VOLUME 3 HIGHWAY STRUCTURES: INSPECTION AND MAINTENANCE
SECTION 4 ASSESSMENT

PART 7

BD 48/93

THE ASSESSMENT AND STRENGTHENING OF HIGHWAY BRIDGE SUPPORTS

SUMMARY

This Departmental Standard gives the requirements for the assessment and strengthening of existing bridge supports for vehicle collision loading.

INSTRUCTIONS FOR USE

This is a new document to be incorporated into the Manual.

1. Remove existing contents pages for Volume 3 and insert new contents pages dated 1993.

2. Insert BD 48/93 into Volume 3, Section 4.

3. Archive this sheet as appropriate.

THE DEPARTMENT OF TRANSPORT **BD 48/93**

THE SCOTTISH OFFICE INDUSTRY DEPARTMENT

THE WELSH OFFICE
Y SWYDDFA GYMREIG

THE DEPARTMENT OF THE ENVIRONMENT FOR NORTHERN IRELAND

The Assessment and Strengthening of Highway Bridge Supports

Summary: This Departmental Standard gives the requirements for the assessment and strengthening of existing bridge supports for vehicle collision loading.

Printed and Published by the
above Overseeing Departments

Price: £1.00

REGISTRATION OF AMENDMENTS

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

REGISTRATION OF AMENDMENTS

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

VOLUME 3	HIGHWAY STRUCTURES: INSPECTION AND MAINTENANCE
SECTION 4	ASSESSMENT

PART 7

BD 48/93

THE ASSESSMENT AND STRENGTHENING OF HIGHWAY BRIDGE SUPPORTS

Contents

Chapter

1. INTRODUCTION

General

1.1 This Standard shall be used for the assessment and possible subsequent strengthening of existing bridge supports subject to the enhanced collision loading given in Table 2/1. For assessment and strengthening purposes the collision loading given in this document supersedes Clause 6.8.1 and Table 15 of BD 37/88 (DMRB 1.3).

1.2 It is intended that existing bridge supports should be made sufficiently strong or be adequately protected, to resist collision impact forces without allowing collapse of the supported structure. It is accepted that in doing this they may well suffer considerable damage and need to be repaired or reconstructed.

Scope

1.3 This Standard is applicable to all road bridges (including accommodation bridges) and footbridges over the carriageway of roads, with supports located within 4.5m of the edge of the carriageway; the carriageway being defined as in Clause 3.2.9 of BD 37/88 (DMRB 1.3).

1.4 Sign and signal gantries and pipe bridges need not be assessed for impact loading using analytical methods. However, each structure should be individually assessed to ensure that it is adequately protected by a safety fence or barrier which has a containment level equal to or greater than an open sided box beam. In those situations where it appears that there is a significant risk of a gantry being hit by an errant vehicle, eg a gantry leg close to the point of a bifurcation, consideration should be given to providing some extra protection to the support such as a plinth or cutwater.

Implementation

1.5 This Standard should be used forthwith for assessments of highway bridge supports. Supports which fail these assessments should be strengthened (or protected) in accordance with this Standard. The programmes for assessment and strengthening will be determined by the Overseeing Department.

1.6 A programme of research involving the consideration of the varying probabilities of occurrence and the modes of application of collision loading, is currently under way. Practical results for further guidance may not be available for some time. It is therefore recommended that only supports considered to be particularly at risk or which form part of a critical construction programme, should be strengthened until further guidance is issued.

2. COLLISION LOADING

Nominal loads

2.1 The nominal collision loads acting horizontally on bridge supports together with their height of application, are given in Table 2/1. Supports shall be assessed for their ability to resist the main and residual load components acting simultaneously. Loads normal to the carriageway shall be considered separately from loads parallel to the carriageway.

2.2 Where protective plinths 1.5m high are provided to footbridge supports, they should be assessed for the combined main and residual load components. The supports themselves should be designed for the residual load component shown in Table 2/1.

2.3 For all bridge elements except foundations and elastomeric bearings, the effects due to vehicle collision need only be considered at the ultimate limit state. The value of the partial safety factor for loading γ_{fL} shall be taken as 1.5 for both assessment and strengthening. However, for foundations where a permissible stress approach is used, and elastomeric bearings which are considered at the serviceability limit state only, a γ_{fL} factor of 1.0, shall be used.

2.4 For collision loading on supports, no primary or other secondary live loads need be considered. However, following an impact the overall integrity of a damaged structure shall be assessed at the ultimate limit state, under the primary live loading derived using combination 1 serviceability limit state γ_{fL} factors given in Table 1 of BD 37/88 (DMRB 1.3); γ_{f3} shall be taken as 1.0. When HB loading is applied, only 30 units need be considered.

	Load normal to the carriageway below	Load parallel to the carriageway below	Point of application on bridge support
	kN	kN	
Main load component	500	1000	At the most severe point between 0.75m and 1.5m above ground level adjacent to support
Residual load component	250 (100)	500 (100)	At the most severe point between 1m and 3m above ground level adjacent to support

Note: Figures shown in brackets shall be applied to footbridges in urban locations with robust plinths (see 2.2).

TABLE 2/1 Collision Loads on Supports of Bridges Over Highways

3. ANALYSIS

General

3.1 The two methods of analysis which can be adopted for impact loading are:

I. A quasi-static method in which the impact force is replaced by an equivalent static load. (See 3.3).

ii. A rigorous dynamic analysis.

The quasi-static approach is simpler to apply than the dynamic analysis but it may yield more conservative results. For the assessment of existing bridge supports, a quasi-static analysis should be carried out in the first instance. If the structure fails this assessment dynamic analysis may be used.

Quasi-static Analysis

3.2 For assessment of bridge supports, the nominal loads given in Table 2/1 can be multiplied by a reduction factor of:

$$\left(\frac{30}{30 + m}\right)$$

where m is the mass of the support member in tonnes. This reduction is based on momentum conservation and assumes that the support member alone participates in the dynamic response. Hence the deck loading or weight of foundation cannot be included when calculating m. For the assessment of bridge supports this reduced value of impact loading shall be applied statically.

3.3 It has been shown by laboratory impact tests (Ref 2), that a considerable amount of the impact energy is lost through local damage and vibration. Therefore, for the assessment of foundations, deck slabs and other members directly connected to the support member, the loads in Table 2/1 can be reduced by 50% and treated as acting statically. For more remote members, for example piling systems, the loads shown in Table 2/1 can be reduced by 75% and treated as acting statically.

4. ASSESSMENT AND STRENGTHENING

Assessment

4.1 Concrete bridge supports are to be assessed in conjunction with Departmental Standard BD 44 (DMRB 3.4). However, when considering shear, flexure and bending the values of γ_{mv}, γ_{mc} and γ_{mb} may be reduced by 10%, for both characteristic and worst credible strength applications. Steel supports shall be assessed in conjunction with BD 13 (DMRB 1.3) and foundations in conjunction with current Departmental Standards and with relevant British Standards in so far as they have been implemented by the Overseeing Department. However, when checking for bearing, the ultimate bearing capacity shall be used.

4.2 In an assessment it should be recognised that in many instances considerable damage may be sustained by an individual support member including failure of the member, its bearings or foundations, without the structure itself failing. Large rotations, lateral displacements and local damage may also occur. However under these movements the support system as a whole must still be capable of carrying the imposed load from the deck above. (See 2.4). Non-linear methods such as plastic analysis may be used.

4.3 Bridge supports, including ramps and staircases of footbridges, whose removal would not affect the overall integrity of the structure (see 2.4) need not be assessed for collision loading. However, engineers should satisfy themselves that after impacting and removing one support, a vehicle will not damage adjacent supports and thereby cause a collapse of the bridge deck.

Strengthening

4.4 Structures which fail assessments will require additional protection or strengthening so as to be able to sustain the collision loads given in Table 2/1.

4.5 Strengthening schemes for structures which fail assessment shall be designed in accordance with current design Standards and Codes of Practice. However, non-linear methods of analysis may be used where appropriate. In the case of foundations, when checking for bearing the ultimate bearing capacity shall be used.

4.6 Schemes should be devised on an individual basis and take account of construction and traffic management costs as well as aesthetics. Strengthening should wherever possible be carried out with other maintenance or improvement works in order to minimise delays to road users.

4.7 Methods considered for strengthening bridge supports should include the following:

i. Providing structural continuity by tying together slender supports to form a more robust structure.

ii. Increasing the size of the supports. This may be achieved by casting a mass concrete collar or plinth around an existing slender member, or casting vulnerable individual columns into a leaf pier.

iii. Providing continuity to prevent collapse. It may be possible in some cases to provide continuity at the deck which would prevent a collapse in the event of the loss of one support.

iv. Fixing an articulated pier. Sufficient strength may be achieved by the locking up of low level bearings and providing for movement at the deck. However, the consequence of thermal and future foundation movement should be fully taken into account. It may be necessary to replace the upper bearing by a sliding one. When resulting movements at the pier top are large, local strengthening of the bridge deck may be necessary.

v. Introducing structural redundancies by providing additional supports or strengthening deck members.

Protection

4.8 As an alternative to strengthening, supports that fail assessment may be protected by means of an appropriate vehicle restraint system. Advice on a suitable system may be obtained from the Overseeing Department.

4.9 Designers should be aware that, with some vehicle restraint systems, there is a tendency for the vehicle to climb the system and tilt over. Where a bridge support is close to the restraint system, it may be subject to a high level impact. In such cases the designer should assess the bridge supports for the residual load components only, unless more accurate information on the likely resulting impact loading is available.

5. REFERENCES

1. Design Manual for Roads and Bridges

Volume 1: Section 3 General Design

BD 13/90 Design of Steel Bridges. Use of BS 5400 Part 3: 1982 (DMRB 1.3)

BD 37/88 Loads for Highway Bridges (DMRB 1.3). *[For the assessment and strengthening of bridges, Clause 6.8.1 and Table 15 are superseded by the collision loading given in BD 48/93]*

Volume 3: Section 4 Assessment

BD 44/90 The Assessment of Concrete Highway Bridges and Structures (DMRB 3.4)

2. Impact Loading of a Reinforced Concrete Beam to Column Joint. ACI special publication SP-73-8, 1982.

6. ENQUIRIES

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

Chief Highway Engineer
The Department of Transport
St Christopher House
Southwark Street
London SE1 OTE

T A ROCHESTER
Chief Highway Engineer

The Deputy Chief Engineer
The Scottish Office Industry Department
Roads Directorate
New St Andrew's House
Edinburgh EH1 3TG

J INNES
Deputy Chief Engineer

The Director of Highways
Welsh Office
Y Swyddfa Gymreig
Government Buildings
Ty Glas Road
Llanishen
Cardiff CF4 5PL

K J THOMAS
Director of Highways

Chief Engineer - Roads Service
Dept. of the Environment for
Northern Ireland
Commonwealth House
Castle Street
Belfast BT1 1GU

W J McCOUBREY
Chief Engineer - Roads Service

Orders for further copies should be addressed to:

DOE/DOT Publications Sales Unit
Government Building
Block 3, Spur 2
Lime Grove
Eastcote HA4 8SE

Telephone No: 081 - 429 5170