SUMMARY

This Standard covers the design requirements of collision protection beams for the superstructures of existing bridges over highways and for tunnel entrances.

INSTRUCTIONS FOR USE

1. Remove existing contents pages for Volume 2.

2. Remove BD 65/97 from Volume 2, Section 2, which is superseded by BD 65/14 and archive as appropriate.


4. Insert BD 65/14 into Volume 2, Section 2 after Part 4

5. 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.
Design Criteria for Collision Protection Beams

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1. INTRODUCTION

General

1.1 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, (refer to their reports in chapter 6), 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 Standard is to give guidance on the engineering requirements of such beams.

1.2 Major changes in this version of BD 65 are:

   (i) Use of Eurocodes for the design of Collision Protection Beams (CPBs).
   
   (ii) Updating Regulations and references, including up-to-date reports by BSPG.
   
   (iii) Amending design loads for the design of holding down bolts, anchorages, plinths, bases and structural aspects of foundations.
   
   (iv) In clause A.4, change chord length from 16 m to 25 m. This is consistent with TD 27 (DMRB 6.1.2).

1.3 CPBs should not be necessary for new bridges as they should comply with the headroom requirement in accordance with TD 27 (DMRB 6.1.2). However, CPBs may be installed to protect existing bridge superstructures or road tunnel entrances, having substandard headroom or a history of bridge strikes, from the effects of collision by road vehicles or the loads that are carried by road vehicles. Two beams are normally required for each structure, one at each approach, across the full carriageway width.

The CPB support must be integral with the bridge, or tunnel supports, see 1.11.

Additional requirements for the continued effective operation of such beams are also given.

Scope

1.4 This Standard is intended for the design of CPBs. Some examples of CPBs are given in Annex B.

1.5 CPBs must be designed in accordance with the relevant parts of Eurocodes. Refer to the Overseeing Organisation’s requirements for the use of Eurocodes for the design of highway structures.

1.6 The requirements given for the design and operation of CPBs are only intended for installations proposed at existing bridge or road tunnel sites. However, increasing the headroom, by either reducing the carriageway level below or increasing the bridge soffit level above, should be considered as a preferred option where reasonably practicable.

1.7 The selection of relevant road or rail bridge or tunnel site locations for the installation of CPBs is outside the scope of this Standard. However, bridges which are suitable for installation of CPBs must be agreed with the Overseeing Organisation taking into account of, amongst other things and where relevant, the potential for damage to the superstructure due to bridge strike, the safety of railway, road or tunnel, the potential effect on train services (delay and cancellations), road usage and history of bridge strikes. Other interested stakeholders must be consulted.
1.8 The specification and provision for recording collisions and/or warning-alarm system equipment is outside the scope of this Standard. Where such systems are considered necessary, references should be made to the Overseeing Organisation.

Legal requirements

1.9 The installation of a CPB at any site will only be permitted if the beam and its supports are constructed to form an integral part of the main bridge or tunnel structure.

1.10 For the protection of existing railway bridges over the highway, Sections 16 and 46 of the Railway Clauses Consolidation Act 1845 apply. Permissible alterations to the bridge will include the possibility of minimal widening so that it spans a greater length of highway than before. In Scotland, the Railway Clauses Consolidation (Scotland) Act 1845 applies.

1.11 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 and is not permitted. In Scotland, Section 90 of the Roads (Scotland) Act 1984 applies. In Northern Ireland, Article 73 of the Roads (Northern Ireland) Order 1993 applies.

1.12 Height-restriction signs required to warn of a low bridge with substandard headroom must be placed immediately in advance on posts or on the bridge. Advance traffic signs must also be provided at the last possible place where a vehicle may take an alternative route or turn around. The proposed signs on the bridge must be agreed with the Overseeing Organisation and the proposed advanced traffic signs must be agreed with the highway authority for the approach roads if different.

1.13 The signed headroom must be adjusted as required to conform to the Traffic Signs Manual Chapter 4 Warning Signs and to satisfy the geometric requirements of the measured headroom. See also 4.12. The installation of a CPB may require the existing signed headroom to be amended. The traffic sign must be in compliance with ‘The Traffic Signs Regulations and General Directions’ (TSRGD), in Northern Ireland the Traffic Signs Regulations (Northern Ireland) apply. Some guidance is given in the document ‘Prevention of strikes on bridges over highways – a protocol for highway managers and bridge owners’.

1.14 Hazard warning markings on the CPB must be provided in accordance with the Traffic Signs Manual Chapter 4 Warning Signs. For illustrative purposes, some examples are shown in Annex B.

Implementation

1.15 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).

Approval procedure

1.16 Technical information for each scheme which proposes the installation of a CPB over the highway, at a particular site, must be submitted for approval in accordance with the technical approval procedure requirements of BD 2 (DMRB 1.1.1). The structure Category (see BD2 (DMRB 1.1.1)) must be agreed with the Technical Approval Authority. Most CPB will be Category 0, but this may be raised to a higher Category if considered appropriate.
Definitions and Abbreviations

1.17 For the purpose of this Standard, the following definitions apply:

**Bridge Strike** is a vehicular collision on the bridge soffit caused by a vehicle or load that is carried by a road vehicle.

**Carriageway** is the part of the running surface which includes all the traffic lanes, hard shoulders, hard strips and marker strips.

**Collision protection beam (CPB)** is a horizontal structural member positioned close to, and following, the soffit alignment of the front face of a vulnerable bridge or tunnel, in order to provide protection from the impact of vehicles or their loads which exceed the structure’s headroom.

**Measured headroom** is the minimum headroom at an existing bridge or tunnel site.

See Annex A.

**Signed headroom** is the headroom value which appears on the signs at, or in advance of, bridges or tunnels with substandard headroom.

**Substandard headroom** applies to a highway structure whose headroom lies below the maintained headroom standard as defined in TD 27 (DMRB 6.1).

Mandatory Sections

1.18 Sections of this document contain requirements. These requirements must be complied with or a prior agreement to a Departure from Standard must be obtained from the Overseeing Organisation.

Mutual Recognition

1.19 Where there is a requirement in this specification for compliance with any part of a ‘British Standard’ or other technical specification, that requirement may be met by compliance with:

(a) A standard or code of practice of a national standards body or equivalent body of any EEA state or Turkey;

(b) Any international standard recognised for use as a standard or code of practice by any EEA state or Turkey;

(c) A technical specification recognised for use as a standard by a public authority of any EEA state or Turkey; or

(d) A European Technical Assessment issued in accordance with the procedure set out in regulation (EU) No 305/2011

Provided that the relevant standard imposes an equivalent level of performance and safety provided for by the stated Standard or technical specification.
‘EEA State’ means a state which is a contracting party to the agreement on an European Economic Area signed at Oporto on the 2nd of May 1992 as adjusted or amended.

‘British Standard’ means any standard published by the British Standards Institution including adopted European or other international standards.

**Devolved Administration Issues**

1.20 Not applicable.
2. GENERAL PRINCIPLES AND SPECIFICATIONS

General

2.1 A CPB is intended to either slow or stop a vehicle which is over-height for the measured headroom at a particular bridge or tunnel site. The beam must be sufficiently robust to remain in place and effective after several severe strikes without requiring major repair. The supports of such a beam must form an integral part of the main bridge or tunnel structure. In order to protect a structure the soffit level of a CPB is to be set marginally lower than the measured headroom, sufficient to ensure that a colliding vehicle or its contents will impact on the CPB rather than the bridge deck or tunnel entrance face (see 4.7).

Appearance

2.2 The overall appearance is important for CPBs. Consideration must be given to providing a structure with simple clean lines, which is in keeping with the structure it is intended to protect, and its maintenance requirements. Reflective finishes which might dazzle in conditions of strong sunlight or reflected light from vehicle headlamps, must be avoided. However, traffic signs must be illuminated in accordance with ‘The Traffic Signs Regulations and General Directions’ (TSRGD), in Northern Ireland the Traffic Signs Regulations (Northern Ireland) apply.

Adaptability for replacement

2.3 The CPB should be designed to allow for ease of replacement following impact damage. Particular attention should be given to the design of the supports to allow transmission of forces to the substructure without damage. CPBs designed in sections may offer advantages in economy of erection, dismantling and re-use, particularly on sites with restricted access.

Attachment of signs and equipment

2.4 All signs and any other warning equipment supplied must be securely attached to a CPB structure using vibration resistant fixings. The structural design of a CPB must make adequate provision for the attachment of any equipment. Any subsequent modifications to structural members must only be carried out with the agreement of the Overseeing Organisation.

Protection for road users and pedestrians

2.5 The design of the CPB intends to provide sufficient structural integrity (see 2.1) so that on impact the CPB should remain whole and does not collapse and become a hazard to road users and pedestrians below.

Electrical earthing

2.6 All metal components of a CPB installation must have electrical continuity in accordance with BS 7671. Provision must be made to allow for any electrical equipment required to be earth bonded. The earthing system must be in accordance with BS 7430 Code of practice for earthing.

Use of dissimilar metals

2.7 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.
Maintenance access

2.8 Appropriate provisions for the maintenance and inspection of CPB installations must be agreed with the Overseeing Organisation.

2.9 Access for maintenance should be provided by a hoisted platform from a vehicle stationed on the road below.

Control of vandalism

2.10 Appropriate measures should be taken to prevent unauthorised access to a CPB. An example is shown in photograph B.4.

2.11 The requirements and advice in this document are given on the basis that the construction and/or maintenance of CPB is carried out using the Specification for Highway Works (MCHW Vol.1).
3. ACTIONS

Specified actions

3.1 A CPB must be designed as a bridge-type structure and the actions must be as specified in BS EN1991 and BS EN1990, as implemented by the Overseeing Organisation. In the design of CPB subject to accidental action due to vehicular impact, there is no need to consider combination with other accompanying variable actions.
4. DESIGN

General

4.1 A collision protection beam (CPB) must be constructed from suitable materials which are sufficiently strong to resist vehicle collisions without endangering the public and are durable in conditions of prolonged exposure (see 2.1). The chosen materials must behave in a non-brittle manner upon impact and must be readily repairable to restore structural strength for accumulated damage resulting from minor collisions. Infill materials, where used, must not be considered to act compositely for strength purposes, however, infill material may be considered to serve such purposes as providing restraint to buckling of webs, the distribution of collision loading and the provision of a measure of internal corrosion protection, where necessary. The CPB soffit must be smooth and without bolt head projections or the like.

4.2 Structural elements must be designed in accordance with the relevant parts of Eurocodes, as implemented by the Overseeing Organisation, together with the special requirements described in this chapter. The design working life of a CPB must be taken as Category 2 in accordance with BS EN 1990 and with a design working life of 30 years.

Other materials

4.3 If structural materials other than those covered in the Eurocodes are proposed then the designer must satisfy the Overseeing Organisation that the CPB offers at least equivalent protection to that of conventional materials.

Damage criteria

4.4 The designer must provide guidance for future maintenance or replacement purposes, and the extent and positions of possible local collision damage which can be accepted without requiring repair or replacement of the CPB.

4.5 The condition of the existing sub-structure to which the CPB support structure will be joined must be surveyed for condition and any weak areas strengthened. A system of dowelling or formation of shear keys to integrate the support and substructure must be checked by the designer for adequacy to transfer all design loadings from the CPB supported ends.

4.6 Holding down bolts, anchorages, plinths, bases and structural aspects of foundations must be designed to resist locally an accidental load effect corresponding to at least 1.25 times the characteristic resistance of CPB which need not be combined with any other variable load. The design must ensure that in the event of a severe collision, only the CPB and holding down bolts require replacement. The anchorages, plinths, bases and structural aspects of foundations should survive, in an undamaged state (see 2.3). The design of such items must include for the effects of any corrosion.

Soffit level

4.7 In general, for non-arched structures, the soffit level of a CPB must be set at 10 mm plus a maximum of 10 mm for construction and self-weight deflection tolerance below the soffit line of the structure it is to protect. The leading face side of a CPB must be positioned to ensure that it takes the initial strike. The transverse soffit slope of a CPB must generally follow that of the longitudinal gradient of the road under (see Annex A). Adjustments in level, along the longitudinal axis of a CPB must also be made to allow for the following geometric conditions:
i. Where the transverse gradient of the highway differs from the longitudinal gradient of the bridge that is to be protected; level adjustment must be made to allow the CPB to catch over-height vehicles which, either purposely, or, during loss of control, approach the bridge in any lane of the carriageway.

ii. Where the longitudinal gradient of the highway differs from the transverse gradient of the bridge to be protected and a wedging effect would be caused if the over-height vehicle could pass into an area of diminishing headroom; the CPB at the higher headroom approach side must be set to provide the same headroom as the CPB on the side with the lowest headroom.

iii. No point of the soffit surface of a CPB, when in its final position, must restrict headroom to less than 20mm below the soffit line of the structure it is to protect. Purpose fabricated metal shims and packing plates (see 2.7) must be provided, at the CPB supports, for fine adjustment of level. An allowance for the self-weight deflection of the CPB must be included.

4.8 For arched structures the CPB soffit level must be set to form an imaginary chord line whose levels are set by the top side of an imaginary test rectangle, see Annex A, which just passes under the CPB when the test rectangle is placed transversely, in any position across a lane which permits high vehicles.

**Vertical deflection and camber**

4.9 The calculated vertical structural deflection at the mid-span of a CPB under serviceability conditions for permanent actions such as self-weight should, when appropriate, be counteracted by an appropriate amount of pre-camber applied to the CPB.

**Horizontal position**

4.10 The minimum horizontal clearance between a CPB and the structure it is to protect must be 100 mm plus the calculated mid-span horizontal deflection of the CPB under impact at the ultimate limit state. Access to allow room for maintenance of the CPB and the protected structure must be considered when deciding the actual clearance value. The CPB must, however, be positioned so that it can reasonably be considered to be a part of the protected structure and should lie parallel to it rather than askew.

**Protection of metalwork against corrosion**

4.11 Steelwork must be protected in accordance with the requirements of the 1900 series of the Specification for Highway Works.

**Available headroom remeasurement**

4.12 The available headroom must be measured immediately after the CPB is installed, the height to be signed recalculated conforming to the Traffic Signs Manual Chapter 4 (see 1.13) and appropriate signs erected before the road is opened to traffic.
5 NORMATIVE REFERENCES

BD 2/12 Technical Approval of Highway Structures (DMRB 1.1.1).

TD 27/05 Cross Sections and Headroom (DMRB 6.1.2).

BSI Publications: BSI Customer Services, 389 Chiswick High Road, London W4 4AL


BS 7430: Code of practice for earthing.

BS 7671: Requirements for electrical installations. IET Wiring Regulations.


6 INFORMATIVE REFERENCES


In Scotland: The Railways Clauses Consolidation (Scotland) Act: 1845 (http://www.legislation.gov.uk/ukpga/Vict/8-9/33/contents)


7. ENQUIRIES

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

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Note: This document was notified in draft to the European Commission in accordance with Directive 98/34/EC, as amended by Directive 98/48/EC.
ANNEX A: DETERMINATION OF SOFFIT LEVEL OF COLLISION PROTECTION BEAMS AND MEASURED HEADROOM

General

A1. In order to determine the soffit level of collision protection beams and the measured headroom at a bridge or tunnel site a level survey is to be carried out before a CPB is installed. Critical levels are to be rechecked at the time of installation. Survey records, calculations and any alterations proposed must be submitted to the Overseeing Organisation for agreement.

Survey to determine soffit level of CPBs

A2. The stages of the survey are as follows:

i. Each carriageway of the roadway local to the proposed installation is to be divided into a rectangular grid and the grid intersections marked on the road surface. The grid is to start 25 m before a bridge or tunnel entrance face and continue through to finish 25 m after the exit face. Longitudinal grid lines are to be positioned at not greater than 2 m spacings between the edges of the trafficked surface. Where lane markings are provided these should define the lanes. If lane markings do not exist then the lanes should be as defined in accordance with BS EN 1991-2. Transverse grid lines are required at intervals of 2 m along the road. Additional transverse grid lines are required immediately below the front face projections of both the proposed CPB position and the structure to be protected. Further survey points should also be established at any local high points in the carriageway or local low points or projections of the bridge soffit or tunnel roof.

ii. The road and soffit or roof levels should be accurately surveyed at each grid and additional survey points, and the height of the bridge or tunnel measured above each grid intersection should be determined.

A3. The soffit level of the collision protection beams is to provide the headroom at the location of the least measured height less 10 mm subject to level adjustments for positioning CPBs (see 4.7) as shown in the typical situations in Figure A1 (to an exaggerated scale). In determining the CPB soffit levels, a construction and self-weight deflection tolerance of 10 mm (downwards) subject to the provision of camber (see 4.8) is permitted to be used i.e. the CPB soffit level may, in places, provide a clearance up to 20 mm less than the least height clearance.

Determination of measured headroom

A4. The measured headroom above each grid point intersection at the CPB face must be the minimum determined by subtracting the greater of the local sag curve correction, if any, within the sag curve zones 12.5 m either side of the CPB outer faces at each CPB location determined in accordance with TD27 for the road sag radius from the measured height under each CPB.

A5. If the road sag radius is less than the values shown in TD27, the sag curve correction may be determined from first principles using $v = L^2/8r$ where $v$ = versine in metres, $L$ = chord length in metres of road sag radius, $r$ = sag radius of curve in metres.

A6. The measured headroom is to be used to determine the signed headroom in accordance with the Traffic Signs Manual.
Figure A.1  Conditions for CPB Level Adjustments

CASE 1

\[ \times A, B \text{ and } D \text{ are the Measured Headroom.} \]

\[ \text{CPB soffit line adjustment to } ABC \text{ (not } AE) \]

Carriageway (cross section)

CASE 2

\[ \text{CPB soffit line lowered from } A \text{ to } B \]

Carriageway (longitudinal section)

CASE 3

\[ \text{Rectangle ABCD 3.0m wide by trial Measured Headroom between kerb lines.} \]

\[ \text{Signed height to be determined in accordance with the Traffic Signs Manual based on actual Measured Headroom.} \]
ANNEX B: PHOTOGRAPHS

The following photographs, which are provided by Network Rail, show examples of Collision Protection Beams prior to the issue of this Standard. 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).

Photograph B.1  Circular Collision Protection Beam to flat soffit bridge
Photograph B.2  Collision Protection Beam abutment supports

Photograph B.3  Circular Collision Protection Beam to flat soffit bridge showing abutment supports
Photograph B.4  ‘I’ shape Collision Protection Beam with Chevaux des Frise

Photograph B.5  Collision Protection Beam to flat soffit bridge supported from abutment cills
Photograph B.6  Collision Protection Beam to flat soffit bridge supported from abutment extensions. Note the camber to the beam

Photograph B.7  Collision Protection Beam to arch at height of chord markers