Design Manual for Roads and Bridges

Highway Structures & Bridges
Inspection & Assessment

CS 463
Load testing for bridge assessment

(formerly BA 54/94)

Revision 0

Summary
This document describes the requirements for load tests to be used to assist in the strength assessment of bridges.

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

This is a controlled document.

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Release notes

Version	Date	Details of amendments
0	Jun 2019	CS 463 replaces BA 54/94. The full document has been re-written to make it compliant with the new Highways England drafting rules.

Foreword

Publishing information

This document is published by Highways England.

This document supersedes BA 54/94, which is withdrawn.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.

Introduction

Background

Bridges can fail assessment calculation even when they seem to be carrying normal traffic satisfactorily without any undue signs of distress. Load tests can provide additional information which can justify increasing the assessed capacity.

This document explains the rationale behind load testing of bridges.

This document was derived from BA 54/94. It has been edited to reduce ambiguity and repetition, to clarify distinctions between requirements and background information and to improve ease of use by simplifying the text and by rearranging the document in a more logical order.

Additional emphasis has been placed on the need to appropriately manage health and safety issues which may be different for different types of test; including the need to recognise that bridge collapse is an unavoidable risk during proving load tests but cannot be entirely discounted during supplementary tests.

The technical content is otherwise unchanged.

Assumptions made in the preparation of the document

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

Abbreviations

Abbreviations

Abbreviation	Definition
ALL	Assessment Live Load

Terms and definitions

Terms and definitions

Term	Definition
Assessment live load	Theoretical live load model employed for assessment of existing bridges.

1. Scope

Aspects covered

1.1 Load tests described by this document shall be used to assist in the strength assessment of bridges.

1.2 Load testing described by this document shall not be undertaken for masonry arch bridges.

Implementation

1.3 This document shall be implemented forthwith on all schemes involving load testing for bridge assessment purposes on the Overseeing Organisations' motorway and all-purpose trunk roads according to the implementation requirements of GG 101 [Ref 2.N].

Use of GG 101

1.4 The requirements contained in GG 101 [Ref 2.N] shall be followed in respect of activities covered by this document.

2. Application of load testing

Purpose

2.1 Load testing of a bridge shall only be undertaken after calculated assessments using the best available methods and information (such as results of material tests, recorded information on similar bridges and materials, maintenance and strengthening records) fail to show it to comply with the assessment standards.

2.1.1 Load tests may be employed to provide information to supplement reliability analysis.

Applicability

2.2 Load testing shall only be used if analysis shows that there is a realistic possibility of improving the assessed capacity to a level which can satisfy the assessment standards.

2.2.1 Load testing may assist in bridge assessment to bridge types which contain features where hidden strength reserves can be found, or where it is expected to identify additional sources of strength not normally taken into account in the calculations.

2.2.2 Although not intended to be exhaustive, the following is a list of bridge types for which load testing may be usefully employed:

1) small span bridges where either a single-axle or a two-axle bogie could simulate assessment loading;
2) older bridges, of construction types now mainly unused, for which structural idealisation is particularly difficult;
3) in general, bridges without internal structural complexities such as transverse girders (although such complexities by themselves do not mean that all types of tests are pointless);
4) in general, bridges which, at least theoretically, can be termed as simply-supported;
5) bridges where the strength of constituent parts is uncertain owing to lack of design data or knowledge of physical condition.

Constraints

2.3 Where bridges are suspected of having inadequate shear capacity, additional caution shall be used in tests.

NOTE *Particular requirements for such tests are provided within the parts of this document that describe the different types of load tests.*

2.4 Load test procedures shall be devised individually for each bridge assessment.

Types of load tests

2.5 Bridge load tests described in this document shall either be classified as supplementary load tests or as proving load tests.

NOTE 1 *Supplementary load tests are intended to be used as an adjunct to theoretical calculations.*

NOTE 2 *Proving load tests are intended to be used as a complete assessment in place of a theoretical assessment when the assessing engineer suspects that the theoretical assessment has underestimated the actual load capacity of a bridge.*

Management

2.6 Testing shall be carried out under the supervision of a Chartered Engineer with specialist expertise in bridge strength assessment or design.

2.7 Testing shall be undertaken by a competent organisation in possession of the necessary equipment.

2.8 Specialist expertise shall be employed in devising a load test, during the test itself and in the subsequent assessment, especially in deciding the reduction factors relating to earlier collapse tests.

3. Supplementary load tests

Objectives of supplementary tests

3.1 In a supplementary load test, vehicle axle loads or patch loads, or combinations thereof, shall be placed on a bridge to determine individual aspects of its behaviour so that assumptions made in the theoretical assessment can be made more pertinent to the individual structure.

NOTE 1 *Appendix A summarises a typical supplementary test procedure.*

NOTE 2 *Detailed guidelines for conducting supplementary load tests have been published: e.g. Guidelines for the supplementary load testing of bridges [Ref 1.I].*

Test loads

3.2 Load tests shall not cause damage to the bridge.

3.3 Estimates of day to day loading shall be obtained from records or surveys.

3.4 The loads applied in the tests shall not cause effects which exceed those caused by the loads carried by the bridge on a day to day basis.

3.4.1 It is recommended that the test load effects on older bridges should not exceed the original design working load.

3.5 Test load effects in composite bridges shall not exceed 60% of the unfactored serviceability limit state load effects.

NOTE *This limit is to minimise the probability of accidentally damaging the shear connection between concrete and steel elements.*

3.6 Test load effects on other bridges shall not exceed 90% of the unfactored serviceability limit state load effects.

3.7 Load effects in bending tests shall be kept well within the elastic range of the bridge flexural behaviour.

3.8 Load levels in shear tests shall be limited to below the predicted lowest theoretical strength because shear failure can be relatively sudden.

Management of supplementary tests

3.9 Where there is a risk of sudden failure including inadequacy in respect of shear strength, load testing shall only be undertaken if:

1) load levels are kept sufficiently low to ensure that the risk of sudden failure is effectively removed;
2) the load test does not take place over an open route or place;
3) structural failure would not endanger staff engaged in undertaking the test or any other persons.

3.10 The possibility that the bridge will suffer severe damage or collapse is a potential hazard during any test, and the consequential risk to personnel shall be mitigated in accordance with health and safety regulations.

NOTE *Excessive shear loading can lead to a brittle and therefore relatively unsafe failure mode.*

3.11 A test vehicle shall not be deliberately mounted on any element (such as the footway) which was not originally designed to such loads.

Analysis and assessment

3.12 Extrapolation to the behaviour at the ultimate limit state from the results of tests carried out with levels of loading lower than or equal to the serviceability limit state shall only be undertaken if two conditions are satisfied, as follows:

1) the materials and their interconnections are determinable;

2) earlier collapse tests have been carried out on bridges with similar materials and details so that some pattern of load carrying behaviour has been established.

4. Proving load tests

Objectives of proving load tests

4.1 A proving load test shall be used as a complete assessment by itself in place of the theoretical assessment.

NOTE *A proving load test is not intended to improve assumptions employed in bridge assessment.*

4.2 Proving load tests shall be limited to bridges which, on the basis of their assessments, could have been closed to traffic and could otherwise require to be demolished.

Test loads

4.3 Proving tests shall not be employed if the relationship between a test load and a subsequently permissible service loading cannot be determined.

4.4 A test load representing the ultimate limit state level of the assessment live load (ALL), or a reduced proportion of it, shall be applied to a bridge.

4.5 The test load shall be applied in increments until either the entire load is reached or until the load deflection behaviour becomes non-linear.

NOTE *The test load is not likely to be sufficient to develop non-linear behaviour where the failure mode is brittle in nature (e.g. in a shear load test). Therefore, in such cases, the second criterion listed above will not be applicable.*

Management of proving load tests

4.6 The possibility that the bridge will suffer severe damage or collapse is a significant and unavoidable hazard during a proving test, and the consequential risk to personnel shall be mitigated in accordance with health and safety regulations.

4.7 The bridge and any area beneath the bridge which can be affected in the event of bridge collapse shall be closed to all persons while a proving load test is taking place.

Analysis and assessment

4.8 In order to obtain the allowable load, the maximum achieved test load shall be divided first by a factor to allow for the fact that a simplified model load is used to represent the complete ALL and, secondly, by the partial safety factor for the ALL appropriate at the ultimate limit state to obtain the nominal assessment load level.

4.9 Appropriate partial safety factors shall be obtained by referring to CS 454 [Ref 1.N].

4.10 Weight restriction levels, if any, shall be decided from the allowable load detailed in this section and in accordance with CS 454 [Ref 1.N].

4.11 Bridges that have been subjected to proving load tests shall be thoroughly inspected and reassessed at frequent intervals after the test because any structural damage incurred during proving load tests can initially be concealed.

NOTE *Any internal damage can lead to rapidly accelerated subsequent deterioration of the structure and can cause sudden collapse under permitted traffic.*

5. 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	Highways England. CS 454, 'Assessment of highway bridges and structures'
Ref 2.N	Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges'

6. Informative References

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

Ref 1.I	Institution of Civil Engineers. National steering committee for the load testing of bridges. 'Guidelines for the supplementary load testing of bridges'

Appendix A. Example of supplementary load test requirements

A1 Typical supplementary load test instructions

One or more test loads may be placed at various positions on the bridge.

The test load may comprise an axle or a bogie or a vehicle load, or it can comprise some form of ballast (e.g. water tank load).

The test load is designed to generate particular live load effects (for example, the bending moments produced by the assessment live loading).

The loading is to be applied in increments.

The observed strains and deflections can then be compared with corresponding theoretical values.

When this comparison indicates hidden reserve capacity in the bridge, each possible source of the hidden strength such as end fixity, better transverse distribution and composite action can be examined using knowledge gained in earlier collapse tests on similar bridges, where available.

When the hidden strength indicated by the test or a proportion of it can be accounted for and is justified then:

1) the theoretical model can be modified;
2) the assessment calculations can be carried out using the revised model.