



## Bridge design

### Part 7: Bridge assessment



This Australian Standard® was prepared by Committee BD-090, Bridge Design. It was approved on behalf of the Council of Standards Australia on 13 March 2017. This Standard was published on 31 March 2017.

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This Standard was issued in draft form for comment as DR 100294.

Standards Australia wishes to acknowledge the participation of the expert individuals that contributed to the development of this Standard through their representation on the Committee and through the public comment period.

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Australian Standard<sup>®</sup>

## Bridge design

### Part 7: Bridge assessment

Originated as HB 77.7—1996.  
Revised and redesignated as AS 5100.7—2004.  
Second edition 2017.

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Published by SAI Global Limited under licence from Standards Australia Limited, GPO Box 476, Sydney, NSW 2001, Australia

ISBN 978 1 76035 720 7

## PREFACE

This Standard was prepared by the Standards Australia Committee BD-090, Bridge Design, to supersede AS 5100.7—2004, *Bridge design, Part 7: Rating of existing bridges*.

This Standard is also designated as Austroads publication AP-G51.7-17.

The objectives of the AS(AS/NZS) 5100 series are to provide nationally acceptable requirements for—

- (a) the design of road, rail, pedestrian and cyclist path bridges;
- (b) the specific application of concrete, steel, timber and composite construction, which embody principles that may be applied to other materials in association with relevant Standards;
- (c) the assessment of the load capacity of existing bridges; and
- (d) the strengthening and rehabilitation of existing bridges.

The objectives of this Part (AS 5100.7) are to specify requirements for assessment of the geometry, condition, fatigue life, capacity and loading of existing bridges and associated structures, and to specify the method of calculation of the load rating factor of a bridge for a nominated rating vehicle.

The requirements of the AS(AS/NZS) 5100 series are based on the principles of structural mechanics and knowledge of material properties, for both the conceptual and detailed design, to achieve acceptable probabilities that the bridge or associated structure being designed will not become unfit for use during its design life.

Significant differences between this Standard and AS 5100.7—2004 are the following:

- (i) *Methodology* Overall there is a clearer methodology for bridge assessment and load rating including a step-by-step guide and flowchart.
- (ii) *Load rating vehicles* Improved definition and clarity have been provided regarding vehicles used for bridge load rating.
- (iii) *Structural capacity* Greater detail and guidance have been provided including data collection, material properties, and considerations and assessment methods.
- (iv) *Loads* Improved guidance and detail have been provided with standardization of vehicle positioning and multiple vehicles.
- (v) *Structural health monitoring* This has been included in the Standard to provide an overview of the latest technology and guidance on its potential use for bridge assessment.
- (vi) *Historical material standards* Information on past material Standards has been provided to assist bridge assessors in understanding the probable material properties of bridges built to previous Standards.

In line with Standards Australia policy, the words ‘shall’ and ‘may’ are used consistently throughout this Standard to indicate respectively, a mandatory provision and an acceptable or permissible alternative.

Statements expressed in mandatory terms in Notes to Tables are deemed to be requirements of this Standard.

The terms ‘normative’ and ‘informative’ have been used in this Standard to define the application of the appendix to which they apply. A ‘normative’ appendix is an integral part of the Standard, whereas an ‘informative’ appendix is only for information and guidance.

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# STANDARDS AUSTRALIA

## Australian Standard Bridge design

### Part 7: Bridge assessment

## 1 SCOPE AND APPLICATION

### 1.1 Scope

This Standard sets out requirements for the assessment of the geometry, condition, fatigue life, capacity and loading of existing road, rail, pedestrian or cyclist path bridges, culverts and associated structures. It is used to calculate the load rating factor of a bridge for a nominated rating vehicle.

The load and structural capacity requirements used in an assessment and load rating may differ from the original design load and structural capacity requirements because the bridge was not designed to this edition of the AS(AS/NZS) 5100 series. The nominated rating vehicles used for load rating may differ from the design load because of a change in use of the bridge.

Both ULS and SLS are considered in this Standard.

NOTE: For a simplified assessment and load rating using overstress factors, refer to NAASRA *Highway Bridge Design Specification*.

### 1.2 Application

Bridge assessment shall only be carried out after a Level 2 and/or Level 3 inspection has been undertaken to determine the current condition of the bridge.

The method of assessing the ultimate capacity of a bridge for traffic loading shall be in accordance with this Standard.

NOTE: A bridge may have been designed in accordance with a Standard that is now superseded and there may be a difference between the original design requirements and the design requirements in the current edition of this Standard.

The management of capacity deficient bridges is outside the scope of this Standard. The relevant authority shall implement strategies to safely manage these bridges.

For a bridge designed in accordance with the relevant Standard at the time, the load rating factor for the design loading may be taken as 1.0, subject to the bridge being in good working order to the approval of the relevant authority.

Factors and methods from previous editions of the Standard shall not be used to assess bridges unless otherwise approved by the relevant authority.

## 2 NORMATIVE REFERENCES

The following are the normative documents referenced in this Standard:

NOTE: Documents referenced for informative purposes are listed in the Bibliography.

### AS

- 1720 Timber structures
- 1720.1 Part 1: Design methods
- 5100 Bridge design
- 5100.1 Part 1: Scope and general principles
- 5100.2 Part 2: Design loads
- 5100.3 Part 3: Foundations and soil-supporting structures
- 5100.5 Part 5: Concrete
- 5100.8 Part 8: Rehabilitation and strengthening of existing bridges
- 5100.9 Part 9: Timber bridges

### AS ISO

- 13822 Basis for design of structures—Assessment of existing structures (ISO 13822:2001, MOD)

### AS/NZS

- 5100 Bridge design
- 5100.6 Part 6: Steel and composite construction

Heavy Vehicle (Mass, Dimension and Loading) National Regulation

## 3 DEFINITIONS

For the purposes of this Standard, the definitions below apply.

### 3.1 Bridge assessment

A multistage process to determine if a bridge can safely carry a designated traffic load, which involves data collection of bridge construction details, current bridge condition, capacity assessment, load effects, fatigue assessment and load rating.

### 3.2 Fatigue assessment

An estimation of the cumulative damage in a bridge component under repeated loading for the purpose of assessing its theoretical remaining serviceable fatigue life.

### 3.3 General access vehicle (GAV)

A vehicle meeting the general mass limits and other regulatory requirements of the Heavy Vehicle (Mass, Dimension and Loading) National Regulation.

### 3.4 General mass limits (GML)

A vehicle meeting the general mass limits and other regulatory requirements of the Heavy Vehicle (Mass, Dimension and Loading) National Regulation.

### 3.5 Higher mass limit (HML)

Higher mass limits as provided in the Heavy Vehicle (Mass, Dimension and Loading) National Regulation.

### 3.6 Indivisible load

An item that cannot be divided without extreme effort, expense or risk of damage to it, and cannot be carried on any heavy vehicle without contravening a mass requirement or dimension requirement.

### 3.7 Level 2 inspection

A detailed inspection where the condition of every component is visually rated and recorded as a minimum, and which is usually undertaken in close proximity to the component.

### 3.8 Level 3 inspection

A detailed engineering assessment undertaken by a professional engineer on an as-needed basis to investigate the structural integrity of a bridge or its components.

### 3.9 Load rating

The process of determining a load-rating factor.

### 3.10 Load rating factor

A ratio of the available bridge capacity for traffic load effects to the traffic load effects of a nominated rating vehicle (see Clause 14).

### 3.11 Nominated rating vehicle

A design traffic load, a specific road vehicle, a specific train consist, or for a pedestrian bridge a specific pedestrian loading.

### 3.12 Professional engineer

Any one or a combination of the following:

- (a) A person registered in a relevant area of practice on the National Engineering Register.
- (b) Where applicable, a member of a scheme established under Professional Standards Legislation in the relevant jurisdiction.
- (c) A chartered professional engineer (CPEng) or equivalent qualifications recognized by Engineers Australia.

### 3.13 Relevant authority

An agency authorized by legislation or regulation to issue determinations, orders, or other instructions in respect of any subject covered by this Standard.

NOTE: Where compliance with this Standard is not a requirement of a relevant authority, but is a requirement of a body such as an insurance company or association, then that body, or its nominees, may perform the functions of the relevant authority for the purposes of this Standard.

### 3.14 Restricted access vehicle (RAV)

Vehicles that operate under a notice or gazette and vehicles that operate under higher mass limits (HML) that can generally only access certain parts of the road network (a vehicle that is not a GAV).

NOTES:

- 1 An RAV may be a B-double, road train or high performance vehicle.
- 2 Examples of restricted access vehicles are HML semi-trailer, HML B-double, GML road train and HML road train.

### 3.15 Structural health monitoring

The use of various sensing devices and ancillary systems to monitor in situ behaviour of a structure to assess the performance of the structure and assess its condition.

## 4 NOTATION AND ABBREVIATIONS

### 4.1 Notation

The symbols used in this Standard, including their definitions, are listed below.

Unless a contrary intention appears, the following applies:

- Where non-dimensional ratios are involved, both the numerator and denominator are expressed in identical units.
- The units for length and stress in all expressions or equations are to be taken as millimetres (mm) and megapascals (MPa) respectively, unless specifically noted otherwise.

| Symbol        | Definition                                                                                                                                    |
|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| $F_u$         | tensile strength of rivets                                                                                                                    |
| $f_{pb}$      | characteristic minimum breaking strength                                                                                                      |
| $f_{sy}$      | yield strength of reinforcing steel                                                                                                           |
| $k$           | testing modification factor                                                                                                                   |
| $L_R$         | rated load                                                                                                                                    |
| $L_{RV}$      | nominated rating vehicle or loading                                                                                                           |
| $RF$          | load rating factor                                                                                                                            |
| $R_u$         | calculated ultimate capacity                                                                                                                  |
| $S_{CE}^*$    | load effects due to co-existing traffic load (see Clause 14.2)                                                                                |
| $S_g^*$       | load effects due to dead load                                                                                                                 |
| $S_{gs}^*$    | load effects due to superimposed dead load                                                                                                    |
| $S_p^*$       | load effects due to secondary effects of prestress                                                                                            |
| $S_Q^*$       | load effects due to the traffic load used for the assessment and load rating                                                                  |
| $S_s^*$       | load effects due to shrinkage, creep, differential settlement and bearing friction                                                            |
| $S_t^*$       | load effects due to temperature                                                                                                               |
| $W$           | a factor representing the multiple track factor for rail traffic bridges; <i>or</i><br>a factor representing the ALF for road traffic bridges |
| $W_{CE}$      | a factor representing either MTF for rail traffic, or $\Sigma$ ALF for road traffic, for co-existing traffic                                  |
| $\alpha$      | dynamic load allowance                                                                                                                        |
| $\gamma_g$    | load factor for dead load                                                                                                                     |
| $\gamma_{gs}$ | load factor for superimposed dead load                                                                                                        |
| $\gamma_Q$    | traffic load factor                                                                                                                           |
| $\phi$        | capacity reduction factor                                                                                                                     |

## 4.2 Abbreviations

|     |                              |
|-----|------------------------------|
| ALF | Accompanying lane factor     |
| BLF | Branch line freight          |
| DLA | Dynamic load allowance       |
| FLS | Fatigue limit state          |
| GAV | General access vehicle       |
| GCW | Ground contact width         |
| GML | General mass limit           |
| HHF | Heavy haul freight           |
| HLP | Heavy load platform          |
| HML | Higher mass limit            |
| HSP | High speed passenger         |
| LR  | Low relaxation               |
| LSP | Low speed passenger          |
| MLF | Main line freight            |
| MSP | Moderate speed passenger     |
| MTF | Multiple track factor        |
| NR  | Normal relaxation            |
| RAV | Restricted access vehicle    |
| SHM | Structural health monitoring |
| SLS | Serviceability limit state   |
| SR  | Stress relieved              |
| ULS | Ultimate limit state         |

## 5 MATTERS FOR RESOLUTION BEFORE DESIGN COMMENCES

The matters for resolution listed below shall be confirmed as accepted by the relevant authority before commencing the relevant assessment process.

- 1 Strategies for management of capacity deficient bridges (see Clause 1.2).
- 2 Design load rating of 1.0 for a bridge designed in accordance with the relevant Standard at the time, subject to the bridge being in good working order (see Clause 1.2).
- 3 Use of factors and methods from previous editions of the Standard (see Clause 1.2).
- 4 Use of other bridge Standards for assessment [see Clause 6 and Clause 9(h)].
- 5 Use of other than ULS for calculation of the load rating factor (see Clause 8.1.2).
- 6 Use of an alternative method for determining material properties [see Clause 10.2.2.1(iv)].
- 7 Approval of a method for the conversion of material test results to nominal material strengths (see Clause 10.2.2.3).
- 8 Approval of testing method for prestressing steel (see Clause 10.2.2.4).

- 9 Use of working stress to AS 1720.1—1988, or other alternative methods, for the capacity assessment of timber members [see Clause 10.6.4, Items (b) and (c)].
- 10 Use of permissible stress methods for the assessment of masonry arches (see Clause 10.6.5.3).
- 11 Recording of assumptions and methodology in an assessment report (see Clause 10.8).
- 12 Approval of loads for load rating other than in accordance with Clause 11 (see Clause 11.1).
- 13 Co-existing vehicle loads [see Clause 11.3.2(c)].
- 14 Consideration of co-existing vehicles where the bridge is greater than 40 m in length or where geometry dictates that two drivers may not see each other before travelling onto the bridge [see Clause 11.3.3(b)].
- 15 Use of a reduced DLA [see Clause 11.3.3(b) Note 2].
- 16 Compliance and conformity requirement on permit vehicles (see Clause 11.3.4).
- 17 Acceptance of supervision requirements for use of a reduced DLA [see Clause 11.3.6(c)].
- 18 Specification of a braking load and centrifugal load for special bridges or specific bridges (see Clause 11.3.7).
- 19 Approval of alternative rating vehicles for rail bridges (see Clause 11.4.1).
- 20 Proportion of 300LA to be used as a rating vehicles for rail bridges [see Clause 11.4.1(a)].
- 21 Train to be used as a rating vehicles for rail bridges [see Clause 11.4.1(b)].
- 22 Nomination and application of wind loads for rail bridge assessments (see Clause 11.6.1).
- 23 Approval of assessment for exceptional loads (see Clause 11.6.3).
- 24 Approval of modified load factors for the serviceability limit state (see Clause 12.1) or ultimate limit state (see Clause 12.2).
- 25 Approval of a load test (see Clause 15.1).
- 26 Approval of the use of destructive testing results in the load rating of other in-service structures (see Clause 15.3.2).
- 27 Approval of the use of one vehicle only for proof load testing [see Clause 15.4.1 (d)].
- 28 Approval of a procedure for the site-specific assessment of continuous bridges (see Clause 15.4.1).
- 29 Approval of any reduction of the analytical assessments of the traffic load design effects based upon the results of static load testing (see Clause 15.4.2).
- 30 Approval to use superposition of test results for determining the rated load (see Clause 15.4.3 Note).
- 31 Approval for the use of SHM to determine the load rating factor of a bridge (see Clause 16.3).
- 32 Approval for the use of SHM for damage and deterioration detection, and nomination of the required stages of detection and assessment (see Clause 16.4.1).
- 33 Approval to use the results of a static performance load test to extend proof loading tests from other similar bridges (see Clause 16.5.2).
- 34 Approval of other test methods to determine the load rating factor of a bridge (see Clause 17).

## 6 GENERAL

The initial load rating of a bridge is normally based on the original design load, if known, with the load rating factor modified as a result of a current condition assessment. The bridge shall be considered for assessment and load rating as a result of—

- (a) a requirement for it to carry increased traffic or other loads;
- (b) suffering any physical damage from actions including, but not limited to, vehicle overloading, vehicle impact, fire, flooding or scour, ship impact and earthquake;
- (c) deterioration of its components, e.g. by chemical or physical weathering and fatigue effects;
- (d) deficiencies in design and/or construction; or
- (e) rehabilitation or strengthening of a bridge.

The bridge may also be re-rated as a result of differences in the provisions between the original and current bridge design Standard.

In undertaking a bridge load rating, all components of the bridge, including its foundation, shall be considered to ensure that all relevant components are assessed and that their interactive effect on the overall structure has been taken into account.

NOTE: Interactive effects may include the following:

- (a) Potential settlement of piles in continuous structures.
- (b) Settlement of reinforced soil walls supporting abutment sill beams.

The assessment and load rating methods adopted are influenced by safety, assessment costs and the importance of changes to bridge capacity. Assessment and load rating methods include, but are not limited to, the following:

- (i) A comparison check to the original design loading.
- (ii) Simple theoretical analysis based on the parameters in this Standard.
- (iii) More sophisticated theoretical analysis using techniques such as finite element analysis or other advanced analysis methods.
- (iv) Analysis using the results of field investigation of material properties, bridge component dimensions, dead and traffic loads, foundation capacity and the like.
- (v) Bridge-specific traffic load assessment.
- (vi) Field or laboratory test loading, e.g. proof, static and dynamic load testing.
- (vii) Structural health monitoring.

Each method has differing accuracy, which shall be considered in the assessment.

Other bridge Standards may be considered in the assessment, subject to the approval of the relevant authority.

The likely behaviour of the structure shall be taken into account in the analysis considering the material type and structural behaviour.

All assumptions relevant to the assessment and load rating shall be recorded.

## 7 FUTURE GROWTH OF TRAFFIC OR FUTURE STRUCTURAL DETERIORATION

No allowance is made in this Standard for future growth of traffic or for future structural deterioration of the bridge. If such changes are anticipated, they shall be considered in the assessment and load rating. If any change to the traffic or the condition of the bridge should occur that has not been accounted for, the assessment shall be reviewed and, if necessary, the bridge shall be reassessed and a new load rating factor calculated.

## 8 RATING—LIMIT STATES

### 8.1 General

Load rating is based on limit state design methods and compares the available bridge capacity for traffic load effects with the traffic load effects of a nominated rating vehicle.

### 8.2 Ultimate limit state (ULS)

ULS shall be used in calculation of the load rating factor of bridges unless an alternative method is approved by the relevant authority.

### 8.3 Serviceability limit state (SLS)

For bridges where cracking detrimental to the structure, deformation, or vibrations are evident, the bridge and affected components shall be assessed for SLS requirements in accordance with the relevant sections of this Standard.

Where there is no evidence of serviceability-related defects, the assessment need not consider the SLS unless otherwise required in this Standard, provided that neither the use nor the behaviour of the bridge is changed.

### 8.4 Fatigue limit state (FLS)

Load rating for the FLS shall be carried out in accordance with Clause 13.

## 9 BRIDGE ASSESSMENT AND LOAD RATING

A bridge assessment and load rating shall consist of the following steps:

- Step 1: Undertake *data collection* (Clause 10.2).
- Step 2: Determine the *bridge condition* (Clause 10.3).
- Step 3: Measure the bridge components if required to determine the *field geometry* (Clause 10.4).
- Step 4: Determine the *load effects* and *load factors* (Clauses 11 and 12).
- Step 5: Undertake *capacity assessment* (Clause 10.6).
- Step 6: Undertake *fatigue assessment* (Clause 13).
- Step 7: Calculate the *load rating factor* (Clause 14).  
NOTE: Each method of assessment (line model and grillages for example) has differing accuracy, which needs to be considered in the load rating.
- Step 8: Where the load rating factor for a specific bridge and nominated rating vehicle is assessed as being less than required (i.e.  $RF < 1$ ), calculate the load rating factor by undertaking a *higher tier assessment*. This may include—
  - (a) advanced analysis methods;
  - (b) field testing (proof test and dynamic load testing, Clause 15);
  - (c) structural health monitoring (Clause 16); and
  - (d) reference to other recognized Codes and Standards, subject to the approval of the relevant authority.
- Step 9: Determine the *final load rating factor*.

NOTE: A flowchart of the bridge assessment and load rating procedure is shown in Figure 9.

All assumptions relevant to the assessment and load rating shall be recorded.

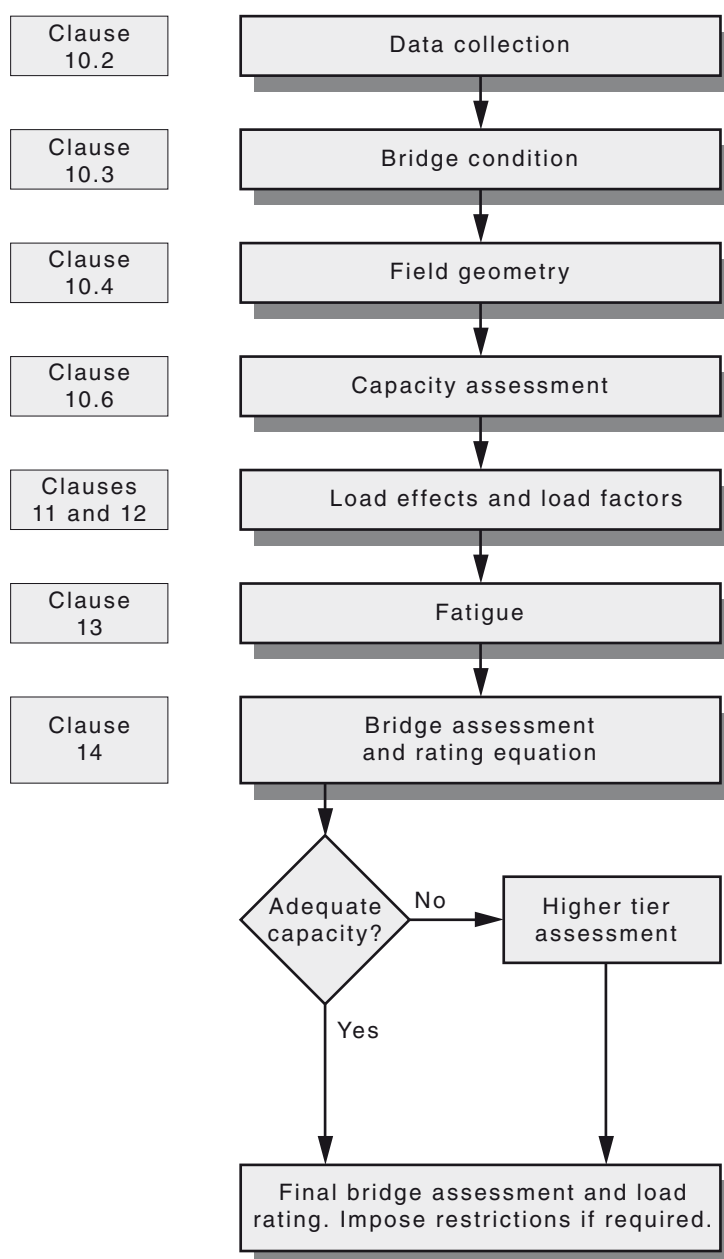


FIGURE 9 FLOWCHART FOR BRIDGE ASSESSMENT AND LOAD RATING

## 10 STRUCTURAL CAPACITY

### 10.1 General

The ULS capacity of concrete, structural steel, and timber components shall be determined in accordance with the relevant Sections of this Standard. Components that do not meet the scope of the AS(AS/NZS) 5100 series and specific requirements of this Standard shall have their capacities calculated using alternative procedures, based on established and recognized theories, analyses, testing and engineering judgement.

The assessment of the structural capacity of a bridge shall be made under the direct guidance of a professional engineer experienced in bridge design or assessment. The assessment of the structural capacity shall include confirmation that the actual structural condition of the bridge has been taken into account in the assessment and load rating.