors across the bottom of the safety cage on the access ladders;

ii. Stop the access ladder short of the ground to which it is necessary to attach a temporary ladder brought to site by the operative;

iii. Provide a plank or sheet of metal that can be installed and locked across the rungs of the lower part of the ladder.

Handrails

F.9 A safety handrail 1.10m high above the walkway or other accessible horizontal surface must be provided round all walkway surfaces that are not protected by other means of similar height.

F.10 All edges of the walkway must be provided with the minimum of a solid up-stand at least 150mm high in the plane of the handrail. 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 must be infilled with either solid plate or with mesh with openings which will prevent the passing of a ball 5mm in diameter, or a combination of both.

F.11 Handrails and infill panels must be in accordance with BS 6180 ‘Protective barriers in and about buildings’. The category must be as defined in Table 1 of the BS.

Ladders

F.12 Where access ladders are required, they must comply with the general requirements of BS 4211 ‘Ladders for permanent access’; Class B.

F.13 Where the public has pedestrian access to the highway upon which the gantry is located consideration must be given to 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.

F.14 Experience to date suggests that gantries on motorways are not at risk from unauthorised access, whereas on public highways the risk may be dependent on the locality. Gates or hinged flaps are a possible hindrance to authorised personnel and must only be fitted where experience indicates they are necessary.

Lifting Equipment

F.15 Where lifting equipment is specified, lifting points and davits must be provided to carry a safe working load of 100 kg (1 kN). A permanently fixed metal plate or inscription, stating the maximum safe working load, in characters not less than 10mm high, must be positioned either adjacent to the hook or on the davit. All lifting equipment must be tested in accordance with the current requirements of the Health and Safety Executive. Lifting equipment must be positioned over the back of the hard shoulder or hard strip, unless otherwise agreed.

Variable Actions (Imposed Loading)

F.16 In England imposed loading should only be included if agreed by the TAA. Guidance on typical imposed loading to be considered if agreed by the TAA is set out in clauses F.17 and F.18.

F.17 On gantries of the portal and cantilever types, characteristic imposed load must consist of at least 0.5 kN per metre run of the useable length of walkway. Cantilevers with an outreach of less than 7.5m, must 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.

F.18 Walkways and maintenance platforms must 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.

F.19 Combinations of actions are to be derived in accordance with BS EN 1990. The relevant partial factors and combination factors not covered in BS EN 1990 must be in accordance with Table F.1.

Table F.1

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

F.20 Where permanent access is provided, a permanently fixed metal plate or inscription, stating the maximum number of persons and weight of equipment, in characters not less than 10mm high, must be positioned where it can be clearly read from the usual point of access.

Annex G: Table of Gantry Features

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

Item No	Feature	Reference	Requirement
1	Gantry type	2.1	Standard/Managed Motorway/Passively Safe
2	Function	1.3	Support signs/signals/other equipment
3	Span arrangement	3.7, 3.9	Cantilever/single portal/twin portal/other
4	Spans		Specify individual/range (m)
5	Over span	D.10 (f), (g)	Yes/No
6	Location	D.3 to D.7	Specify/wind speed for design
7	Signs	3.17, C.9, C.10	None/specify No ht x w (m)
8	Illumination of signs	C.11 to C.13	Specify type: none/external/internal/LED
9	Retroreflective sheeting		Specify type, none/type
10	Variable message sign	C.14	None/rotating prism/other
11	Signals	C.18	None/No & position of MS/EMS/EMI/CMI
12	CCTV	C.19, C.20	None/location
13	Mounting for signal control equipment	C.21, C.23	None/location & method
14	Other equipment	C.23, C.26	None/specify
15	Power distribution	C.25	None/location
16	Lifting facilities	F.15	None/location
17	Other parties equipment	C.26	None/specify

Item No	Feature	Reference	Requirement
18	Ground works for control/power cabinets/ lay by	C.27, C.28	None/provision
19	Design working life	3.2, 3.3	No. of years
20	Flexibility in future use	C.16, C.22 , C.23	Capable of being re-configured and/or re-positioned
21	Use of over-bridge	3.9 to 3.11	No/details
22	On elevated structures	3.21	No/details
23	Colour of structure	D.11 to D.13	Specify
24	Restraint systems	6.13	Yes/No/Dependent on set out
25	Other		Specify any other requirement