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The Assessment and Strengthening of Road Bridge Supports

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Standards

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For all documents that existed within the NRA DMRB or the NRA MCDRW prior to the launch of TII Publications, the NRA document reference used previously is listed above under 'historical reference'. The TII Publication Number also shown above now supersedes this historical reference. All historical references within this document are deemed to be replaced by the TII Publication Number. For the equivalent TII Publication Number for all other historical references contained within this document, please refer to the TII Publications website.

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Part 5
NRA BD 48/14

The Assessment and Strengthening of Road Bridge Supports

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Summary:

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

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VOLUME 3 ROAD STRUCTURES: INSPECTION AND MAINTENANCE

SECTION 4 ASSESSMENT

PART 5

NRA BD 48/14

THE ASSESSMENT AND STRENGTHENING OF ROAD BRIDGE SUPPORTS

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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 NRA BD 37.

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 is the part of the running surface which includes all traffic lanes, hard shoulders, hard strips and marker strips. The carriageway width is the width between raised kerbs. In the absence of raised kerbs it is the width between safety fences, less the amount of set-back required for these fences, being not less than 0.6m or more than 1.0m from the traffic face of each fence. The carriageway width shall be measured in a direction at right angles to the line of the raised kerbs, lane marks or edge marking.

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, e.g. 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 may be used for assessments of road bridge supports. Supports which fail these assessments should be strengthened (or protected) in accordance with this Standard. Only supports considered to be particularly at risk should be strengthened.

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 NRA BD 37; 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
Main load component	kN 500	kN 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

Table 2/1: Collision Loads on Supports of Bridges Over Roads

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

3. ANALYSIS

General

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

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

b) 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 3), 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 NRA BD 44. 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 NRA BD 13 and foundations in conjunction with NRA BD 74, other relevant NRA assessment standards and with relevant British Standards in so far as they have been implemented by the National Roads Authority. 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 the requirements of the National Roads Authority. 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:

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

b) 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.

c) 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.

d) 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.

e) 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 National Roads Authority.

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

5.1 NRA Design Manual for Roads and Bridges (NRA DMRB)

NRA BD 13 Design of Steel Bridges. Use of BS 5400 Part 3: 1982

NRA BD 37 Loads for Highway Bridges. *[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]*

NRA BD 44 The Assessment of Concrete Road Bridges and Structures

NRA BD 74 Foundations

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

6. ENQUIRIES

6.1 All technical enquiries or comments on this document or any of the documents listed as forming part of the NRA DMRB should be sent by e-mail to infoDMRB@nra.ie, addressed to the following:

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