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**VOLUME 2    STRUCTURES:  
DESIGN  
SECTION 2    SPECIAL STRUCTURES**

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**PART 5**

**BD 65/97**

**DESIGN CRITERIA FOR COLLISION  
PROTECTION BEAMS**

**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.    Insert BD 65/97 into Volume 2, Section 2 after Part 4.
2.    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**



**THE SCOTTISH OFFICE DEVELOPMENT DEPARTMENT**



**THE WELSH OFFICE  
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**THE DEPARTMENT OF THE ENVIRONMENT FOR  
NORTHERN IRELAND**

# **Design Criteria for Collision Protection Beams**

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**REGISTRATION OF AMENDMENTS**

Amend No	Page No	Signature & Date of incorporation of amendments	Amend No	Page No	Signature & Date of incorporation of amendments

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**Contents**

Chapter

1. Introduction
2. General principles and specification
3. Design loading
4. Design
5. References
6. Enquiries

Annex A: Method of Determining Measured  
Headrooms

Annex B: Plates

# 1. INTRODUCTION

## General

1.1 Collisions of heavy goods vehicles with bridge superstructures and certain tunnel entrances continue to occur at an undesirably high rate and are a major concern to the various authorities. A working party set up by the Department of Transport continues to look into the problems of bridge bashing. A number of measures have been recommended by the working party already, in their 1982 and 1988 reports, with the purpose of reducing the possibility of a catastrophic outcome from such collisions. One of the recommended measures is the provision of collision protection beams. The purpose of this Standard is to give guidance for the engineering requirements of such beams.

1.2 Collision Protection Beams (or CPBs as defined in 1.14) may be installed to protect existing bridge superstructures or road tunnel entrances, having sub-standard headroom or a history of bridge bashing, from the effects of collision by road vehicles. Two beams are normally required for each structure, one at each approach, across the full carriageway width. The CPB support shall be integral with the bridge, or, tunnel supports. Additional requirements for the continued effective operation of such beams are also given.

## Scope

1.3 This Standard is intended for the design of CPBs which are constructed in materials suitable for the performance requirements of a CPB. Some examples of CPBs previously constructed by British Rail are given in Annex B.

1.4 CPBs shall be designed in accordance with the relevant Parts of BS 5400, as implemented by the Overseeing Organisation, except where otherwise specified.

1.5 The requirements given for the design and operation of CPBs are only intended for installations proposed at existing bridge or road tunnel sites.

1.6 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, some guidance is available in the Bridge Bashing Working Party 1988 Report and in the Department of Transport's Circular Roads Notice 5/87.

1.7 The specification and provision for recording collisions and/or warning-alarm system equipment is outside the scope of this Standard. The appropriate division of the HA should be contacted when advice is required.

In Scotland the Driver Information Branch of The Scottish Office Development Department Roads Directorate should be contacted.

## Legal requirements

1.8 The installation of a CPB at any site shall only be permitted if it is reasonable to consider that the beam and its supports are constructed to form an integral part of the main bridge or tunnel structure and it has been approved by the Overseeing Organisation.

1.9 For the protection of existing railway bridges, over the highway, Sections 16 and 46 of the Railway Clauses Consolidation Act 1845 shall 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 1945 applies.

1.10 Any proposed CPB which is intended to be placed in advance of a bridge or tunnel and is attached to **free-standing supports** shall **not** be permitted under Section 178 of the Highways Act 1980. In Scotland, Section 90 of the Roads (Scotland) Act 1984 applies.

1.11 Mandatory height-restriction signs required to warn of a low bridge shall be placed both in advance, to oncoming traffic, and upon any CPB in accordance with the requirements of the Overseeing Organisation. The installation of a CPB may require the existing signed headroom to be amended. Reference should be made to 'Damage to bridges by road vehicles - traffic signs at bridges' published by the Department of Transport.

## Implementation

1.12 This Standard should be used where instructed by the Overseeing Organisation.

## Approval procedure

1.13 Full technical information for each scheme which proposes the installation of a CPB over the highway, at a particular site, shall be submitted for approval in accordance with the technical approval procedure requirements of BD 2 (DMRB 1.1).

## Definitions and Abbreviations

1.14 The meaning and definition of terms used in this Standard shall generally be in accordance with BS 6100 unless otherwise defined below:

**Carriageway** for the purposes of this Standard shall include any hard shoulders and hard strips.

**Collision protection beam (CPB)** is a horizontal structural member positioned close to, and following the soffit cross-fall 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 effective 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).

**Overseeing Organisation** is the appropriate Highway Authority for government owned highways in England, Scotland, Wales and N Ireland.

## 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 shall 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 an important consideration for CPBs. Consideration shall be given to providing a structure with simple clean lines, which is in keeping with the structure it is intended to protect, and which shall require minimum maintenance. Reflective finishes which may dazzle, in conditions of strong sunlight or reflected light from vehicle headlamps, shall be avoided. However, traffic sign faces and the yellow stripes of black and yellow markings need to be of reflective material to be effective at night.

### Adaptability for replacement

2.3 The CPB shall be designed to allow for ease of replacement following impact damage. Particular attention shall be given to the design of the supports to allow transmission of forces to the substructure without damage (cf bridge parapets). CPBs designed in sections may offer advantages in economy of erection, dismantling and reuse, particularly on sites with restricted access.

### Attachment of signs and equipment

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

### Protection for road users and pedestrians

2.5 The design of CPB shall provide sufficient structural integrity so that on impact the structure remains whole and collapse does not occur.

### Electrical earthing

2.6 All metal components of a CPB installation shall have electrical continuity in accordance with the Institution of Electrical Engineers Regulations. Where required, provision shall be made to allow for any electrical equipment required to be earth bonded and also any additional earthing connection necessary through the support structure by the provision of individual earthing rods.

### Use of dissimilar metals

2.7 Where dissimilar metals are to be used, the connections shall be designed, with reference to BS PD 6484, in order to avoid the risk of galvanic corrosion. The electrical bonding of all metal components must nonetheless be maintained.

### Maintenance access and safety

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

2.9 Where electrical or warning equipment is provided other than lighting or signing, then a fitted walkway of 600mm minimum clear width and of slip resistant finish shall be provided.

2.10 A safety handrail, in accordance with BS 6180: Table 1, shall be provided 1.10m above and around any horizontal surface to be walked upon during an inspection or maintenance works. The bottom 150 mm of the handrail plane shall have a continuous solid upstand. The remainder of the handrail plane shall have 10mm maximum size safety mesh securely attached. Any access ladders shall comply with Class B of BS 4211. All items of this clause shall be purpose fabricated.

2.11 Guidance for the health and safety of workers at roadwork sites shall be as given in SA 6 (MCHW 0.3.5).

**Control of vandalism**

2.12 Appropriate measures shall be taken to prevent unauthorised access to a CPB.

## 3. DESIGN LOADING

### Loads to be considered

3.1 A Collision Protection Beam (CPB) shall be designed as a bridge-type structure and the loads shall be as specified in BS 5400:Part 2, as implemented by BD37 (DMRB 1.3) and BD60 (DMRB 1.3.5). Only Load Combination 4 shall be considered. No other live or accidental loads shall be applicable.

## 4. DESIGN

### General

4.1 A collision protection beam (CPB) shall 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. The material shall be selected to form a beam which is sufficiently robust to remain integral, in place and effective after several severe strikes without requiring major repair. The chosen materials shall behave in a non-brittle manner upon impact and shall be readily repairable to restore structural strength for accumulated damage resulting from minor collisions. Infill materials, where used, should 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 shall be smooth and without bolt head projections or the like.

4.2 Any steel or concrete structural elements shall be designed in accordance with the relevant parts of BS 5400, as implemented by the Overseeing Organisation, together with the special requirements described in this chapter.

### Other materials

4.3 If structural materials other than those of steel or concrete are proposed then the agreement of the Overseeing Organisation is required regarding the criteria for their design and use. The Overseeing Organisation will need to be assured that such materials offer in use levels of safety, suitability and fitness for purpose which are equivalent to those of steel or steel/concrete.

### Damage criteria

4.4 The designer shall, as far as is practicable, 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 shall be surveyed for condition and any weak areas strengthened. A system of dowelling or formation of shear keys to integrate the support and sub-structure shall be checked for adequacy to transfer all design loadings from the CPB supported ends.

4.6 For the design of holding down bolts, anchorages, plinths, bases and structural aspects of foundations the factor  $\gamma_n$  shall be taken as 1.75 for the ultimate limit state and 1.30 for any serviceability limit state. The purpose of the enhanced  $\gamma_n$  factors is to ensure that in the event of a severe collision the items described should survive, in an undamaged state, and only the beam section of the CPB may need replacement. The design of such items shall include for the effects of any corrosion.

### Soffit level

4.7 In general, for non-arched structures, the soffit level of a CPB shall be set just (ie 10 to 20mm) below the soffit line of the structure it is to protect. The leading face side of a CPB shall be positioned to ensure that it takes the initial strike. The transverse soffit slope of a CPB shall generally follow that of the longitudinal gradient of the road under. Adjustments in level, along the longitudinal axis of a CPB shall 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 shall 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 shall 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, shall restrict headroom to an amount more than 20mm below the measured headroom value. Purpose fabricated metal shims and packing plates (see 2.7) shall be provided, at the CPB supports, for fine adjustment of level. An allowance for the self weight deflection of the CPB shall be included.

For arched structures the CPB soffit level shall 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. The signed height will require adjustment to conform with the regulations and to satisfy the geometric requirements of the measured headroom.

#### **Vertical deflection and camber**

4.8 Where the calculated vertical structural deflection at the mid-span of a CPB exceeds 6mm under serviceability conditions for self weight and superimposed dead loadings then the calculated deflection shall be counteracted by an appropriate amount of pre-camber applied to the CPB.

#### **Horizontal deflection and placing of a CPB**

4.9 The minimum horizontal clearance between a CPB and the structure it is to protect shall be 100mm 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 shall 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.

#### **Drainage**

4.10 The requirements of BD57 and BA57 are applicable to CPBs.

#### **Protection of metalwork against corrosion**

4.11 Steelwork shall be protected to the requirements of the 1900 series of the Specification.

#### **Brickwork, blockwork and stonework**

4.12 Where such materials are used to face any extended abutment walls, for example, particular attention shall be given to specifying a suitable mortar; layout of non-corrodable facing anchorages, ties and any reinforcement to mortar beds; vertical support to facings and the gap (30mm minimum) between the facing and the wall for effective sealing.

#### **Available headroom remeasurement**

4.13 The available headroom must be re-measured when the CPB is installed, and the height to be signed re-calculated accordingly.

#### **Hazard warning markings**

4.14 Warning markings shall be painted on the full front face surface areas of a CPB which is visible to the driver of an oncoming vehicle. The markings shall be stripes of 150mm minimum to 250mm maximum width and of 300mm minimum height. The stripes shall be of alternating yellow and black colour and sloping at 45 degrees to the vertical. The direction of slope (see example at Plate B1), as viewed by oncoming traffic, shall be to the right for the CPB face to the right of the road centre line and to the left for the remaining section of CPB face.

## 5. REFERENCES

### 1 Bridge Bashing Working Party Reports

Damage to Low Bridges: Bridge Height Gauges: DoT, November 1982

A Strategy For The Reduction Of Bridge Bashing: HMSO, 1988

### 2 Legal Requirements

The Highways Act: 1980.

*In Scotland:* Roads (Scotland) Act: 1984

The Railways Clauses Consolidation Act: 1845

*In Scotland:* The Railways Clauses Consolidation (Scotland) Act: 1845

The Traffic Signs Regulations And General Directions: 1994 and Statutory Instrument 2139: 1989 (currently under revision)

### 3 Manual Of Contract Documents For Highway Works

Volume 1: Specification For Highway Works: (MCHW1): HMSO.

Volume 2: Notes For Guidance On The Specification For Highway Works: (MCHW2): HMSO.

SA 6 (MCHW 0.3.5) - Introduction of "Planning for Safety".

### 4 British Standards

BS 4211: Specification for Ladders for Permanent Access to Chimneys, Other High Structures, Silos and Bins.

BS 5400: Steel, Concrete and Composite Bridges:  
Part 2: Specification for Loads.  
Part 3: Code of Practice for Design of Steel Bridges.  
Part 4: Code of Practice for Design of Concrete Bridges.  
Part 5: Code of Practice for Design of Composite Bridges.

BS PD 6484: Commentary on Corrosion at Bimetallic Contacts and its Alleviation.

BS 6180: Code of Practice for Protective Barriers In and About Buildings.

### 5 Design Manual for Roads and Bridges

Volume 1: Section 1: Approval Procedures

BD 2 (DMRB 1.1) - Technical Approval of Highway Structures on Motorways and Other Trunk Roads

Part 1. General Procedures. [In N Ireland refer to DoE (NI) Roads Service, Technical Approval Scheme.]

Volume 1: Section 3: General Design

BD 13 Design of Steel Bridges: Use of BS 5400: Part 3: 1982. (DMRB 1.3)

BD 16 Design of Composite Bridges: Use of BS 5400: Part 5: 1979. (DMRB 1.3)

BD 24 Design of Concrete Bridges: Use of BS 5400: Part 4: 1984. (DMRB 1.3.1)

BD 37 Loads For Highway Bridges. (DMRB 1.3)

BD 60 The Design of Highway Bridges for Vehicle Collision Loads. (DMRB 1.3.5)

Volume 6: Section 1: Road Geometry - Links

TD 27 Cross Sections and Headroom (DMRB 6.1.2)

## **6 Traffic Signs**

Traffic Signs Manual: Chapter 4: Warning Signs: HMSO

Network Management Advisory Leaflet 'Damage to bridges by road vehicles - traffic signs at bridges'

## **7 Circular Roads Notice**

5/87 - Damage to Bridges by Road Vehicles/Traffic Signs at Bridges (DoT)

## 6. ENQUIRIES

Approval of this document for publication is given by the undersigned:

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All technical enquiries or comments on this document should be sent in writing as appropriate to the above.

## Annex A

### METHOD OF DETERMINING MEASURED HEADROOM

#### General

A1. In order to determine the measured headroom at a bridge or tunnel site a level survey is to be carried out shortly before a CPB is to be installed. Critical levels are to be re-checked at the time of installation. Survey records, calculations and any alterations proposed shall be submitted to the Overseeing Organisation for approval.

#### Survey stages

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 20m before a bridge or tunnel entrance face and continue through to finish 20m after the exit face. Longitudinal grid lines are to be positioned at not greater than 2m spacings between the edges of the trafficked surface. Where lane markings are provided these shall define the lanes. If lane markings do not exist then the lanes shall be as defined in BD37 (DMRB 1.3). Transverse grid lines are required at intervals of 2m 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. Adjustments shall be made, as described, where the longitudinal alignment of the road follows a dipping curvature (a 'sag curve').
- ii. The road and soffit or roof levels shall be accurately surveyed at each grid and additional survey point. The basic height clearances above the relevant grid intersections shall be calculated.
- iii. Where a part or all of a longitudinal grid line lies on a sag curve (of radius R metres) the basic height clearances, within the sag curve zone and for 8m either side, shall be adjusted by deducting a value of  $31/R$  metres. This deduction allows for the longest currently permitted vehicle total load length of 15.65m.
- iv. The minimum height clearance, adjusted if necessary, shall be determined along each longitudinal grid line. The smallest value of minimum height clearance for each carriageway is the measured headroom.

#### Soffit level of CPB

A3. Trial CPB soffit level datums are to be determined above each grid point intersection at the CPB face (see Fig A1). Each trial level is calculated by adding to the grid point road level the following:

- i. The measured headroom
- ii. The local sag curve correction, if any, at the CPB face ( $+ 31/R$  metres, R is road sag radius at the CPB face location).
- iii. A deduction of 10mm

A4. The CPB soffit levels for construction are determined by a line of best-fit which passes through, or, just above the trial level datum points. In seeking the line of best-fit, a construction and self weight deflection tolerance of 10mm (downwards) is permitted to be used ie the CPB soffit level may, in places, provide a clearance up to 20mm less than the measured headroom. Fig A2 shows (to an exaggerated scale) typical situations which require level adjustments for positioning CPBs (see 4.7). However, at no stage during its operation shall any point of the CPB soffit provide a clearance less than that shown on the height restriction signs.

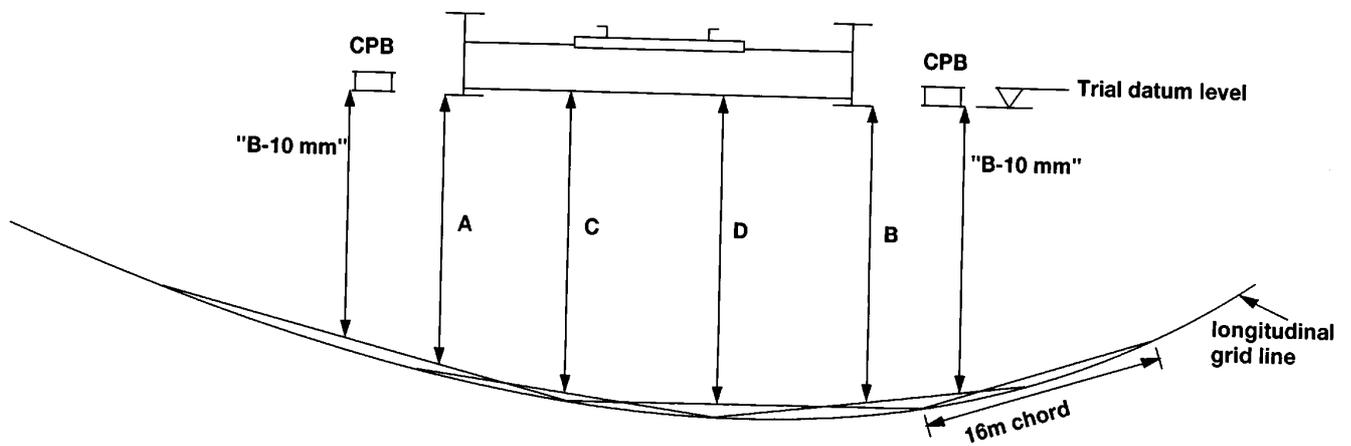
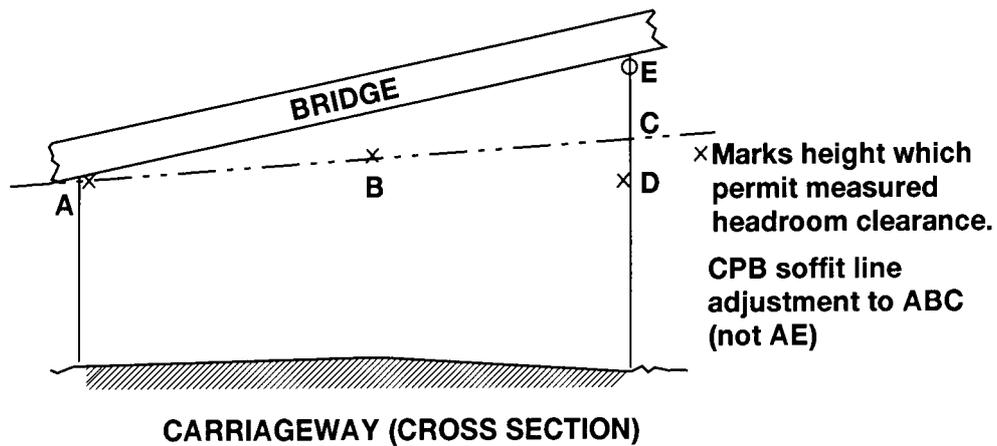
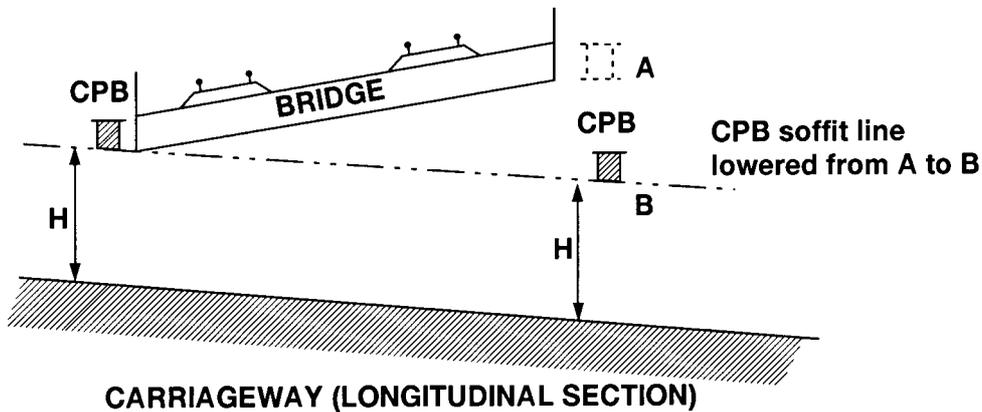


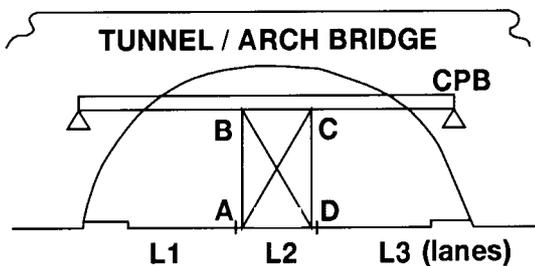
Figure A.1 Determination of Trial Datum Levels and Measured Headroom



**CASE 1**



**CASE 2**



**CASE 3**

Trial rectangle ABCD moved across lanes to define soffit level of CPB.

Rectangle 3.0m wide and height = proposed signed height value, plus a minimum of 75 mm and a maximum of 150 mm (signing tolerance less 10mm).

Figure A.2 Conditions for CPB level Adjustments

# ANNEX B

## PLATES

The following plates show examples of Collision Protection Beams which have been designed and constructed by British Rail prior to the issue of this Standard. The plates are included for illustrative purposes only.

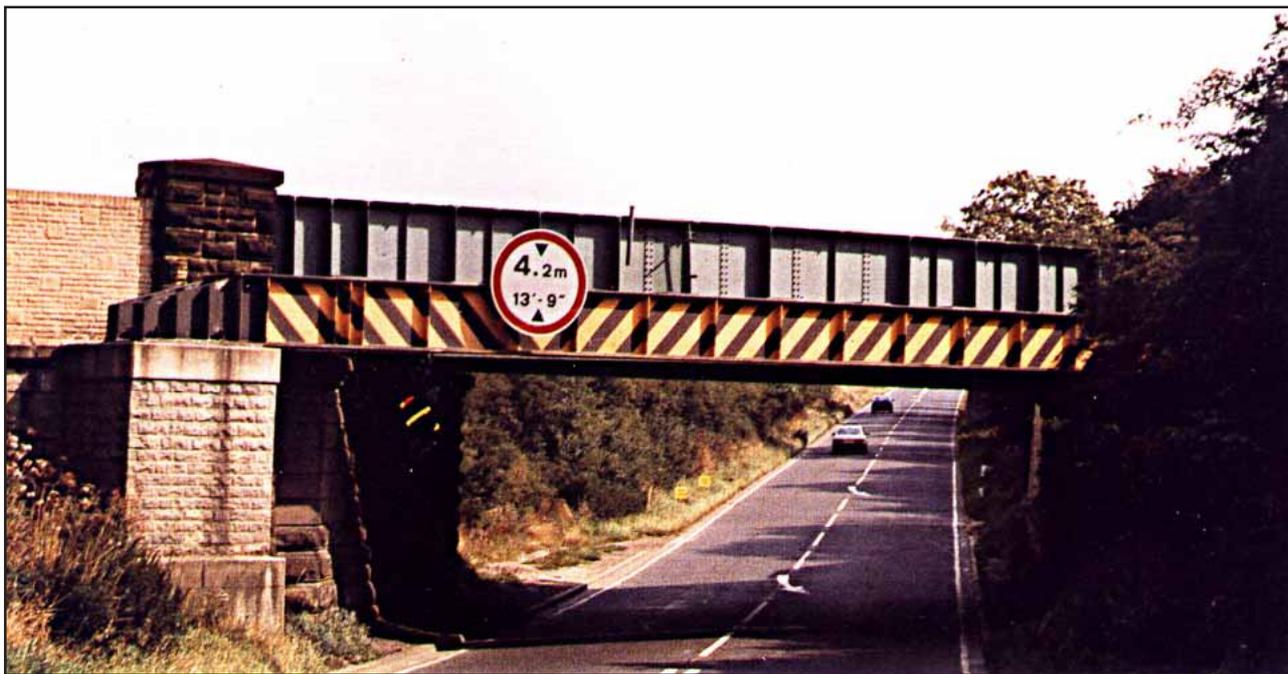


Plate B.1 Collision Protection Beam

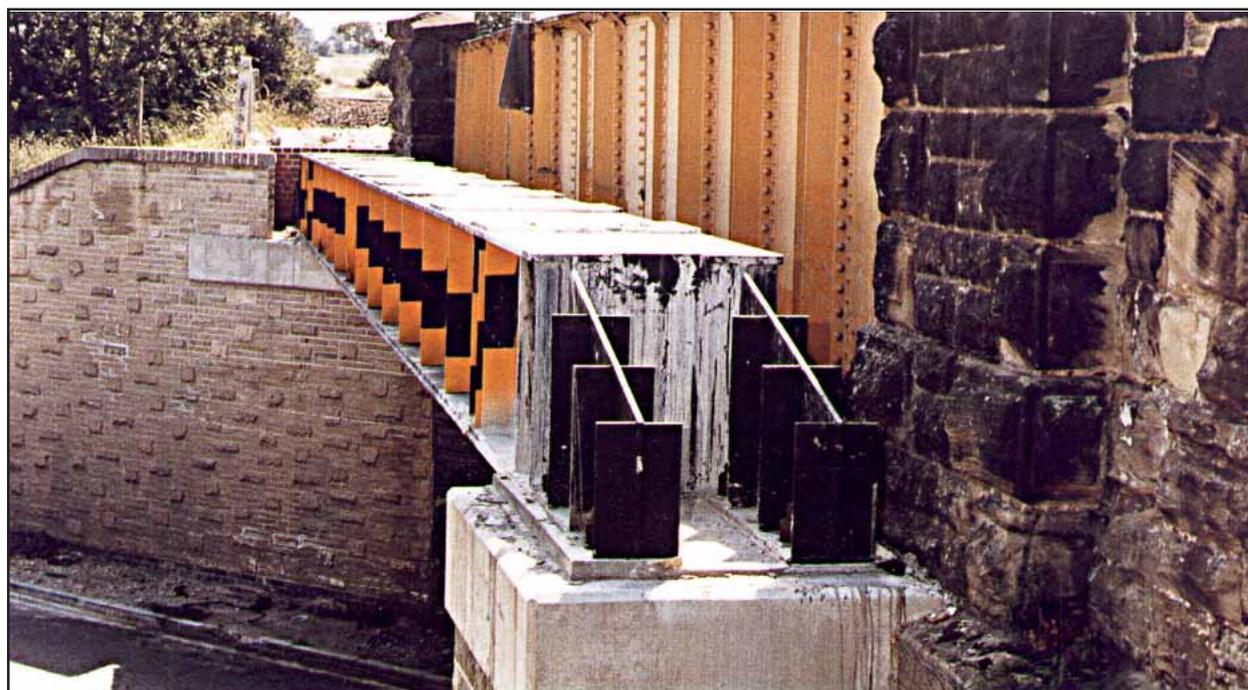


Plate B.2 Collision Protection Beam (End View)

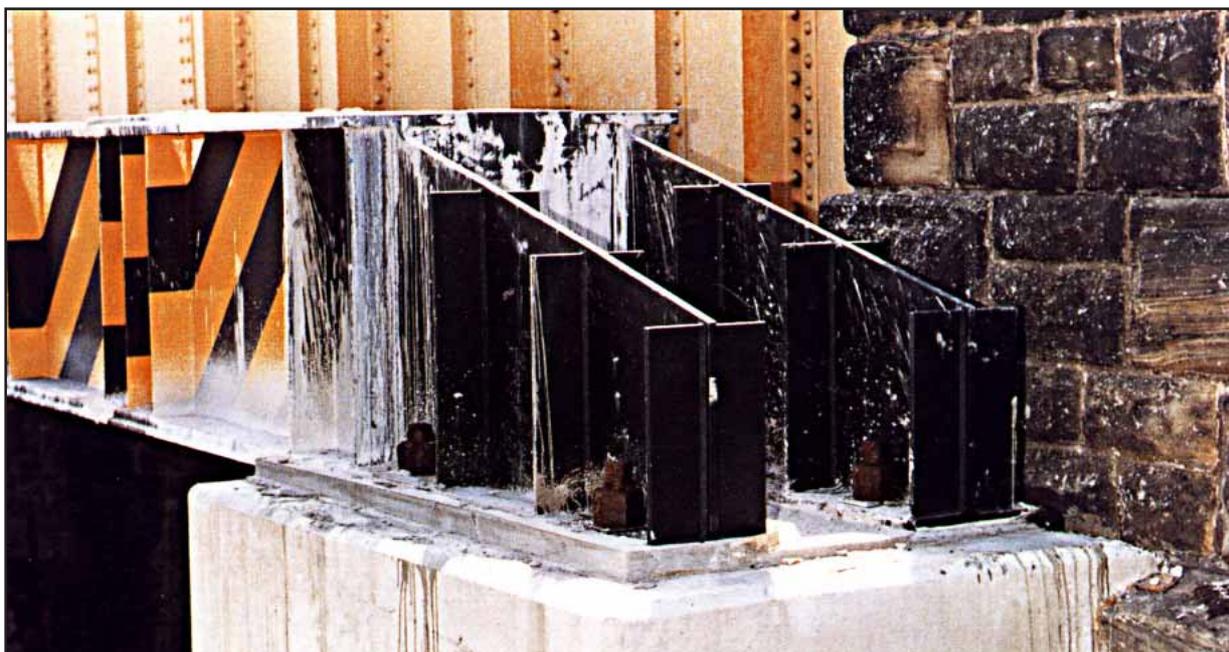


Plate B.3 Collision Protection Beam (Anchorage)



Plate B.4 Collision Protection Beam