Design Manual for Roads and Bridges

Highway Structures & Bridges
Design

CD 366
Design criteria for collision protection beams

(formerly BD 65/14)

Revision 0

Summary
This document contains the requirements for the design of beams protecting existing structures from serious damage due to bridge strikes by over-height vehicles.

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

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

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Release notes

Version	Date	Details of amendments
0	Mar 2020	CD 366 replaces BD 65/14. This full document has been re-written to make it compliant with the new Highways England drafting rules.

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Foreword

Publishing information

This document is published by Highways England.

This document supersedes BD 65/14, which is withdrawn.

Contractual and legal considerations

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

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Introduction

Background

Collisions of heavy goods vehicles with bridge superstructures and tunnel entrances are a major concern to bridge owners, highway authorities and other interested parties such as the haulage industry. A working party, which was originally set up by the then Department of Transport and which is currently known as the Bridge Strike Prevention Group (BSPG), continues to consider issues relating to bridge strikes. A number of measures have been recommended by the BSPG (Bridge Strikes [Ref 1.I]), with the purpose of reducing the number and severity of bridge strikes. One of the recommended measures is the provision of collision protection beams. The purpose of this document is to provide the requirements for the design of such beams.

Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 7.N] apply to this document.

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Abbreviations and symbols

Abbreviations

Abbreviation	Definition
BSPG	Bridge Strike Prevention Group
CPB	Collision Protection Beam
DMRB	Design Manual for Roads and Bridges
TSRGD	The Traffic Signs Regulations and General Directions

Symbols

Symbol	Definition
L	Chord length
r	Vertical sag radius
v	Sag curve correction
$\psi 1$	Factor for frequent value of a variable action
$\psi 2$	Factor for quasi-permanent value of a variable action

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Terms and definitions

Terms

Term	Definition
Bridge strike	An event when a vehicle or load that is carried by a road vehicle collides with a structure soffit.
Carriageway	The part of the running surface which includes all the traffic lanes, hard shoulders, hard strips and marker strips.
Collision protection beam	A horizontal structural member which protects a structure from bridge strikes.
Maintaining Agent	The organisation with delegated responsibility for the maintenance of a highway structure defined in CG 300 [Ref 11.N].
Measured headroom	The minimum distance between road surface and structure soffit, measured at right angles to the road cross section and adjusted for sag curvature. NOTE: Measured headroom is modified by the addition of a CPB.
Signed headroom	The headroom value which appears on the signs at, or in advance of, bridges or tunnels with substandard headroom.
Substandard headroom	A highway structure whose headroom lies below the maintained headroom standard defined in DMRB document CD 127 [Ref 2.N].
Technical Approval Authority	The organisation responsible for agreeing the Approval in Principle and subsequently accepting the relevant certificates defined in CG 300 [Ref 11.N].

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1. Scope

Aspects covered

1.1 This document shall be used for the design of collision protection beams (CPBs) on existing structures.

NOTE 1 *A CPB is intended to prevent an over-height vehicle from striking the structure that it protects by either stopping or slowing the vehicle.*

NOTE 2 *Some examples of CPBs are given in Appendix A.*

1.2 The process for selecting which existing structures are to have CPBs installed is outside the scope of this document but the process shall include the requirements given in Section 2.

NOTE *The specification and provision for recording collisions and/or warning-alarm system equipment are not included in the scope of this document.*

Implementation

1.3 This document shall be implemented forthwith on all schemes involving CPBs on the Overseeing Organisations' motorway and all-purpose trunk roads according to the implementation requirements of GG 101 [Ref 7.N].

Use of GG 101

1.4 The requirements contained in GG 101 [Ref 7.N] shall be followed in respect of activities covered by this document.

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2. Procedures

Decision to install CPBs

2.1 CPBs shall only be installed where it is not practical to increase the headroom by reducing the carriageway level below and/or increasing the bridge soffit level above.

2.1.1 The decision to install a CPB should be based on:

1) whether the structure has 'substandard headroom' as defined in CD 127 [Ref 2.N];
2) any history of bridge strikes;
3) the potential for damage to the structure due to a bridge strike;
4) the safety of routes carried by the structure;
5) the potential effect of delays due to emergency closure following a bridge strike; and
6) the amount and type of traffic under the structure.

Technical approval

2.2 Technical approval for CPBs, shall be obtained in accordance with the technical approval procedure requirements of CG 300 [Ref 11.N].

2.3 Maintenance and inspection of CPB installations shall be agreed with the Overseeing Organisation and Maintaining Agent.

2.3.1 CPBs should be designed to be inspected and maintained at the same intervals as the structure to which it is affixed.

2.4 The structure category, see CG 300 [Ref 11.N], shall be agreed with the Technical Approval Authority.

2.4.1 Most CPBs should be category 0 but this could be raised to a higher category in accordance with the requirements in CG 300 [Ref 11.N].

Documentation

2.5 The as-built / safety file shall include:

1) guidance for future maintenance and replacement;
2) the extent and positions of possible local collision damage to the CPB which can be accepted without requiring repair or replacement; and
3) survey records and headroom calculations.

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3. Layout

Position

3.1 The collision protection beam (CPB) and its supports must form an integral part of the existing structure in accordance with the Highways Act 1980 [Ref 5.N].

NOTE *A CPB on free-standing supports in advance of a bridge or tunnel can be considered as an obstruction to the highway contrary to Section 178 of the Highways Act 1980 [Ref 5.N].*

3.1.1 The CPB should be positioned so that it is considered to be a part of the protected structure.

3.1.2 The CPB should lie parallel to the protected structure rather than askew.

3.2 CPBs for the protection of existing railway bridges, over the highway, must be in accordance with Sections 16 and 46 of the Railway Clauses Consolidation Act Railways Act 1845 [Ref 9.N].

3.2.1 Permissible alterations to a bridge may include the possibility of minimal widening so that it spans a greater length of highway than before.

3.3 CPBs shall be provided across the full width of each carriageway where traffic approaches the structure.

NOTE *Two beams are normally required for each structure, one at each approach, across the full carriageway width.*

3.3.1 For segregated carriageways, CPBs may be provided across the full width of a segregated carriageway on the side of a structure facing on-coming traffic where all of the traffic flows in the same direction.

3.3.2 CPBs should not be provided over carriageways with one-way traffic leading away from the structure.

Soffit level

3.4 The CPB soffit levels shall be chosen so that over-height vehicles strike the CPB before striking the structure soffit.

3.5 The 'measured headroom' to the CPB shall be 10mm, plus a maximum of 10mm for construction and self-weight deflection tolerance, less than the 'measured headroom' of the structure it is to protect.

NOTE *The CPB is positioned between 10mm and 20mm below the bridge.*

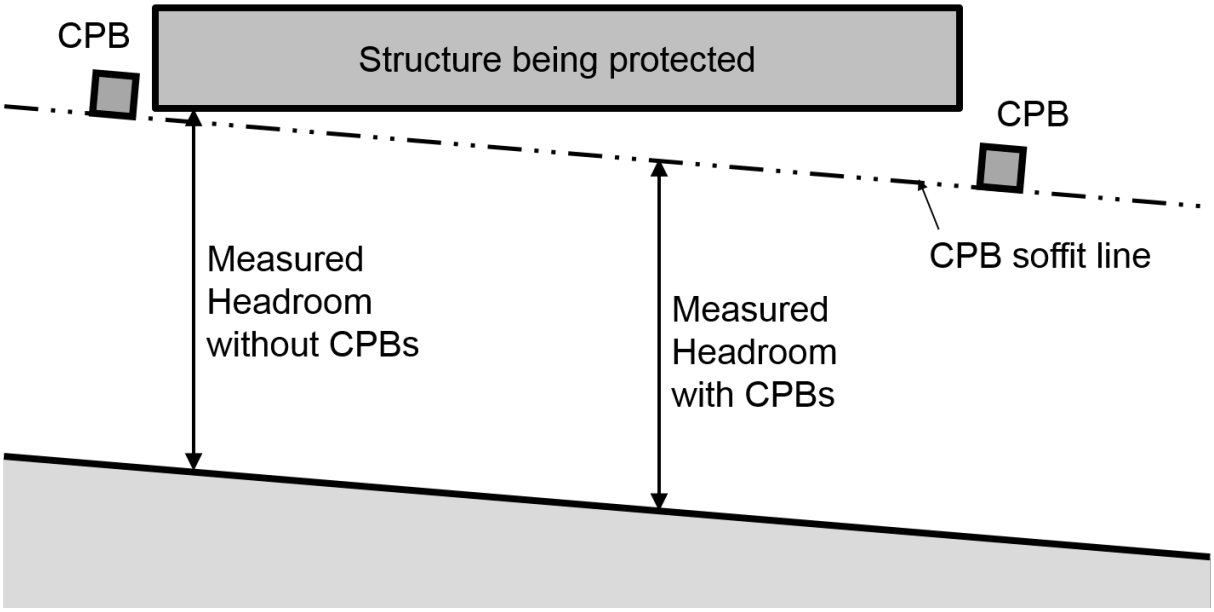
3.6 The design shall include a means of adjusting the level of the CPB at time of installation to accommodate construction tolerances and inaccuracies in predicted deflection.

3.7 The CPB soffit in the direction of traffic shall be parallel to the road surface so that high vehicles do not become wedged under the CPB.

3.8 The 'measured headroom' to the CPB shall be the same at each end of the structure as shown in Figure 3.8.

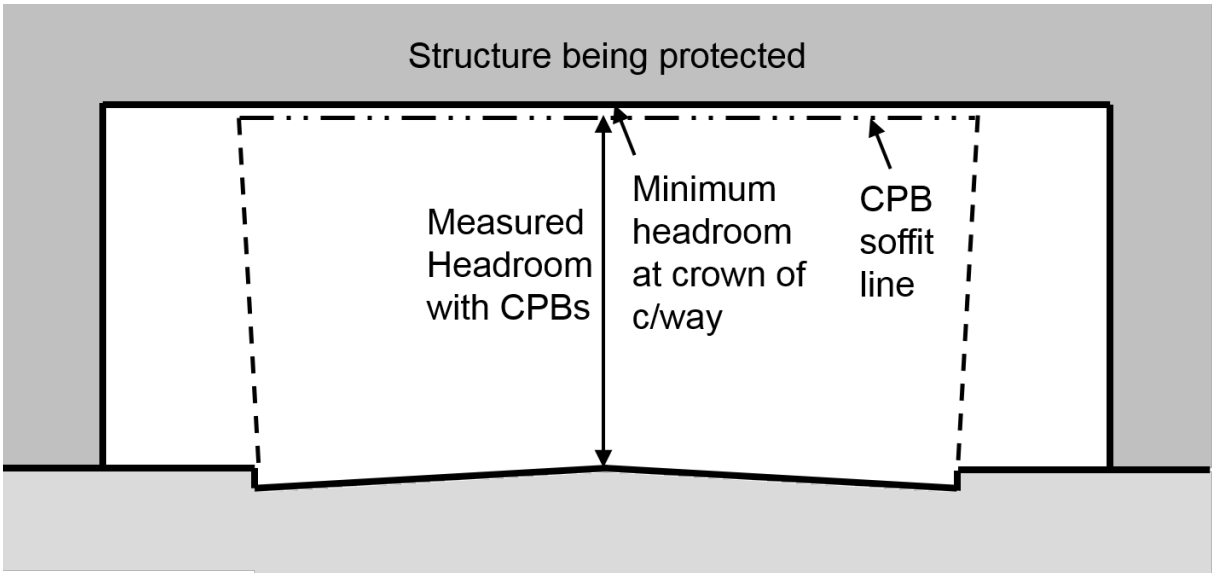
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Figure 3.8 Typical longitudinal section along road under structure



3.9 For non-arched structures where the minimum headroom is at the crown of the carriageway under the bridge, the CPB shall be parallel to the structure soffit, as shown in Figure 3.9.

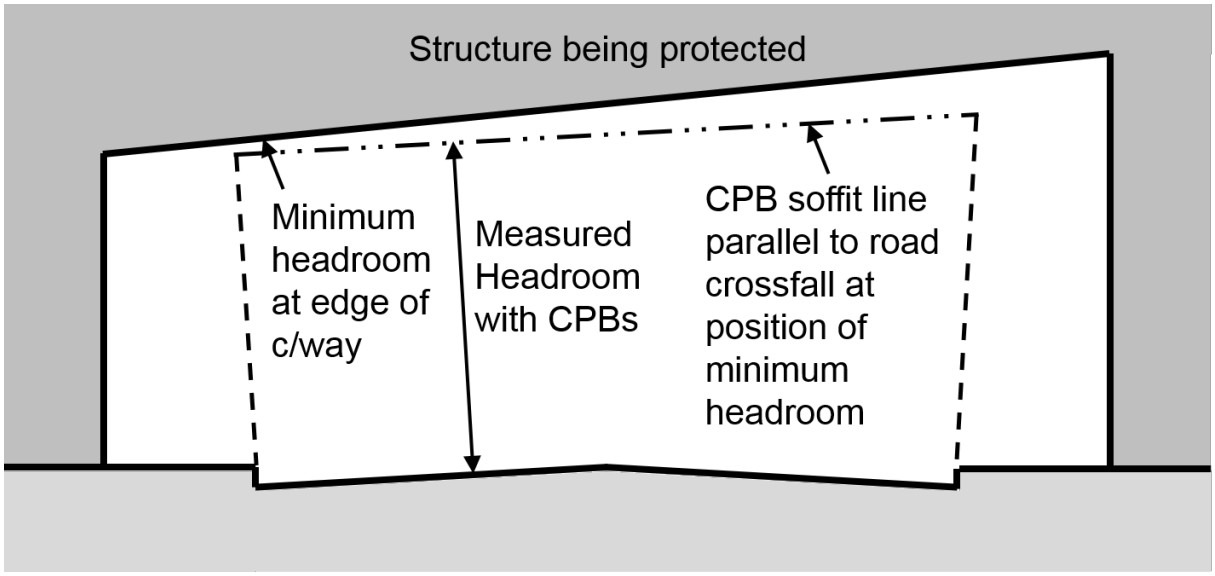
Figure 3.9 Typical cross section through road under structure where minimum headroom is at the crown of the carriageway



3.10 For non-arched structures where the minimum headroom is at the edge of the carriageway under the bridge, the CPB shall be parallel to the road crossfall at the minimum headroom position, as shown in Figure 3.10.

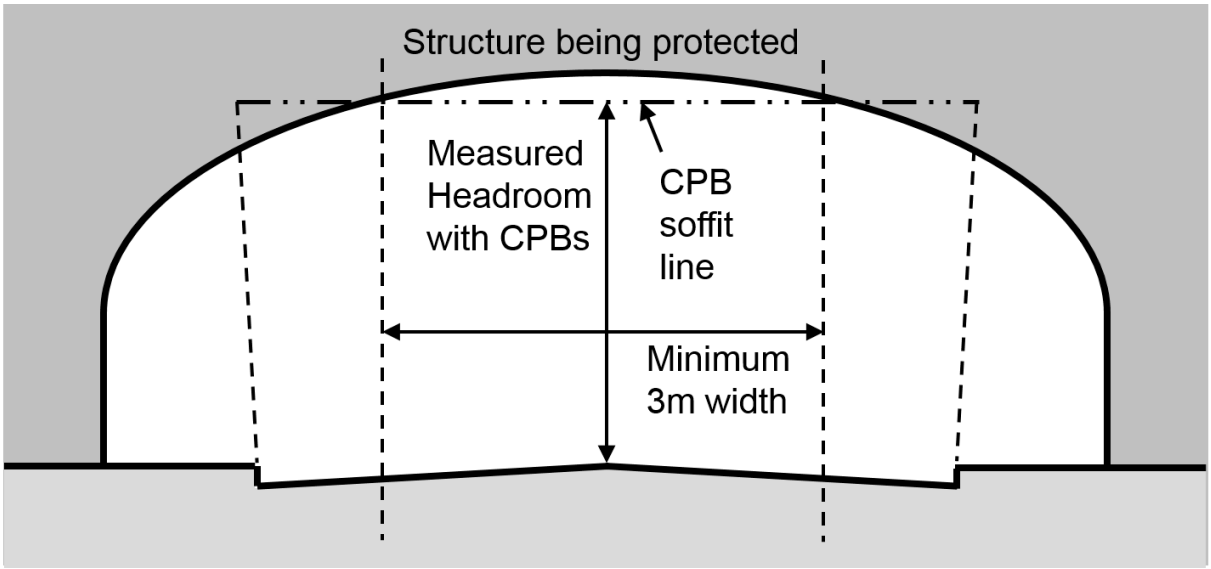
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Figure 3.10 Typical cross section through road under structure where minimum headroom is at the edge of the carriageway



3.11 For arched structures, the CPB levels shall be set to maximise measured headroom over a minimum 3m width of carriageway as shown in Figure 3.11.

Figure 3.11 Typical cross section through road under arched structure



3.12 The CPB shall be pre-cambered where necessary to achieve the desired profile after permanent deflection.

3.13 Headroom shall be determined by surveys before CPB installation as follows:

1) the structure soffit and the road surface is to be accurately surveyed up to 25m minimum beyond each structure face;
2) survey points are to be at maximum 2m intervals throughout with additional lines of points at:
   a) lane markings;
   b) structure faces;
   c) proposed CPB front faces;

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3) the survey is to pick up any local high points in the carriageway or local low points or projections of the structure soffit;

4) headroom is to be determined measured at right angles to the road cross section.

3.14 The levels which are critical to determining the 'measured headroom' for the structure shall be re-measured at the time of CPB installation.

3.15 The 'measured headroom' shall be taken as the minimum headroom for the carriageway after correction for sag curvature.

3.16 Where the road alignment is on a sag curve, the radius of sag curvature shall be determined from the survey and an adjustment for sag curvature made.

3.17 The correction for sag alignment shall be based on a chord length of 25m.

3.17.1 Adjustments for sag curvature may be made in accordance with CD 127 [Ref 2.N], by graphical methods or using the formula $v = \frac{L^2}{8r}$ where: v = sag curve correction, L = chord length, r = vertical sag radius.

Horizontal clearance

3.18 The minimum horizontal clearance between a CPB and the structure it is to protect shall be 100mm plus the calculated horizontal deflection of the CPB under impact at the ultimate limit state.

3.19 The minimum horizontal clearance between a CPB and the structure shall allow for maintenance of the CPB and the protected structure.

3.19.1 Where the design is based on plastic section resistance, the effect of plastic deformation should be taken into account when calculating deflection.

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4. Design

General

4.1 A CPB installation shall comprise:

1) the CPB itself and any fixings, which is to be replaceable following impact damage; and
2) the supporting structure, which is to be designed to survive an impact on the CPB in an undamaged state.

4.2 The CPB shall not be weakened by an impact up to the design load, so that it can remain in place and effective after impact without requiring structural repairs.

NOTE *CPBs designed in sections can offer advantages in economy of erection, dismantling and re-use, particularly on sites with restricted access.*

4.3 On impact, the CPB shall not fragment or collapse onto the road below.

Design standards

4.4 The CPB and its fixings shall be designed for Impact on Superstructures as defined in BS EN 1991-1-7 [Ref 3.N], with the UK NA to BS EN 1991-1-7 [Ref 15.N] as implemented by CD 350 [Ref 12.N].

4.5 For impact loads on the CPB, $\psi 1$ and $\psi 2$ shall be zero, i.e. there is no need to include other accompanying variable actions.

4.6 Structural elements of the CPB shall be designed in accordance with the relevant parts of Eurocodes, as implemented by CD 350 [Ref 12.N], together with the special requirements described in this section.

4.6.1 CPBs should be designed as bridge-type structures.

4.7 The design working life of a CPB shall be taken as category 2 with a design working life of 30 years.

4.7.1 The service life of finishes to the TPB should be defined.

Supporting structures

4.8 The supporting structure shall be designed so that wherever the impact load is applied, the design resistance of the support structure is at least 1.25 times the governing characteristic resistance of the CPB or its fixings.

NOTE *The supporting structure connects the CPB to the existing structure.*

4.9 A 'special inspection' as defined in CS 450 [Ref 6.N] shall be undertaken to identify the condition of the parts of the existing structure supporting the CPB.

4.10 A system of dowelling or formation of shear keys shall be provided to integrate the CPB supporting structure with the existing structure, sufficient to transfer all design loads.

4.11 The design of the supporting structure shall include for the effects of any corrosion.

Materials

4.12 The CPB shall be readily repairable to restore structural strength for accumulated damage resulting from minor collisions.

4.12.1 Structural materials other than those covered in the Eurocodes may be used providing it can be demonstrated that the CPB offers at least equivalent protection to that of conventional materials.

4.13 All conductive components of a CPB installation shall have electrical continuity in accordance with BS 7671 [Ref 10.N] and BS EN 62305 [Ref 8.N].

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Finishes

4.14 Reflective finishes which can dazzle in conditions of strong sunlight or reflected light from vehicle headlamps, shall be avoided.

4.15 The CPB soffit shall be smooth and without bolt-head projections or similar.

4.16 Where required, CPBs shall include measures to prevent unauthorised access.

NOTE *An example of measures to prevent unauthorised access is included in Appendix A, shown in photograph A.4.*

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5. Signs and markings

5.1 Height-restriction signs required to warn of a low bridge with substandard headroom shall be located and illuminated in accordance with TSM (Guidance) [Ref 4.N].

5.2 Traffic signs must conform to and be illuminated in accordance with TSRGD 2016 [Ref 13.N].

NOTE 1 Some examples of hazard warning markings on CPBs are shown in Appendix A.

NOTE 2 Guidance on signs and markings is given in the document 'Prevention of strikes on bridges over highways – a protocol for highway managers and bridge owners' Bridge Strikes [Ref 1.I].

5.3 The 'signed headroom' shall be determined from the measured headroom based on the survey after CPB installation and calculated in accordance with the TSM Chapter 4 [Ref 14.N].

NOTE The installation of a CPB can require the existing signed headroom to be amended.

5.4 All signs and any other warning equipment supplied shall be securely attached to a CPB structure using vibration-resistant fixings.

5.5 Any electrical equipment shall be earth bonded in accordance with BS 7430 [Ref 1.N].

5.6 Traffic signs in advance of the structure shall be provided at the last possible place where a vehicle is able to take an alternative route or turn around.

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6. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Ref 1.N	BSI. BS 7430, 'Code of practice for protective earthing of electrical installations'
Ref 2.N	Highways England. CD 127, 'Cross-sections and headrooms'
Ref 3.N	BSI. BS EN 1991-1-7, 'Eurocode 1 - Actions on structures - Part 1-7 General actions - Accidental actions'
Ref 4.N	The National Archives. Department for Transport. TSM (Guidance), 'Guidance. The Traffic Signs Manual'
Ref 5.N	The National Archives. legislation.gov.uk. Highways Act 1980, 'Highways Act 1980'
Ref 6.N	Highways England. CS 450, 'Inspection of highway structures'
Ref 7.N	Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges'
Ref 8.N	BSI. BS EN 62305, 'Protection against lightning'
Ref 9.N	HMSO. Railways Act 1845, 'Railway Clauses Consolidation Act 1845'
Ref 10.N	BSI. BS 7671, 'Requirements for Electrical Installations, IET Regulations'
Ref 11.N	Highways England. CG 300, 'Technical approval of highway structures'
Ref 12.N	Highways England. CD 350, 'The design of highway structures'
Ref 13.N	The Stationery Office. TSRGD 2016, 'The Traffic Signs Regulations and General Directions 2016'
Ref 14.N	The Stationery Office. TSM Chapter 4, 'Traffic Signs Manual Chapter 4 - Warning Signs'
Ref 15.N	BSI. NA to BS EN 1991-1-7, 'UK National Annex to Eurocode 1 - Actions on structures - Part 1-7 General actions - Accidental actions'

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7. Informative references

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

Ref 1.I	Network Rail on behalf of Bridge Strike Prevention Group. Bridge Strikes, 'Prevention of strikes on bridges over highways: a protocol for highways managers and bridge owners'

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Appendix A. Examples

The following photographs, which are provided by Network Rail, show examples of collision protection beams prior to the issue of this document. The photographs are included for illustrative purposes only and should not infer they are in full compliance with the appropriate traffic signs regulations. (Photographs/images copyright Network Rail. Network Rail will permit free copy and distribution. No action under copyright laws will be pursued).

Figure A.1 Circular collision protection beam to flat soffit bridge



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Figure A.2 Collision protection beam abutment supports



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Figure A.3 Circular collision protection beam to flat soffit bridge showing abutment supports



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Figure A.4 'I' shape collision protection beam with chevaux de frise



Figure A.5 Collision protection beam to flat soffit bridge supported from abutment Cills



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Figure A.6 Collision protection beam to flat soffit bridge supported from abutment extensions. Note the camber to the beam



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Figure A.7 Collision protection beam to arch at height of chord markers



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Highway Structures & Bridges
Design

CD 366
England National Application Annex to CD 366 Design criteria for collision protection beams

(formerly BD 65/14)

Revision 0

Summary
There are no specific requirements for Highways England supplementary or alternative to those given in CD 366.

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

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Release notes **2**

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Release notes

Version	Date	Details of amendments
0	Mar 2020	Highways England National Application Annex to CD 366.

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Department for Infrastructure
An Roinn Bonneagair

Highway Structures & Bridges
Design

CD 366
Northern Ireland National Application Annex to CD 366 Design criteria for collision protection beams

(formerly BD 65/14)

Revision 0

Summary
This National Application Annex gives the Department for Infrastructure Northern Ireland specific requirements for the design of beams protecting existing structures from serious damage due to bridge strikes by over-height vehicles.

Feedback and Enquiries
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated team in the Department for Infrastructure, Northern Ireland. The email address for all enquiries and feedback is: dcu@infrastructure-ni.gov.uk

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Release notes

Version	Date	Details of amendments
0	Mar 2020	Department for Infrastructure Northern Ireland National Application Annex to CD 366.

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Foreword

Publishing information

This document is published by Highways England on behalf of the Department for Infrastructure, Northern Ireland.

Contractual and legal considerations

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

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Introduction

Background

This National Application Annex gives the Department for Infrastructure Northern Ireland-specific requirements related to the design criteria for collision protection beams.

Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 2.N] apply to this document.

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Abbreviations

Abbreviations

Abbreviation	Definition
CPB	Collision protection beam

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NI/1. Layout

NI/1.1 With respect to Section 5 Traffic signs must conform to and be illuminated in accordance with the Traffic Signs Regulations (NI) 1997 (TSR(NI) 1997 [Ref 4.N]).

NI/1.2 The collision protection beam (CPB) and its supports must form an integral part of the existing structure, since a CPB on free-standing supports in advance of a bridge or tunnel is an obstruction to the highway contrary to Section 178 of the Highways Act 1980 [Ref 1.N].

NOTE *In Northern Ireland Article 73 of the Roads (Northern Ireland) Order 1993 (R(NI)O 1993 [Ref 3.N]) applies.*

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NI/2. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Ref 1.N	The National Archives. legislation.gov.uk. Highways Act 1980, 'Highways Act 1980'
Ref 2.N	Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges'
Ref 3.N	legislation.gov.uk. R(NI)O 1993, 'The Roads (Northern Ireland) Order 1993'
Ref 4.N	The Stationery Office (TSO). Department for Infrastructure (DfI). TSR(NI) 1997, 'The Traffic Signs Regulations (Northern Ireland) 1997'

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Highway Structures & Bridges
Design

CD 366
Scotland National Application Annex to CD 366 Design criteria for collision protection beams

(formerly BD 65/14)

Revision 0

Summary
This National Application Annex gives the Transport Scotland specific requirements for the design of beams protecting existing structures from serious damage due to bridge strikes by over-height vehicles.

Feedback and Enquiries
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Transport Scotland team. The email address for all enquiries and feedback is: TSStandardsBranch@transport.gov.scot

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Release notes

Version	Date	Details of amendments
0	Mar 2020	Transport Scotland National Application Annex to CD 366.

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Foreword

Publishing information

This document is published by Highways England on behalf of Transport Scotland.

Contractual and legal considerations

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

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Introduction

Background

This National Application Annex gives the Transport Scotland specific requirements for the design of beams protecting existing structures from serious damage due to bridge strikes by over-height vehicles.

Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 2.N] apply to this document.

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Abbreviations

Abbreviations

Abbreviation	Definition
CPB	Collision protection beam

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S/1. Layout

S/1.1 The collision protection beam (CPB) and its supports must form an integral part of the existing structure, since a CPB on free-standing supports in advance of a bridge or tunnel is an obstruction to the highway contrary to Section 178 of the Highways Act 1980 [Ref 1.N].

NOTE *In Scotland, Section 90 of the Roads (Scotland) Act 1984 (Roads(S) 1984 [Ref 5.N]) applies.*

S/1.2 CPBs for the protection of existing railway bridges, over the highway, must be in accordance with Sections 16 and 46 of the Railways Act 1845 [Ref 3.N] and in this context, permissible alterations to a bridge include the possibility of minimal widening so that it spans a greater length of highway than before.

NOTE *In Scotland the Railway Clauses Consolidation (Scotland) Act 1845 Railways (Scotland) 1845 [Ref 4.N] applies.*

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S/2. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Ref 1.N	The National Archives. legislation.gov.uk. Highways Act 1980, 'Highways Act 1980'
Ref 2.N	Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges'
Ref 3.N	HMSO. Railways Act 1845, 'Railway Clauses Consolidation Act 1845'
Ref 4.N	legislation.gov.uk. Railways (Scotland) 1845, 'Railways Clauses Consolidation (Scotland) Act 1845'
Ref 5.N	The Stationery Office. Roads(S) 1984, 'Roads (Scotland) Act 1984'

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Llywodraeth Cymru
Welsh Government

Highway Structures & Bridges
Design

CD 366
Wales National Application Annex to CD 366
Design criteria for collision protection beams

(formerly BD 65/14)

Revision 0

Summary
There are no specific requirements for Welsh Government supplementary or alternative to those given in CD 366.

Feedback and Enquiries
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Welsh Government team. The email address for all enquiries and feedback is: Standards_Feedback_and_Enquiries@gov.wales

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Release notes

Version	Date	Details of amendments
0	Mar 2020	Welsh Government National Application Annex to CD 366.

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