AS 7636:2021

Railway structures

Infrastructure Standard

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This Australian Standard® AS 7636 Railway structures was prepared by a Rail Industry Safety and Standards Board (RISSB) Development Group consisting of representatives from the following organisations:

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The Standard was approved by the Development Group and the Enter Standing Committee Standing Committee in Select SC approval date. On Select Board approval date the RISSB Board approved the Standard for release.

Choose the type of review

Development of the Standard was undertaken in accordance with RISSB's accredited process. As part of the approval process, the Standing Committee verified that proper process was followed in developing the Standard

RISSB wishes to acknowledge the positive contribution of subject matter experts in the development of this Standard. Their efforts ranged from membership of the Development Group through to individuals providing comment on a draft of the Standard during the open review.

I commend this Standard to the Australasian rail industry as it represents industry good practice and has been developed through a rigorous process.

Deb Spring
Chief Executive Officer
Rail Industry Safety and Standards Board

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Document details

First published as: AS 7636 Railway Structures

ISBN Enter ISBN.

Document history

Publication Version	Effective Date	Reason for and Extent of Change(s)
2021	Select Board approval date	
2013	5 June 2013	First issue

Draft history (Draft history applies only during development)

Draft version	Draft date	Notes
PC Draft	23/08/2021	Draft for public comment

Approval

Name	Date
Rail Industry Safety and Standards Board	Select Board approval date

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This Standard was prepared by the Rail Industry Safety and Standards Board (RISSB) Development Group AS 7636 Railway structures. Membership of this Development Group consisted of representatives from the organisations listed on the inside cover of this document

Objective

The objective of this Standard is to provide the minimum requirements for the design, manufacture, construction, maintenance, decommissioning and disposal of rail structures. It is not intended to supplant higher performance standards based on local experience and good engineering practice, which may be contained in structural and material standards, codes, guidelines and procedures of individual rail organisations.

The intent of application of this Standard is that it results in consistent treatment of rail structures across the Australian rail industry.

This paragraph is used to provide statement about this Standards of significant technical changes from any previous edition of the document and/or objective for the revision. … only change this paragraph if it is applicable

Compliance

There are four types of provisions contained within Australian Standards developed by RISSB:

1. Requirements.
2. Recommendations.
3. Permissions.
4. Constraints.

Requirements – it is mandatory to follow all requirements to claim full compliance with the Standard. Requirements are identified within the text by the term 'shall'.

Recommendations – do not mention or exclude other possibilities but do offer the one that is preferred. Recommendations are identified within the text by the term 'should'.

Recommendations recognise that there could be limitations to the universal application of the control, i.e. the identified control is not able to be applied or other controls are more appropriate or better.

Permissions – conveys consent by providing an allowable option. Permissions are identified within the text by the term 'may'.

Constraints - provided by an external source such as legislation. Constraints are identified within the text by the term 'must'.

For compliance purposes, where a recommended control is not applied as written in the standard it could be incumbent on the adopter of the standard to demonstrate their actual method of controlling the risk as part of their WHS or Rail Safety National Law obligations. Similarly, it could also be incumbent on an adopter of the standard to demonstrate their method of controlling the risk to contracting entities or interfacing organisations where the risk may be shared.

RISSB Standards address known hazards within the railway industry. Hazards, and clauses within this Standard that address those hazards, are listed in Appendix J

This Standard includes a commentary on some of the clauses. The commentary directly follows the relevant clause, is designated by 'C' preceding the clause number and is printed in italics in a box. The commentary is for information and guidance, it does not form part of the requirements and recommendations of this Standard.

Contents

Appendix Contents

1 Scope and general

1.1 Scope

1.1.1 This Standard provides a whole-of-life approach to rail structures used in Australian rail operations, and covers:

(a) general management requirements;

(b) design;

(c) manufacturing;

(d) construction and commissioning;

(e) monitoring and maintenance;

(f) decommissioning and disposal.

1.1.2 This Standard applies:

(a) to heavy rail networks, and can be applied to light railway and cane railway networks;

(b) to all structures adjacent to, below and above railway track where they could affect or be affected by rail operations.

(c) to all gauges; however, the core knowledge on which this Standard has been developed is based upon the following principal gauges:

i. narrow gauge of 1067 mm;
ii. standard gauge of 1435 mm;
iii. broad gauge of 1600 mm.

1.1.3 Railway structures addressed in this Standard include the following asset classes and structure types, as defined in Appendix B.1:

(a) bridges;

(b) culverts and subways;

(c) tunnels;

(d) retaining walls;

(e) miscellaneous structures.

1.1.4 Typical railway structure material types that are addressed in this Standard include:

(a) timber;

(b) steel (including wrought iron);

(c) concrete;

(d) brick and masonry;

(e) other miscellaneous materials (e.g. fibre reinforced plastics).

1.2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document:

- AS 1111.1: ISO Metric Hexagon Bolts and Screws – Product Grade C, Part 1 Bolts
- AS 1170 Structural Design Actions
- AS 1657: Fixed Platforms, Walkways, Stairways and Ladders – Design, Construction and Installation
- AS 1252 High-strength Steel Bolts with Associated Nuts and Washers for Structural Engineering
- AS 1289 Method of Testing Soils for Engineering Purposes
- AS 1391 Metallic Materials – Tensile Testing at Ambient Temperature
- AS 1428.1 Design for Access and Mobility
- AS 1597.1 Precast reinforced concrete box culverts
- AS 1657 Fixed Platforms, Walkways, Stairways and Ladders – Design, Construction and Installation
- AS 2159 Piling – Design and Installation
- AS 2312 Guide to the Protection of Structural Steel Against Atmospheric Corrosion by the Use of Protective Coatings
- AS 2327.1 Composite Structures – Simply Supported Beams
- AS 2601 The Demolition of Structures
- AS 3600 Concrete Structures
- AS 3703 Long-span Corrugated Steel Structures
- AS 3725 Design for Installation of Buried Concrete Pipes
- AS 4058 Precast Concrete Pipes (Pressure and Non-pressure)
- AS 4100 Steel Structures
- AS 4676 Structural Design Requirements for Utility Services Poles
- AS 4678 Earth Retaining Structures
- AS 4680 Hot-dip Galvanised (Zinc) Coatings on Fabricated Ferrous Articles
- AS 5100 Bridge Design (Suite)(Series)
- AS 7633 Railway Infrastructure – Track Clearances
- AS 7637 Railway Infrastructure – Hydrology and Hydraulics
- AS 7638 Railway Infrastructure – Earthworks
- AS 7724 Unauthorized movement protection – operational requirements
- AS / NZS 2041.1 Buried corrugated metal structures
- AS / NZS 3679.1 Structural steel Hot-rolled bars and sections
- AS / NZS 3679.2 Structural steel Welded I sections
- AS / NZS 5131 Structural steelwork - Fabrication and erection
- UIC 774-3 (E) Track / bridge interaction - Recommendations for calculations

- AREMA Manual for Railway Engineering, Volume 2 - Structures

NOTE: Documents for informative purposes are listed in the Bibliography at Appendix K.

1.3 Terms, definitions and abbreviations.

For the purposes of this document, the terms and definitions given in RISSB Glossary: https://www.rissb.com.au/products/glossary/ and the following apply:

1.3.1
abutment
end support of bridge

1.3.2
batter
sloping earth surface formed when excavating a cutting or forming an embankment

1.3.3
bearings
means of transferring the loads from bridge superstructure elements into the substructure, and in some cases act to permit some rotation and translation of the ends of the span

1.3.4
BFB
broad flange beam

1.3.5
certification
process by which an independent competent person confirms/attests the compliance of a design or construction to required safety, quality and purpose parameters within Commonwealth, State or Territory legislation relevant to their operations

1.3.6
expansion switch

two rails appropriately matched and fastened at the longitudinal interface to provide virtual continuity of the running rail and gauge faces while allowing controlled longitudinal slip

1.3.7
fatigue
the potential for initiation of a defect caused by weakening of material due to cyclic loading

1.3.8
girders
main spanning beams of bridges and culverts. They may be timber, rolled steel beams, fabricated plate girders, reinforced or prestressed concrete beams, or steel trusses

1.3.9
guardrail
rail or rails (inside or outside the running rail) used to restrain lateral movement of a derailed rolling stock wheel set. Used to protect structures or control the lateral movement of the wheelset on bridges or in other higher risk situations. As per AS 7642.

1.3.10
load rating
calculation of the load carrying capacity of a structure within the limits of design code requirements, assessed against a specific reference load or against design load

1.3.11
pier
intermediate support of a multiple-span bridge or culvert

1.3.12
scouring
flowing water picking up and carrying away soil, sand, rock or gravel material from around bridge supports

1.3.13
settlement
vertical movement of all or part of a structure due to the compression or failure of material under the footing

1.3.14
differential settlement
uneven settlement of supports that can cause structural overload

1.3.15
spalling
loss of material at the surface which occurs in concrete, stone or brick elements. It can occur in non-reinforced elements due to localized concentrations of compressive stress but is usually caused by corrosion of reinforcement in concrete.

1.3.16
span
portion of a bridge structure that is the length between adjacent piers and/or abutments. The main members of spans are generally girders, slabs or trusses

1.3.17
structurally critical member
members of a structure that are critical to the strength and safety of the structure, and where failure of the member could lead to catastrophic failure

1.3.18
substructure
part of the structure below the bearings, or deck where bearings are not present. It includes abutments and piers and their foundations.

1.3.19
superstructure
part of the structure above the bearings, or abutment / piers where bearings are not present, and is the spanning part of the structure

1.3.20
transom
timbers or composite members spanning between girders or stringers on an open deck railway bridge structure. The running rails are fixed directly to the transoms

1.3.21
waterway
area of bridge or culvert opening containing all or part of a watercourse spanned by the structure

1.3.22
wingwalls
retaining walls adjoining abutments which carry soil pressure loads from the backfill and surcharge they retain

2 General requirement for management of railway structures

2.1 General

2.1.1 All rail structures shall be designed, constructed and maintained to the relevant Australian Standards, requirements specified in this Standard and the requirements of the RIM.

2.1.2 Rail organisations shall document minimum training requirements and associated competency certifications relevant to perform each type of work on all railway structures in accordance with the relevant Standard. Where required by legislation this should include requirements for current professional registration.

2.2 Interface coordination

2.2.1 General

2.2.1.1 The design of each structure should be integrated considering all associated requirements, such as:

(a) track alignments and clearances;

(b) service routes;

(c) overhead wiring and signalling infrastructure;

(d) drainage;

(e) earthing and bonding;

(f) maintenance access; and

(g) architectural treatments.

2.2.1.2 For structures owned by others or owned by the RIM that interface with other infrastructure owners, the RIM shall ensure there is a safety interface agreement covering the responsibilities of each party in relation to the management of the structure and end of asset life requirements.

> *C2.2.1.2 Commentary*
> *The major stakeholder, which will always be involved in the management of structures, is the RIM. However, for bridges, tunnels and other structures which could support road or infrastructure other than rail, major stakeholders can also include the road manager, the municipal council, and private and/or corporate property developers (including lessors where applicable) and owners.*

2.2.2 Operational parameters

2.2.2.1 The permissible parameters of operation for each train should be compatible with limitations identified within the track and civil infrastructure, including any limitations identified for railway structures.

2.2.2.2 An interface coordination plan should be developed and should include practices for the communication of the permissible parameters of operation to all relevant persons and organisations.

2.2.2.3 The attention of rolling stock operators should be specifically drawn to infrastructure locations that do not meet the normal operating standards for the track.

2.2.3 Provision for services

2.2.3.1 Provision should be made when designing and constructing structures for services for which the RIM owns or is accountable, or which are owned by other authorities and utilities.

2.2.3.2 Coordination with the relevant owners should be undertaken to ensure that the location and fixing of service ducts is, wherever possible, are designed so that future access to the structure and to service ducts for inspection and maintenance is safe and unimpeded.

2.3 Structures owned by others

2.3.1 Where structures are owned by other persons or organisations and are subject to agreements whereby the RIM can require that person or organisation to rate the functional capacity of the structure, it shall be so rated and certified as per the relevant standards and applicable regulatory requirements.

2.3.2 Where a structure owned by another person or organisation is considered to present an unacceptable risk to the safe passage of trains or people, the RIM shall:

(a) notify the relevant person or organisation in writing, requesting maintenance and load reports, an action plan to reduce the risk to acceptable levels and an anticipated timeline to make the required repairs or changes;

(b) assess the need to impose operational restrictions or other means to reduce any immediate risk;

(c) where the risk has not been satisfactorily addressed report the situation to the appropriate regulatory authorities for resolution.

2.4 Documentation and record management

2.4.1 The RIM shall maintain relevant documentation on all railway structures, so that the capacity of the infrastructure to perform its required function is recorded, and any change to that capacity is documented.

2.4.2 The RIM must establish and maintain local policies and procedures for the maintenance of records, ensuring compliance with the requirements of the Rail Safety National Law and State and/or Territory legislation.

2.4.3 Documentation shall be maintained during the operational life and until all components of the railway structure have been completely removed.

2.4.4 Documentation shall be available for audit purposes, in accordance with Australian Standards and the relevant Commonwealth, State and/or Territory legislation.

2.4.5 At a minimum, documentation on railway structures should include:

(a) a register providing a description of all structures to be inspected – this description should be in terms of primary material of construction and should define each structural category and member accordingly;

(b) a system for defining their location on the network;

(c) governing standards, procedures and work instructions applicable to their management through each life cycle stage;

(d) design and rating records, including digital analysis data where appropriate, required to achieve the specified functional capability;

(e) detail design reports, specifications and any warranty certification requirements;

(f) hazard locations that have the potential to impact on defined functional capacity;

(g) maintenance plans, including special maintenance plans (where required);

(h) inspection and assessment requirements, including details from visual inspections, commissioned detailed engineering inspections, investigations and analysis when required, and records of the inspections and assessments carried out and when results of recommendations will be actioned;

(i) recording and tracking of structure defects during subsequent structures inspections until the defect is corrected and removed;

(j) engineering drawings detailing as constructed, and any modification, repair or renewal works conducted on the infrastructure.

2.4.6 Detailed design drawings shall include design criteria and any other information that is relevant to ensuring that the new structure can be constructed and maintained in accordance with the design.

This information is typically summarised on the general arrangement drawing or technical notes sheet and should include the following:

(a) Structure location or nearest station.

(b) Track (line and kilometrage).

(c) Design standards (including edition year or version).

(d) Construction technical specification references.

(e) Design life.

(f) Design clearances including rolling stock kinematic envelopes.

(g) Design loadings (including load factors and design collision loads).

(h) Site geotechnical investigation design profiles and properties.

(i) Site hydrological and hydraulic summary information (including flood immunity levels).

(j) Design drainage criteria (where applicable).

(k) Structure earthquake design categories and nominated importance levels.

(l) Construction category for steelwork applicable to AS/NZS 5131.

(m) Design fire resistance (where applicable).

(n) Heritage registers.

(o) Environmental issues.

(p) Design assumptions (including material and section properties where applicable).

(q) Design methodology and analysis methods used (where applicable).

(r) Design fatigue life (including loading, cycles and assumptions).

(s) Technical maintenance plan (TMP) references.

2.4.7 Construction drawings should include;

(a) construction sequence;

(b) assumptions for design loads;

(c) lifting arrangements for major components;

(d) inspection and maintenance requirements;

(e) replaceable components;

(f) geotechnical information; and

(g) hydrology information (including souring and water flow assumptions).

2.5 Risk management

2.5.1 The RIM shall ensure that appropriate risk management processes are implemented and / or undertaken to ensure that health and safety is qualified by what is reasonably practical.

2.5.2 Reasonably practical requires consideration of, at a minimum, the following relevant matters:

(a) The likelihood of the hazard or the risk occurring.

(b) The degree of harm that might result from the hazard or the risk.

(c) Knowledge about the hazard or the risk, and ways of eliminating or minimising the risk.

(d) The availability and suitability of ways to eliminate or minimize the risk, including engineering, administrative and behavioural strategies.

(e) After assessing the extent of the risk and the available ways of eliminating or minimising it, the cost associated with eliminating or minimising it, including whether the cost is grossly disproportionate to the risk.

2.5.3 Where additional stakeholders could have a duty in relation to the structure, the RIM shall retain responsibility for ensuring that rail operations are conducted in a safe manner.

2.5.4 Structures risk management entails an assessment of all risks to maintenance and repair staff, adjacent roads and rail infrastructure, pedestrian, and livestock traffic, with reference to the structure, the layout of adjacent infrastructure, site characteristics, climatic hazards, signage, design and maintenance access requirements.

2.5.5 The purpose of the risk management process is to assess and quantify the identified risks, and to specify or recommend measures aimed at mitigating those risks.

2.5.6 Risk management should involve conducting risk reviews throughout the life of the structure, particularly when significant changes to an as-designed structure's configuration or structurally critical elements occur, either rapidly or progressively throughout its life cycle, or when the structures use changes (i.e. more rail movements or loading etc).

3 Design

3.1 Function

3.1.1 The function of this section is to provide guidelines and set standards to ensure that railway structures:

(a) built adjacent to, on or over, or to support the railway (e.g. underbridges) are safe and fit for purpose;

(b) owned by others, on or adjacent to the railway corridor, comply with the relevant standards, and are sound, of safe construction, and maintained in safe condition.

3.1.2 Design, in relation to a structure, includes the design of all or part of the structure, and the redesign or modification of a design.

3.2 General requirements

3.2.1 The structure shall be designed to comply with safe design requirements in accordance with the relevant standards, and in such a manner that it shall be capable of carrying and transferring the loads, within the allowable stresses, including permanent effects such as self-weight and creep and shrinkage .

3.2.2 The structure shall be designed so that there is at least one safe and feasible method for its construction, maintenance, and its subsequent decommissioning.

3.2.3 Where this Standard is silent, design shall comply with Australian Standards, RIM standards, the general requirements of the AREMA Manual of Railway Engineering Volume 2 - Structures, and other relevant international codes, standards and guidelines.

3.2.4 The design of all structures shall evaluate construction constraints particularly under live road and rail operation conditions and track possession constraints.

3.2.5 The structure shall be designed in such a manner that it will not affect the safety of railway operations or the safety of persons whose duties take them on or near the line. The design should consider:

(a) groundwater (particularly in tunnels);

(b) potential arcing of electric power equipment;

(c) sighting for train drivers;

(d) sighting for track staff;

(e) provision of positions of safety;

(f) provision of emergency access;

(g) provision of inspection and maintenance access;

(h) access to infrastructure attached to bridge structures, e.g. signs and lights;

(i) bonding and earthing.

3.2.6 Where relevant, consideration should be given so that the design allows the structure to be executed in such a way that it is not able to be damaged by accidental events or vandalism.

3.2.7 Safe design of the structure includes the integration of control measures early in the design process to eliminate or, if this is not reasonably practical, to minimize risks to health and safety through the life of the structure being designed.

3.2.8 General definitions and diagrammatic examples of structural components are provided in Appendix B of this Standard.

3.3 Design management

3.3.1 Where appropriate, a design management plan should be developed that clearly details the design requirements and constraints, strategy, planning, resource requirements, and financial management of the design project.

3.4 Design considerations

3.4.1 General

3.4.1.1 The design of all new or replacement structures shall assess the following:

(a) whole-of-life considerations;

(b) environment and heritage;

(c) accessibility;

(d) design loads including construction equipment / maintenance (and dynamic response) for current and known future operating requirements;

(e) safety in design;

(f) intended life and use;

(g) clearances;

(h) suitability of materials;

(i) services and utilities;

(j) continuously welded rail;

(k) constructability and construction methodology;

(l) aesthetics of the structure;

(m) drainage and waterway requirements;

(n) geometry – alignment and approaches;

(o) impact and derailment protection;

(p) earthquake;

(q) maintenance / inspection requirements, e.g. bearings (and jacking points), handrail, ballast.

3.4.2 Whole-of-life considerations

3.4.2.1 Structures shall be designed and detailed to ensure durability for the purpose for which they were required.

3.4.2.2 Structures should be designed and detailed to:

(a) minimize maintenance;

(b) safely facilitate inspection and maintenance activities;

(c) enable safe dismantling and removal of the structure at end of life.

3.4.2.3 Specific maintenance and inspection procedures shall be documented on the construction drawings.

3.4.3 Environment and heritage

3.4.3.1 The design shall assess all potential impacts to environmental and heritage matters and shall comply with the legal and associated regulatory requirements.

3.4.3.2 Relevant State and/or Territory registers shall be referenced before planning any changes to structure assets, to ensure that changes comply with the requirements of all relevant heritage acts.

3.4.3.3 The design process shall accommodate the procedures, timings and commitments associated with obtaining heritage, tenure, environmental and other government approval requirements.

3.4.4 Accessibility

3.4.4.1 Designs for structures should provide safe access for inspection and maintenance. This can include access steps, ladders, cages, walkways, refuges and fixing points, and:

(a) where possible, jacking points should be provided to facilitate bearing maintenance and replacement as necessary;

(b) where box girder bridges are provided with access hatches to voids in the superstructure, access hatches should be provided outside in a safe accessible area away from rail traffic.

3.4.4.2 Where elements of a structure are to be accessed by pedestrians, cyclists and/or animals, consideration should be given to the provision of accessibility by all as per the requirements of relevant Standards and State and/or Territory regulatory requirements .

3.4.4.3 Structures that are to provide above-ground walkways for pedestrians, cyclists, or animals (including equestrian access) shall be fit for purpose and in compliance with safety regulations, AS 5100 and State and/or Territory regulatory requirements.

3.4.4.4 Safe access to and safe working on the structures shall be provided in accordance with the requirements of AS 1657.

3.4.5 Design loads

3.4.5.1 General

3.4.5.1.1 Loads shall be calculated as per requirements in the relevant design Standards for the unique operating requirements on which the structure is to be used. Design should also consider other possible loads from, for example, maintenance vehicles.

3.4.5.1.2 Design load shall be as specified in relevant Australian standards, or as specified by the RIM. Operational loads may be assessed for traction/braking charts for longitudinal loads.

3.4.5.1.3 Design should take into consideration the possibility of the design loads on the structure being exceeded in future, or to minimize the risk of the design loads being exceeded in future. Examples include:

(a) ensuring adequate drainage of the structure to deter ponding;

(b) allowances for changes in surfacing material where applicable.

3.4.5.1.4 All load factors shall be in accordance with relevant Australian standards, except as varied with the approval of the RIM.

3.4.5.1.5 Live load design shall be based on loading configuration diagrams as provided by the RIM for underbridges and the relevant road authority for vehicle traffic loads.

3.4.5.1.6 Suitable mitigation measures to minimize any risks of increases to actual dead loads should be implemented, otherwise allowances should be made for the increases, such as ballast load and increased load from ballast lift.

3.4.5.1.7 All design live loads, superimposed dead loads, allowances and load factors used shall be shown on the general arrangement drawings of the structure.

3.4.5.1.8 Further design load information is provided in Appendix C.

3.4.5.2 Environmental loads

3.4.5.2.1 Earthquake loading for structures shall be undertaken on a risk-based approach based on regional conditions, and comply with AS 1170, AS 5100 and other relevant risk and relevant material standards as appropriate.

3.4.5.2.2 The class of bridge for seismic loading, in accordance with AS 5100, should be as follows:

(a) Bridges supporting running lines as classified in AS 7630 are Type BEDC 4 (i.e., essential to post-earthquake recovery).

(b) Bridges supporting sidings as classified in AS 7630 are Type BEDC 2, except for bridges over roadways or railways which are Type BEDC 3.

3.4.5.2.3 Wind loading for all structures shall be designed in compliance with AS 5100 and AS 1170 where relevant.

3.4.5.3 Dynamic load allowance

3.4.5.3.1 The dynamic load allowance (DLA) used in the load rating assessment of railway underbridges shall be in accordance with AS 5100. The RIM may approve a different DLA for specific consists.

3.4.5.4 Derailment and collision impact load allowance

3.4.5.4.1 When designing underbridges consideration should be made of the impact loads relating to derailments and collisions. Further guidance is provided in the RISSB Code of Practice - Derailment Containment and Protection for Rail Underbridges.

3.4.6 Safety in design

3.4.6.1 The RIM shall be responsible for ensuring that the designer of the structure clearly understands their responsibilities and obligations to ensure the design of the structure will not affect the health and safety of persons:

(a) during construction of the structure;

(b) when the structure has been constructed and is being used for the purpose it was originally designed for;

(c) when the structure is maintained;

(d) where the structure has been decommissioned and/or is not being used for the purpose it was originally designed for, yet has not been removed and/or demolished, and either all or partial components remain (i.e., abutments on bridges).

3.4.7 Intended use and life

3.4.7.1 Bridge structures, retaining walls and major culverts shall be designed for a minimum 100-year life in accordance with AS 5100.1. A different design life may be used to match the life cycle of other railway infrastructure. Any variance to a 100-year life cycle shall be subject to the approval of the RIM.

3.4.7.2 Other structures shall be designed for the design life specified in the relevant Australian Standards or RIM specifications. Any reduction to specified design life shall be subject to the approval of the RIM.

3.4.7.3 The design life of structures should align with the life cycle of the rail infrastructure it supports.

3.4.7.4 The design life of structures shall be assessed in accordance with the relevant standards and manufacturers' recommendations for the materials and components.

3.4.8 Adequacy of structure gauging, clearances, and dimensions

3.4.8.1 The design shall allow for the required horizontal, vertical and below rail clearances and dimensions in accordance with AS 7633 or as specified by the RIM.

3.4.8.2 If the design covers work adjacent to running tracks, then the design shall provide adequate trackside clearances for maintenance purposes. Additional clearance for construction or heavy maintenance equipment may be included.

3.4.8.3 The minimum recommended clearance should be the kinetic envelope as defined in AS 7633, plus 200 mm.

3.4.8.4 Construction clearances shall be risk assessed as part of SID process and take into consideration proposed construction methodology.

3.4.9 Suitability of Materials

3.4.9.1 Materials used in the design shall be the most appropriate to the function and requirements of the structure, taking into consideration durability and maintenance.

3.4.9.2 Where steel structures are preferred because of economic, aesthetic, or practical considerations, and component size precludes galvanising, weathering steel, or steel protected in accordance with AS 2312, should be used.

3.4.9.3 Corrosion protection systems, including preparation and maintenance, shall be shown on structural drawings.

3.4.9.4 Fibre composite, engineered timber products and other new materials may be used, subject to the approval of the RIM.

3.4.10 Services and utilities

3.4.10.1 Where provision for services owned by other authorities and utilities is required, the RIM shall:

(a) consult with the relevant authorities and, where appropriate, make provision for these services in the structure;

(b) design the location and the fixing of such services, so as to allow safe and unimpeded access to the structure for inspection and maintenance.

3.4.11 Use of continuously welded rail

3.4.11.1 Continuously welded rail (CWR) may be used across bridges and culverts.

3.4.11.2 When designing a new bridge or proposing a new installation of CWR across an existing bridge, the possible interaction between the bridge structure and CWR shall be assessed in accordance with AS 5100.2 and UIC 774-3 (E).

3.4.11.3 Any specific requirements for fastenings or expansion switches shall be clearly identified in the structural drawings for the bridge.

3.4.11.4 The use of CWR shall not impede the free movement of bearings.

3.4.11.5 Mechanical rail joints between lengths of CWR shall not be located on transom top bridges or within 30 m of the bridge end.

3.4.11.6 Where CWR is used on transom bridges rail anchors shall allow sufficient movement within the track to prevent buckling of the rail in high temperatures. This may be achieved by:

(a) expansion switches;

(b) using fastenings that permit a limited amount of movement e.g. elastic fastenings. Further information on fastenings is provided in AS 7639.

3.4.12 Constructability

3.4.12.1 The RIM should balance design efficiency with short construction times (specifically to fit in with block possessions) when producing plans and design specifications, taking careful consideration where design efficiency is compromised for shorter construction periods.

3.4.13 Aesthetics of the structure and surrounds

3.4.13.1 All structures in urban areas and visually important sites in rural areas should be given appropriate aesthetic design considerations where practicable.

3.4.13.2 In situations where aesthetics are a major consideration in the design, materials adopted may be varied from those specified in other sections of this Standard on the basis of aesthetic assessment. Any such deviation should be subject to the approval of the RIM.

3.4.14 Hydrology, drainage, and waterway requirements

3.4.14.1 All hydrology, drainage and waterway requirements shall be designed in accordance with Australian Rainfall and Runoff Guidelines, Austroads Waterway Design Manual, AS 5100, AS 7637 and RIM requirements.

3.4.14.2 Scour protection shall be provided where there is history of scouring and washaways, and/or where hydraulic assessments indicate a scouring potential.

C3.4.14.2 Commentary

Flood discharges are generally to be determined for average return intervals (ARI) of 10 year, 20 year, 50 year, 100 year, 2000 year and probable maximum flood (PMF) events.

3.4.14.3 Hydraulic design for a bridge or drainage structure shall conform with the requirements of AS 7637.

3.4.14.4 Bridge structures should have positive drainage systems to prevent water discharging from the bridge to the watercourse or road or rail below. Drainage should be designed to capture the water and drain it away from the track structure at the bridge end.

3.4.14.5 New ballast top bridges should be provided with a waterproofing membrane to protect the deck concrete. The membrane should be protected by a ballast mat.

3.4.14.6 Where the design of the bridge or drainage structure is for a new track alignment that runs parallel to an existing track or road, the waterway of the adjacent drainage structure shall be compared with that of the designed structure, to ensure that there is no adverse hydraulic impact as a result.

C3.4.14.6Commentary

In particular, the design of the bridge or drainage structure should be checked for any backwater effect caused by raised floodways or access roads downstream. Similarly, considerations are to be taken to ensure that there are no adverse backwater effects caused by the design of bridge or drainage structures to any adjacent structures or tracks.

3.4.14.7 Further design information is provided in appendix C.

3.4.15 Geometry – alignment and approaches

3.4.15.1 Consideration should be given during preliminary design, to maximize lateral stability and minimize the force of braking loads and impacts on the structure due to alignment approach.

3.4.15.2 The design of bridge approach embankments shall make allowances to avoid long-term settlement of approaches. Reinforced soil transition approach or other suitable transition approach to an abutment shall be provided for all rail bridges, except where there is a rock foundation at up to 3m depth from rail level.

3.4.16 Impact and derailment protection

3.4.16.1 All piers and columns supporting elevated structures over roads or railway tracks should comply with the provisions of collision protection and loading in AS 5100 and the RISSB Code of Practice - Derailment Containment and Protection for Rail Underbridges. Where compliance with AS 5100 cannot be met the RIM shall define the specifications for impact and derailment protection to minimize risks to safety.

3.4.16.2 Bridge spans over roadways with less than the regulated vertical clearance shall be risk assessed for collisions by road traffic. Where deemed necessary by the relevant road or rail authority protection barriers shall be installed to protect the bridge spans from collision.

3.4.16.3 Design of protection beams for underbridges with low clearance shall comply with AS 5100.

3.4.17 Impact from falling objects

3.4.17.1 Measures should be implemented to minimize the risk of falling objects (or objects being thrown) from bridge spans onto vehicular, pedestrian, or other traffic.

3.5 Design criteria

3.5.1 Bridges

3.5.1.1 All bridges shall be designed in accordance with AS 5100.

C3.5.1.1 Commentary

Further requirements and recommendations relevant to the design of bridges are given in Appendix Cof this Standard.

3.5.1.2 The design of metal arch bridges shall comply with the requirements of AS 3703.

3.5.2 Bridge deck and track interface

3.5.2.1 General

3.5.2.1.1 Bridge decks shall be designed so as to be suitable for the type of track to be laid across the bridge. This includes review and evaluation of the interaction between:

(a) rails / fastenings;

(b) bridge deck / bearings; and

(c) substructure / foundations.

3.5.2.1.2 A track-bridge model may be used to aid the design. The model should include the following elements:

(a) Rail and guardrail stiffness.

(b) Bridge deck stiffness.

(c) Embankment stiffness.

(d) Expansion switches (where used).

(e) Track – bridge stiffness.

(f) Support stiffness.

3.5.2.2 Rail attachment

3.5.2.2.1 Rails shall be attached using fastenings that met the requirements of AS 7639.

3.5.2.2.2 Where guardrails are used the rail support plates may accommodate both the running rail and guardrail.

3.5.2.2.3 The minimum clearance from the top of the bridge deck to the underside of the running rail shall be 60 mm to facilitate rail maintenance.

3.5.2.2.4 Where grout is used under the rail plate, the maximum height of the grout bed shall be 60 mm and the minimum height shall be 15 mm.

For grout thicknesses less than 24 mm, high density polyethylene (HDPE) packers may be used instead of grout.

3.5.2.2.5 Anchor bolts for rail attachment shall be designed for the actions resulting from the design horizontal loads.

3.5.2.2.6 High impact epoxy grouts and mortars developed to withstand the high dynamic effects from rail traffic and movement of the deck and to the maximum thickness specified shall be used.

3.5.2.2.7 Grout shall not contain metallic elements.

3.5.2.2.8 Cementitious grouts shall not be used.

3.5.2.2.9 Grout beds shall provide a minimum of 75 mm edge distance to the outside of the rail plate anchor bolt to avoid cracking of the grout.

3.5.2.2.10 Where epoxy grout pads are poured under suspended rail plates (top down construction), HDPE pads used under the rail plate shall be at least 8 mm in thickness to prevent heat distortion and warping.

3.5.2.2.11 Where the hog of a girder or track grading results in gaps under the rail greater than 60 mm, galvanized steel packers (not HDPE) may be used and designed so that the full lateral restraint to the holding down bolt is provided.

3.5.2.3 Track slabs

3.5.2.3.1 Track slabs in bridge structures shall be designed as one-way slabs in accordance with AS 5100. The design of track slabs on ground shall comply with the requirements of AS 5100 and the specific geotechnical parameters of the site.

3.5.2.4 Ballast deck bridges

3.5.2.4.1 Ballasted desk bridges are structures that have a slab or trough capable of holding ballast in conventional track construction. Concrete is commonly used in more recent structures. In older structures, the deck is often formed by buckle plates or pressed steel trough units.

3.5.2.4.2 Ballasted track can be used to ease of track maintenance and reduce track degradation and misalignment at bridge ends.

3.5.2.4.3 Ballasted track should comply with AS 7639.

3.5.2.4.4 The distance between the inside face of the kerb, deflection barrier or the face of a through type deck and the centre line of track shall not be less than 2300 mm unless otherwise authorized by the RIM.

3.5.2.4.5 Kerbs on ballasted track underbridges shall be either derailment kerbs or ballast kerbs

3.5.2.5 Directly attached track bridge

3.5.2.5.1 Track directly fixed to bridge decks may be constructed where constraints, such as limited vertical clearances, exist below or above the track prohibiting the construction of a ballasted track underbridge.

3.5.2.5.2 The top surface of the direct fixation deck slab should be cast to match the design track superelevation where practical, to avoid the use of plinths and deep packers under the high rail.

3.5.2.5.3 Where a continuous plinth to support the high rail cannot be avoided, openings in the plinth shall be incorporated to permit transverse track drainage.

3.5.2.5.4 The distance between the inside face of the kerb, deflection barrier or face of a through type deck and the centre line of track shall not be less than 2300 mm or other dimension as required by the RIM.

3.5.2.5.5 Kerbs on direct fixation underbridges shall be either derailment kerbs or standard kerbs.

3.5.2.6 Transom top track bridges

3.5.2.6.1 Transom top track bridges shall be designed in accordance with AS 5100 and RIM specifications.

3.5.3 Culverts and subways

3.5.3.1 Culverts and subways shall be designed as per the loading effects prescribed in AS 5100, unless otherwise modified and approved by the RIM to suit the track classification and operating environment.

C3.5.3.1 Commentary

Further requirements and recommendations relevant to the design of culverts are given in Appendix C of this Standard.

3.5.3.2 Precast concrete box culverts supporting railway tracks shall be designed as per the loading effects prescribed in AS 5100, unless otherwise modified and approved by the RIM, and shall comply with the requirements in AS 1597.1

3.5.3.3 Concrete pipes supporting railway tracks shall be designed as per the loading effects prescribed in AS 5100, unless otherwise modified and approved by the RIM, and shall comply with the requirements in AS 3725 and AS 4058.

3.5.3.4 Buried corrugated metal pipe culverts supporting railway tracks shall be designed as per the loading effects prescribed in AS 5100, unless otherwise modified and approved by the RIM, and shall comply with the requirements of AS 2041.

3.5.4 Tunnels

3.5.4.1 All tunnels shall be designed to comply with the requirements of all relevant Australian Standards and specific site geotechnical parameters.

3.5.4.2 Tunnels shall be designed to accommodate transit space requirements, services, plant and equipment, and maintenance requirements.

3.5.4.3 Where necessary tunnels may incorporate niches to accommodate refuges, plant and equipment. Further guidance on refuges can be found in RISSB Refuges – Bridge and Tunnels Guideline.

3.5.4.4 Tunnel linings and fittings shall be designed to mitigate the effects of stray currents from overhead wiring systems.

3.5.4.5 Drainage systems shall be designed to collect and dispose of any seepage, surface water and operational water (e.g. from sprinkler systems) that enters the tunnel in order that the track infrastructure is kept well drained and that no seepage drips onto the track.

3.5.4.6 The RIM shall have processes and procedures for identifying and managing failure of the drainage system to ensure the safety of operations.

3.5.4.7 Drainage shall be configured so that in the event of a blockage, any overflow will not affect operations or the reliability of the infrastructure. Drainage design should also allow for any potential seepage and water used in firefighting.

3.5.4.8 An assessment shall be made on the required level of waterproofing and drainage media required behind the tunnel lining and an assessment made of the possible effects of any build-up of water pressure behind the lining against those of allowing some seepage through the lining and onto the track bed.

3.5.4.9 Tunnels and their associated systems shall be designed to allow acceptable noise and vibration during operation.

C3.5.4.9 Commentary
Operational noise and vibration (inclusive of air-borne and ground-borne noise and vibration within the relevant State and Federal regulatory requirements could be considered acceptable.

3.5.4.10 Tunnels shall be designed to comply with acceptable and regulatory levels of fire safety for train crews, rail passengers and all other staff, contractors, emergency services personnel, and, where appropriate, the public.

3.5.4.11 All overhead wiring, tunnel lighting and all other electrical wiring shall be designed and installed in compliance with the relevant Australian Standards.

3.5.4.12 Structures to be constructed over and/or adjacent to tunnels shall be suitably designed to allow for the interface with the tunnel infrastructure.

C3.5.4.12Commentary

Further requirements and recommendations relevant to the design of tunnels are given in Appendix Cof this Standard.

3.5.4.13 Further design information is provided in appendix C.

3.5.5 Platforms

3.5.5.1 Platforms shall be designed to:

(a) AS 4678, AS 1170 or AS 2327.1;

(b) meet accessibility requirements of AS 1428.1;

(c) satisfy specific requirements of the relevant legislation; or

(d) RIM requirements as appropriate.

3.5.5.2 All new platforms should be designed for construction on straight track, unless otherwise approved by the RIM.

3.5.5.3 The slope of the platform surface shall be designed to slope away from the track to direct run off away from the track and reduce the risk of unsecured mobility devices such as prams rolling towards the track.

3.5.5.4 Clearance gaps and stepping height tolerances shall be determined by the RIM.

3.5.5.5 Materials used in passenger platform construction should be non-flammable. Generally, the floor of the platform should be of concrete construction with asphalt surfacing. Ceramic tactile ground surface indicators (TGSIs) are preferred. Materials that reduce the risk levels for graffiti and vandalism are preferred.

3.5.5.6 Other materials used in passenger platform construction other than those detailed in Clause 5.2.6.3 shall be subject to the approval of the RIM.

3.5.6 Air space developments

3.5.6.1 All designs of air space developments are to comply with the requirements of AS 1170.4, AS 5100, the National Construction Code 2019, other relevant Australian Standards and RIM standards.

3.5.7 Overhead wiring and gantry structures

3.5.7.1 The components of overhead wiring structures and gantry structures shall be designed in accordance with relevant Australian Standards and RIM standards including those listed below:

(a) Steel structures shall be designed to AS 4100, and hot-dip galvanized in accordance with AS 4680.

(b) Concrete footings shall be designed to AS 5100, AS 3600 and AS 2159.

(c) The design of electric components shall be designed to all relevant Australian Standards, and in accordance with the operational requirements of the railway.

(d) Pole structures supporting road or railway signalling equipment shall be designed to AS 4676.

3.5.8 Buffer stops

3.5.8.1 Buffer stops shall be designed in accordance with AS 7724, relevant Australian Standards and RIM standards.

3.5.8.2 Buffer stops shall be designed with due consideration of the adequate protection of people and property at or beyond the end of the track.

3.5.8.3 A risk assessment shall be carried out to determine the design criteria, and to:

(a) determine whether additional overrun protection is required;

(b) determine whether energy absorbing, or rigid buffer stop is required.

3.5.8.4 A risk assessment shall assess the following factors:

(a) speed of rail vehicles approaching the line/siding termination;

(b) proximity and criticality of adjacent structures, buildings, facilities and residential/commercial property;

(c) type and mass of rail vehicles;

(d) track usage level;

(e) train patronage level;

(f) potential proximity of personnel/public;

(g) concourse areas (where located at the end of the tracks and/or same ground level);

(h) any other site-specific relevant factors.

3.5.8.5 The average grade and length of the dead-end track shall be designed appropriately for the speed and type of vehicle approaching the buffer stop.

3.5.8.6 The design of buffer stops shall be suitably robust for the current/future known operations of the railway and shall be designed using proven structural design methods.

3.5.9 Retaining walls and rock shelters

3.5.9.1 Retaining walls and rock shelters shall be designed to AS 4678, AS 7638, AS 5100.3, other relevant Australian Standards and RIM standards.

3.5.10 Miscellaneous structures

3.5.10.1 All miscellaneous structures shall be designed to the relevant Australian Standards and RIM standards for the type of structure.

C3.5.10.1 Commentary

Description of miscellaneous structures in this Standard is given in Appendix B.

3.6 Clearances

3.6.1 Horizontal and vertical clearances for bridges, structures and services shall comply with the requirements and recommendations in AS 7633 and other operational requirements and guidelines as defined by the RIM.

3.7 Signage

3.7.1 Designers should ensure that provision is made in the design for the location and installation of warning plaques and other relevant signage, including structure identification plaques, limited clearance warnings, refuge locations and details on loading constraints.

3.7.2 The location of signage should be clearly visible and fixing details should not impair the structural integrity of any structural component.

3.7.3 All bridges and other fixed structures included within the scope of this Standard shall have a unique identification.

3.7.4 Unique identification shall be conspicuous from both road and rail, where appropriate.

3.8 Walkways / refuges / handrails

3.8.1 Appropriate risk assessment shall be carried out to determine the need for walkways / refuges / handrails.

3.8.2 Where walkways / refuges / handrails are required, these shall be designed to comply with AS 1657 and any RIM requirements.

3.9 Derailment containment system

3.9.1 The RIM shall be responsible for ensuring appropriate derailment containment systems (such as guardrails) are implemented in accordance with RISSB Code of Practice - Derailment Containment and Protection for Rail Underbridges, and RIM requirements.

4 Manufacturing

4.1 General

4.1.1 RIMs shall ensure that all manufacturers, subcontractors, and suppliers involved in the supply, manufacture and acceptance of structural materials and off-the-shelf components shall be quality assured and have appropriate procedures in place to guarantee the quality of the materials.

4.1.2 The RIM shall ensure that all structural materials and components shall conform to the requirements and test standards of the relevant Australian Standards and shall be in accordance with the relevant engineering drawings and specifications.

4.1.3 The RIM shall check that component materials meet manufacturing standards and are within acceptable tolerance limits for the track, its geometry, and the operating regimes.

4.1.4 Procedures for supervising the testing and acceptance of component materials shall be in place, consistent with the requirements of the rail organisation's quality and safety management systems.

4.1.5 The RIM shall obtain all relevant certificates of physical tests and of chemical analysis conducted on component materials from the manufacturers.

4.2 Non-standard structural components

4.2.1 Identification

4.2.1.1 Non-standard structural components refer to all structural elements that require some site-specific design requirements. Typical elements include:

(a) built-up steel members;

(b) prestressed concrete members;

(c) lattice structures;

(d) footings or foundations;

(e) ground anchors;

(f) bridge girders;

(g) gantries;

(h) wing walls / retaining walls.

4.2.1.2 The manufacture of all elements within non-standard structural components shall be in accordance with the design specifications, as detailed in the design and as established in the design process detailed in Section 3 of this Standard.

4.2.1.3 Where new or infrequently used products are specified in the structure design documentation, the RIM shall ensure that any special requirements or practices in relation to the product are understood prior to release of the design documentation. Further guidance regarding type approval is provided in AS 7702.

4.2.2 Fabrication of components

4.2.2.1 The fabrication of all structural steel girders and other components shall comply with AS 5131, other applicable Australian standards, RIM specifications and other reference documents in the technical and manufacturer's specifications.

4.2.2.2 All fabrication work shall be undertaken in accordance with the relevant approved drawings and specifications.

4.2.2.3 Preferred steel grades should be:

(a) hot rolled sections – grade 300, grade 350;

(b) hollow sections – grade C350;

(c) flange and web plates – minimum grade of 250 with designation L15;

(d) other plates and flats – grade 250;

(e) welded sections – grade 300, grade 350.

4.2.2.4 Details of relevant standards for reference of manufacturing specifications for steel fabrication sections are shown in Appendix I.

4.2.2.5 Standard welded I-sections in compliance with AS / NZS 3679.2 used for underbridges shall comply with the relevant sections of AS / NZS 5100.6 and RIM requirements.

4.3 Standard portable prefabricated structures

4.3.1 Standard structures are those that are non-site specific, which can be fabricated off-site and then installed or erected on-site. This may include:

(a) reinforced box culverts;

(b) pipes;

(c) lighting poles;

(d) portable buildings;

(e) portable bridges.

4.3.2 The RIM shall ensure that all off-the-shelf structural elements are fit for purpose for the operational environment and requirements under which they will be used.

4.3.3 The RIM shall ensure that the design and manufacturing procedures of standard and portable structures complies with relevant Commonwealth, State and/or Territory certifications.

4.3.4 Buried corrugated metal structures should not be used unless approved by the RIM.

5 Construction and commissioning

5.1 Construction

5.1.1 General

5.1.1.1 This section specifies the requirements for the construction and commissioning of railway structures.

5.1.1.2 Relevant standard construction specifications shall be used for the manufacture, fabrication, erection and installation of structural components and the construction of associated civil works.

5.1.1.3 Construction planning should take into account:

(a) the likely disruption to road or rail traffic and the economic consequences of such disruption;

(b) the effect of the execution on existing infrastructure;

(c) the equipment (including backup equipment) required for the construction;

(d) any particular requirements to protect road, rail or pedestrian traffic, or infrastructure (inclusive of overhead line equipment (OLE), buried services and requirements when using overhead cranes near operational railway);

(e) the adequacy of any temporary works (including temporary use of permanent works in a completed or uncompleted condition) to ensure adjacent structures are not undermined or de-stabilized;

(f) the need for any temporary bracing or support to structural elements during the construction process;

(g) the disturbance which could be caused to nearby residents;

(h) environmental impacts.

5.1.1.4 All tools, materials and equipment shall be placed and secured in a position so that they cannot fall or be struck by road or railway traffic. When tools, materials and equipment are no longer required they shall be secured or removed from the structure.

5.1.1.5 The RIM shall ensure that adequate processes and methods are put in place to:

(a) predict, identify, and record change in design, construction materials, methods, etc;

(b) react appropriately and, where required, ensure the effective rescheduling of workflows.

5.1.1.6 Where duplication or other civil track construction is being made over existing structures (e.g. culverts), the RIM shall ensure that the necessary inspections and analyses are carried out on the existing structure to ensure it has sufficient capacity to withstand any enhanced live or dead loads that will be imposed both during construction and for future operations, and consideration of differences in design life.

5.1.2 Notifications and other correspondence

5.1.2.1 The RIM should record and approve correspondence and coordination letters with local government authorities, agencies and community groups in relation to the construction works.

5.1.2.2 Where relevant, the construction process should accommodate timings and resources to provide notice and information to adjacent communities, network users and other stakeholders, where they will be adversely affected by the works in any way.

5.1.3 Quality assurance

5.1.3.1 The RIM shall ensure that appropriate quality control processes are implemented, associated with the appropriate on-site evaluation and testing carried out on all construction works:

(a) As part of this quality control process, the RIM shall ensure that any modifications in the design are appropriately approved and shown in the as-built drawings.

(b) The RIM shall ensure an appropriate process is in place for the recording of all as-built drawings, plans, technical queries, test results and other relevant site documentation.

5.1.4 Redundant structures and fittings

5.1.4.1 Where possible, all redundant structures and fittings applicable to this Standard shall be removed.

5.1.4.2 Where not possible to remove redundant structures and fittings, appropriate processes shall be put in place to make the redundant structure safe SFAIRP. The redundant structure should be inspected and monitored as required by the RIM to ensure safety until it is removed.

5.2 Construction procedures

5.2.1 Earthworks and preparation

5.2.1.1 General

5.2.1.1.1 The preparation and clearing of sites for the construction of structural works shall be in accordance with good engineering and environmental practices, and in compliance with relevant legislation, Australian standards, RIM requirements and good practice as specified in this Standard.

5.2.1.2 Excavation

5.2.1.2.1 All aspects of the shoring, excavation and backfilling of excavations for structures shall comply with the requirements of AS 7638.

5.2.1.2.2 Prior to any excavations, the RIM shall obtain all underground network information in the construction area. Should the scope of works change, or plan validity dates expire, the RIM shall reconfirm this information prior to works commencing.

5.2.1.2.3 Prior to any railway corridor excavations being undertaken, the relevant railway and / or external utilities providers (or other cable providers) shall be contacted to determine the locations and depths of all cables affected by the works.

5.2.1.2.4 If an underground asset is damaged during construction, the RIM shall advise the asset owner immediately.

5.2.1.3 Embankments

5.2.1.3.1 Embankment batters and slopes shall be designed in accordance with AS 7638, AS 4678, AS 1289 and other relevant standards.

5.2.2 Bridges

5.2.2.1 Foundations

5.2.2.1.1 Construction, testing and installation of piles shall comply with the relevant Australian Standards and other referenced documents as prescribed in the specification. All work is to be undertaken in accordance with the project drawings.

5.2.2.1.2 Where spread footings are placed on rock or other strong layer with an inclined surface, consideration should be given to providing stepped footings, dowels, or other equivalent anchorage to provide shear resistance to horizontal forces.

5.2.2.2 Reinforced, pre-stressed and post-tensioned concrete structures

5.2.2.2.1 The methodology and materials required for placing, supporting, and stressing of tendons on post-tensioned concrete shall be as specified in the drawings.

5.2.2.2.2 Force required (or gauge pressure), anticipated elongation and sequencing for jacking shall be determined by the RIM and specified on the approved design drawings and/or stressing methodology statement.

5.2.2.2.3 The stressing operation shall be monitored, and the tendon elongations and gauge pressures are recorded to ensure that the tendon is stressed to the force required.

5.2.2.2.4 The design of precast concrete elements shall assess the handling stresses which the element will be subject to, and:

(a) shall make provision for suitable lifting points;

(b) precast concrete elements shall be stored clear of the ground on adequate supports placed on a plane surface, in a manner that shall avoid damage, twisting or warping;

(c) where the ground is of a standard that is not prone to any differential settlement.

5.2.2.2.5 The design / drawings of precast elements should note storage / stacking requirements, i.e. support points etc

5.2.2.2.6 The RIM shall base the acceptability of precast concrete elements on an assurance of:

(a) visual inspection (including the quality of the concrete surface finish);

(b) geometric measurement;

(c) measurement of clear cover to reinforcement;

(d) specified required design concrete strength;

(e) reinforcement spacing and location;

(f) other requirements as specified in AS 3610.

5.2.2.2.7 The RIM shall reject any precast concrete element which fails to meet the standards specified in AS 3600 and other relevant Australian standards.

5.2.2.2.8 For bridges and major concrete structures, AS 5100.5 shall take precedence over AS 3600.

5.2.2.2.9 Concrete incorporated into a structure shall be obtained from a certified concrete plant or, in remote areas, mixed on-site using ingredients from certified suppliers.

5.2.2.2.10 Concrete specification, including admixtures, shall be in accordance with the specifications and/or drawings. Changes shall only be implemented under the approval and instructions of the RIM.

5.2.2.2.11 Specialized concrete or concrete products that are not available from certified concrete plants shall only be supplied and used in accordance with the instructions of the RIM.

5.2.2.2.12 Components of concrete structures defined by the RIM as 'non-structural' may be constructed or repaired with cementitious material that is not from a certified plant, only where the product applied (i.e., approved structural grouts or specialized concrete repair products) is subject to the approval of the RIM.

5.2.2.2.13 The use of cement based repair materials, epoxy resins, cold galvanising and other similar products in the construction and repair of concrete structures shall be in accordance with the material specifications and all relevant safety legislation in relation to the management of hazardous substances.

5.2.2.3 Steel structures

5.2.2.3.1 Steel (or iron) components shall not be heated, bent, or welded, except in accordance with the instructions of the designer and the RIM.

5.2.2.3.2 Where drilling/grinding/flame cutting of a painted steel member is to be performed, the paint in the area shall first be removed in such a way that it does not affect the health of the worker or pollute the environment.

5.2.2.3.3 Consideration should be made in the design to ensure that sufficient manoeuvrability is available to position each of the steel components correctly and safely during construction works.

5.2.2.3.4 Any alterations to in-service trusses or other steel existing components for clearance or other purposes shall be conducted in compliance with AS 5100 and other relevant design standards.

5.2.3 Culverts

5.2.3.1 When extending concrete pipe and box culverts any potential differential settlement between the existing pipe / culvert and its extensions shall be assessed, and appropriate measures be put in place.

5.2.3.2 When extending a metal pipe, and there is a gap between the existing pipe and the new pipe, a strip of suitable impervious membrane should be wrapped around the joint of the pipe to prevent loss of embankment material through the joint.

5.2.3.3 During construction of corrugated metal pipe culverts, it should be noted that backfilling is critical, as uneven backfilling will cause deformation and loss of strength in ring compressions.

5.2.3.4 Backfilling material for all culvert pipes shall comply with the requirements of AS 7638, AS 3725 and other relevant standards, and pipe manufacture's specifications for pH and electrical resistivity.

5.2.3.5 In the installation of pipe and box culverts, the width of trenches shall be as wide as necessary to ensure proper installation and compaction, with the width of trench or spacing between structures subject to backfilling procedures and to be in accordance with relevant Australian standards, with the minimum recommended trench width being the pipe diameter plus 150 mm on either side.

5.2.3.6 Backfill in trenches shall be of a suitable material and compacted as specified by the designer and in accordance with the relevant test methods specified in AS 1289.

5.2.3.7 Where pipes are laid in two or more lines in the same trench or streambed, they shall be separated enough to allow space for thorough compaction of backfill, while ensuring side support of the culverts to prevent collapse of the pipes due to unequal loading.

5.2.3.8 Where corrugated metal pipe (CMP) culverts are used, a concrete invert or other protective measures such as complete internal relining should be considered to protect the paint and galvanising from abrasion by water and other corrosive factors and where a concrete invert is applied, it should cover the lower quadrant of the culvert and / or 30 % of the diameter of the culvert.

5.2.3.9 Where culverts are being constructed as a replacement for existing timber structures, the whole of the existing structure should be removed, if possible, prior to construction of the culvert.

5.2.3.10 Where culverts are being constructed as a replacement for existing timber structures and it is necessary to leave and bury portions of the existing timber structure, any consolidation shall be accounted for, and any components which can decay or deteriorate shall be removed.

5.2.3.11 Where temporary track supports are required while the culvert is being constructed, these shall be designed to allow for the safe passage of trains, in compliance with all relevant loading requirements and in accordance with the relevant work, health and safety legislation.

5.2.4 Retaining walls

5.2.4.1 The RIM should ensure that sufficient working space for the construction of the base slab of the wall is allowed for in the design of the retaining wall.

5.2.4.2 Where there is limited railway corridor available and a safe batter angle to construct the heel of the wall footing is not available, a temporary occupancy of the adjacent land should be obtained by the RIM to permit the excavation of a safe batter while retaining works are being constructed or alternative design solution such as shoring or sheetpiling should be considered.

5.2.4.3 Where construction of the wall is being undertaken in poor ground conditions, the construction methodology shall evaluate the stability of the ground and the groundwater conditions.

5.2.4.4 Where construction of the wall is being undertaken in poor ground conditions, a risk assessment should be conducted and, if necessary, the RIM should ensure the wall is constructed in short panel sections, to minimize the length of unsupported face exposed at any time.

5.2.5 Tunnels

5.2.5.1 Due to the specialist nature of tunnels and associated works, all tunnel construction shall be conducted by competent qualified personnel and experienced contractors.

5.2.5.2 Where greater vertical clearance through existing tunnels is required, it could be necessary to lower the tunnel floor. Checks and analysis shall be undertaken to ensure that the floor excavation does not undermine the arch support.

5.2.5.3 The RIM shall ensure that due consideration is given to the provision of safe and adequate access in the tunnel design and construction works.

5.2.6 Temporary works

5.2.6.1 All temporary work structures required for construction purposes shall be designed and verified by a qualified professional engineer. The on-site construction of temporary work shall also be verified by the RIM.

5.2.6.2 All temporary work structures that support operational railways or could affect railway operations if they collapse, should be independently certified by a qualified professional design engineer and verified by the permanent structure designer.

5.3 Working restrictions

5.3.1 Safe management of construction activities

5.3.1.1 Construction work on, or adjacent to the operational railway, can affect the safety of trains, personnel, passengers, or the general public if not managed effectively. Such work shall be managed with a level of competence that ensures safety at all times and compliance with all relevant safety legislation, Australian Standards, guidelines and codes of practice.

5.3.1.2 The RIM shall ensure that any person/s that plans or manages construction work that will take place on or interface with the operational railway shall have a level of competence which is commensurate with the nature, scale, and location of the construction work in question.

5.3.2 Clearances

5.3.2.1 During construction, cranes and other equipment shall not intrude into the air space above the rail corridor, unless approved suitable mitigation measures have been put in place to minimize risks of collision with traffic and/or overhead equipment and subject to the approval of the RIM.

5.3.2.2 No loads shall pass over or within the clearances specified in AS 7633 to any live overhead wiring or transmission lines located within the rail corridor.

5.3.2.3 During construction, the RIM shall ensure that all construction work is undertaken in accordance with the clearances specified in AS 7633.

5.3.3 Railway safety requirements

5.3.3.1 The RIM shall ensure that all construction works are undertaken in compliance with the railway operational regulatory requirements.

5.3.3.2 The RIM shall ensure that that personnel on-site are aware of all regulatory railway safety requirements.

5.3.4 Electrification restrictions

5.3.4.1 All works conducted near live overhead electrification wires (contact, catenary or feeder) shall not be carried out within the clearances specified in AS 7633 unless mitigating measures have been put in place (e.g. power-off) due to risk of electrical arcing.

5.3.5 Construction sites adjacent to existing structures

5.3.5.1 Excavations shall not be permitted in proximity to existing structures whose foundations could be impacted by excavation works unless it can be demonstrated by proper engineering design and geotechnical assessment, to the satisfaction of the RIM, that the stability of the adjacent structures will not be affected by the work.

5.3.5.2 Before commencing construction processes with the potential to cause structural damage, the RIM shall conduct a survey of all structures, which could be subject to any adverse effect from the operation, or which could give rise to any claim or litigation.

5.3.5.3 The design of new structures that involve excavations near existing railway infrastructure shall assess the stability and structural integrity of the railway infrastructure during construction.

5.3.5.4 For large-scale demolition, excavation or filling work, the installation of a vibration monitoring system should be undertaken to monitor vibration levels on the adjoining rail corridor.

5.4 Structural bolts and anchors

5.4.1.1 Structural connections are generally the weakest elements of a bridge or structure. To reduce the risk of structural failure due to inadequate connection capacity only bolts compliant with the bridge design and relevant Standards shall be used.

5.4.1.2 Where replacement bolts or rivets are required, they should be compliant with existing Australian Standards and RIM standards.

5.5 As-built drawings

5.5.1 On completion of construction, all construction drawings shall be updated to as-built drawings.

5.5.2 All as-built drawings shall be retained in accordance with clause 5.1.3.1 of this Standard.

5.5.3 All as-built drawings or certificates of compliance shall be signed by an appropriately qualified engineer and RIM representative.

5.5.4 The RIM shall ensure that works have been constructed in accordance with the original design intent.

5.6 Commissioning requirements

5.6.1 General

5.6.1.1 All structural construction, including (where appropriate) each stage of construction, shall undergo a commissioning process, satisfying the requirements described in this Standard and in compliance with relevant Australian Standards, prior to putting the structure in service on an operational railway.

5.6.2 Inspection and testing

5.6.2.1 General

5.6.2.1.1 Inspection and/or testing plans shall be prepared for endorsement by the RIM.

5.6.2.2 Hazards and defects

5.6.2.2.1 All hazards and defects identified during commissioning shall be recorded and rectified, where practical.

5.6.2.2.2 Where the rectification requires changes to design, such changes shall be undertaken to meet the requirements of the relevant Australian Standards.

5.6.3 Certification

5.6.3.1 On completion of works, the RIM shall:

(a) sign off all work carried out under the appropriate standards and requirements;

(b) record construction and maintenance work in the structure condition reports;

(c) make the structure condition reports available for independent audit.

5.6.4 Rail safety accreditation

5.6.4.1 Where Commonwealth, State and Territory regulation dictates, the RIM shall ensure that the required rail safety accreditation requirements are carried out as detailed in the Rail Safety National Law and Rail Safety National Law Regulations, prior to commencement of rail operations on any new or rehabilitated construction.

6 Monitoring and maintenance

6.1 General

6.1.1 Assessment and maintenance are the processes that shall be used by the RIM to ensure the condition of structures stays within intended performance limits and is compatible with the operator parameters.

C6.1.1 Commentary

Assessment and maintenance usually consist of the following activities:

(a) inspecting, testing, and monitoring of critical elements of the structures to determine their condition;

(b) recording of irregularities or defects which can affect, or have the potential to affect, the capability of each structure to safely perform its required function;

(c) assessing the inspection, test, and monitoring results to determine the necessary action required for the structure;

(d) taking action before the structure is unable to safely carry out the required functions (e.g. where conditions are outside prescribed performance limits).

6.2 Inspections and monitoring

6.2.1 General

6.2.1.1 The RIM shall have documents and operational procedures to ensure that examinations are regularly carried out and, where appropriate, structural health monitoring conducted to identify any significant changes in condition, loading or environmental conditions, that could indicate deterioration of the structural integrity of the structure.

6.2.1.2 Structural health monitoring should be conducted in accordance with AS 5100.7

6.2.1.3 Special attention should be made to structurally critical members within bridges. A list of typical structurally critical members and details of critical areas for defects in these members are provided in Appendix G

6.2.1.4 When carrying out examinations as per Clause 6.1.1, the RIM shall have in place evaluation procedures to establish whether further action is required, to ensure that the structure does not pose an unacceptable risk to safety or the environment because of its condition or use.

6.2.1.5 For unforeseen incidents (e.g. bridge strikes, floods, and collisions), the RIM shall:

(a) have in place procedures which cover immediate inspection, evaluation, and potential closure and/or decommissioning of the structure; and

(b) ensure appropriate action is taken if the incident has reduced structural integrity or could potentially increase risk to railway operations, the environment, or the public.

6.2.2 Track and other inspections

6.2.2.1 A visual inspection of structures should be undertaken during regular track patrols. Time between inspections should not exceed seven days.

6.2.2.2 While inspecting track (either walking or using digital machine / media vision technology), any irregularities and / or track movements that could indicate structure anomalies and / or conditions that can affect or indicate problems with the integrity of the structure, should be noted and reported to the RIM, including the following:

(a) Changes in the alignment of the structure (e.g. as indicated by track geometry error or movement in vertical or horizontal alignment).

(b) Component or structure member damage (e.g. as caused by derailment, collision, dragging equipment on rolling stock or vandalism).

(c) Other obvious defects that could affect the structure's integrity.

6.2.2.3 Inspections should be carried out at speed consistent with the local conditions and the full scope of the inspection requirements.

6.2.3 Structure Inspections

6.2.3.1 General

6.2.3.1.1 Inspections should be classified as below:

(a) Level 1 – General structural inspection. A visual inspection to check the general serviceability and safety of the structure and identify any emerging problems.

(b) Level 2 – Bridge condition inspection. A detailed inspection, conducted to assess and rate the condition of each element in a structure, in order to identify maintenance needs, model and forecast future changes in condition, and estimate future budget requirements.

(c) Level 3 – Special structural engineering inspection. An extensive inspection which can include physical materials and/or load testing and structural analysis to assess the structural condition and behaviour of the structure, to identify and quantify the current and projected deterioration of the structure, and to assess appropriate management options.

6.2.3.2 General structural (Level 1) inspections

6.2.3.2.1 General structural inspections may be scheduled or unscheduled as per RIM Standards or policies.

6.2.3.2.2 Scheduled general structural inspections shall be undertaken to inspect and record structure condition and identify any significant changes in condition since the previous general inspection.

6.2.3.2.3 General structural inspections should check the general serviceability of the structure, assessing:

(a) the physical condition of visible and safely assessable components of the structure;

(b) whether the structure is safe for operational purposes.

6.2.3.2.4 A general inspection shall be carried out when suspected defects are identified from conditions determined during track inspections.

6.2.3.2.5 Recommendations for frequencies of general structural inspections, latitudes and reporting timeframes are detailed in Appendix D.

6.2.3.3 Bridge condition (Level 2) inspections

6.2.3.3.1 Bridge condition inspections can be scheduled or unscheduled as per RIM Standards or policies.

6.2.3.3.2 Bridge condition inspections shall be undertaken to investigate the condition, behaviour, and integrity of a structure.

6.2.3.3.3 To assess deflection, cracking, deformations, and other abnormal vibrations it could be necessary to conduct the visual inspection during the passage of rail traffic.

6.2.3.3.4 Bridge condition inspections should assess the condition of the structure and its components, analysing the:

(a) physical condition and performance;

(b) structural integrity;

(c) corrective and preventative management requirements.

6.2.3.3.5 Recommendations for frequencies of bridge condition inspections, latitudes and reporting timeframes are detailed in Appendix D

6.2.3.4 Special structural (Level 3) inspections

6.2.3.4.1 Special structural inspections should be undertaken where it is necessary to:

(a) monitor specific defects;

(b) reassess defects following exceeding of rectification dates;

(c) inspect for anticipated hazards following an event, such as heavy rain, flood, earthquake, or fire;

(d) inspect after an unforeseen event, such as an impact from road vehicle or derailed rolling stock.

C6.2.3.4.1 Commentary

Special structural inspections are usually undertaken outside of the prescribed schedule of detailed and general structural inspections. However, in certain circumstances it could be necessary to schedule special structural inspections for structures which are nearing the end of their residual life and/or have been identified in other inspections as requiring special evaluation.

6.2.3.4.2 To assess deflection, cracking , deformations, and other abnormal vibrations it could be necessary to conduct the inspection during the passage of rail traffic.

6.2.3.4.3 Special structural inspections could involve specialized tests and analysis. All tests and analysis undertaken should be carried out by competent experienced personnel in accordance with the relevant Australian Standards.

6.2.3.4.4 Recommendations for frequencies of special structural inspections, latitudes and reporting timeframes are detailed in Appendix D

6.2.3.5 Frequency of inspections

6.2.3.5.1 The RIM shall:

(a) carry out inspections regularly and within reasonable maximum intervals determined through a risk assessment approach and in consideration of the operational environment under which the structure is operating (recommend minimum frequencies as provided in Appendix D;

(b) program inspections so that they are undertaken at regular intervals over the inspection period unless there are mitigating circumstances;

(c) arrange inspections of structures more frequently if necessary to ensure safety.

6.2.4 Recording and reporting

6.2.4.1 General

6.2.4.1.1 Records should be maintained of all inspection details, and at a minimum these records should include the following information for use in the structure condition report and data registers:

(a) type of inspection;

(b) date of inspection;

(c) name of inspector;

(d) location of structure;

(e) description of the structural elements;

(f) clear, concise and accurate descriptions summarising the condition and status of each defect;

(g) sketches and/or photographs detailing the nature and extent of significant defects showing the general structure and all significant defects;

(h) where appropriate, recommend rehabilitation measures, assign condition rating and set rectification dates for completion accordingly.

6.2.4.1.2 The RIM shall document and retain all results of inspections, analyses and testing undertaken in all assessments as part of the structure records, in accordance with the Rail Safety National Law and Rial Safety National Law Regulations.

6.2.4.2 Marking on-site

6.2.4.2.1 When marking defects and cracks on structures:

(a) markings of the cracks should be clearly dated and visible;

(b) care should be taken when undertaking reparatory or maintenance works that relevant marks are not covered and remain clearly visible;

(c) deterioration marks should not be erased. New markings from subsequent inspections should be recorded near the previous information;

(d) the size and description of any defects discovered, and the date of inspection should be appropriately marked on the component.

6.2.4.2.2 Where a concrete structure is deteriorating, appropriate marking or devices should be employed to clearly indicate the progression of the deterioration (i.e., cracking or spalling).

6.2.4.2.3 For steel structures:

(a) all paintwork on steel structures should be marked clearly, showing the company name that conducted the work, the paint system used, the start and finish date, and the type of works carried out (e.g. full clean and paint, spot clean and spot paint, spot clean, spot paint and overcoat);

(b) cracks should be appropriately marked on the relevant component, and the markings should not be removed until repairs have been completed.

6.2.4.3 Data registers

6.2.4.3.1 The RIM should prepare and maintain a register of structures with special defects for the purpose of planning maintenance works and inspections.

6.3 Rating and assessment of existing bridges

6.3.1 Assessment

6.3.1.1 The integrity of structures should be assessed to verify their capacity to safely perform the required function. Where changes to the configuration or condition of the structure have been identified, an appropriate capacity assessment should be made to determine:

(a) required actions; and

(b) the extent and impact of future deterioration and environmental effects on a structure.

C6.3.1.1 Commentary

The methods of assessment are varied and include, but are not limited to, the examples which are provided in Appendix E

6.3.2 Foundation and substructure

6.3.2.1 Foundations and substructures shall be assessed for suitability and integrity.

6.3.2.2 Inspections should be carried out when there is evidence of:

(a) misalignment of track;

(b) abnormal rotation of piers;

(c) abnormal closure of deck joints and bearing movements;

(d) excessive scouring and exposure of footings / piles;

(e) degradation of the sub-structure.

6.3.2.3 Inspections should be carried out following a significant flood event.

6.3.2.4 Underwater and high ground water table area inspections should be carried out in accordance with RIM requirements.

6.3.3 Load rating

6.3.3.1 General

6.3.3.1.1 Load rating of bridges shall be carried out in accordance with AS 5100.7, other relevant Australian Standards and RIM requirements.

6.3.3.1.2 When using original drawings to undertake a desktop load rating analysis all imperial units shall be converted to metric units for the analysis.

6.3.3.1.3 Ratings of railway underbridges should take into account the load effects of current railway loading consists and the current structural condition of the underbridge.

6.3.3.1.4 In the absence of test data or designated steel type (on drawings or in specifications), the values provided in Appendix I shall be used.

6.3.3.1.5 Unless otherwise specified by the RIM, all components and connections (including splices) shall be analysed.

6.3.3.1.6 Bridge component naming should be in accordance with the definitions in this Standard.

6.3.3.1.7 Where applicable, notations shall be in accordance with AS 5100.

6.3.3.1.8 As is ratings shall be based on site measurements, including losses of structural cross-sections due to corrosion, rot and other deterioration causes.

6.3.3.1.9 Calculations and summaries shall be annotated in sufficient detail to clearly distinguish between the 'as is' and the 'as new' rating of individual components.

6.3.3.1.10 The Standards and other reference documents used for the particular rating shall be stated. The values adopted in the calculations, including material properties and load factors, shall also be clearly stated and justified.

6.3.3.1.11 The original design load should be determined from a review of the structure drawings, if available.

6.3.3.2 Loss of section in metal structures

6.3.3.2.1 Losses adopted in calculations shall be clearly stated and justified.

6.3.3.2.2 Any identified loss should be assessed relative to its impact on the structural integrity of the element.

6.3.3.2.3 The RIM should define the acceptable levels of loss for structural elements and the actions required when the level of loss exceeds the defined acceptable level.

6.3.3.2.4 Where testing to determine material tensile properties is undertaken, the requirements of AS 1391 shall be met.

6.3.4 Loads and loading factors

6.3.4.1 The loads, load factors and reduction factors shall be in accordance with AS 5100.2 and the design requirements and recommendations in this Standard.

6.3.4.2 Assessment of load and reduction factors should be based on:

(a) ratings specified in terms of current trains operating on the rail network or the relevant bridge live loading;

(b) standard road or rail live loading as per AS 5100.2

6.3.4.3 For loadings less than 300 LA, future loading requirements should be stated by the RIM.

6.3.4.4 Final approval of the design loads shall be obtained from the RIM.

6.3.5 Load rating results

6.3.5.1 Rating results shall be calculated in accordance with the methodology detailed in AS 5100.7 and expressed as the ratio of member capacity over applied load as specified in AS 5100.7.

6.3.5.2 These results shall be tabulated for as new and as is, both with and without the full DLA specified in AS 5100.7. A suggested load rating results table is provided in Appendix J.

6.3.5.3 Vehicle types and the effect of any speed restrictions in force or as proposed shall be recorded.

6.3.5.4 Rated load for the bridge, whether it be a proportion of the required rating and all other assumptions relevant to the rating of the structure should be recorded.

6.3.5.5 Where the rating is less than unity (1.0), the following shall also be included:

(a) Reduced speed necessary to raise the rating to unity (1.0) - i.e. reducing DLA with respect to lower speed.

(b) Reduced live load factor to raise the rating to unity (1.0), calculated with full DLA.

6.3.5.6 A written report should be prepared on the results of the load rating. The report should include a statement in regard to all standards / codes and other referenced documents used in the rating, as well as details on all material properties, load factors and any assumptions used in the rating.

6.3.6 Defect categories

6.3.6.1 The RIM is responsible for the appropriate inspections and/or monitoring

6.3.6.2 The RIM shall carry out appropriate risk assessments and analysis in proposing a mandatory repair priority system appropriate to system operational requirements.

6.3.6.3 The RIM shall define how defects are assessed and assigned within a defect category.

6.3.6.4 An example defect category table and repair priority table is provided in Appendix F.

6.4 Maintenance

6.4.1 General

6.4.1.1 All maintenance work on existing structures shall be carried out in accordance with approved construction drawings and relevant guidelines and codes of practice.

6.4.1.2 Any changes to as designed structure configuration or structurally critical elements shall be approved by the RIM and accompanied by a relevant risk assessment.

6.4.1.3 All emergency maintenance work shall be adequately maintained and monitored until the structure is upgraded to safe operating condition.

6.4.1.4 Maintenance work should be performed during the service life of a structure to:

(a) maintain its designed load capacity, other functional capability, and safe serviceability;

(b) ensure that the structure completes its designed service life;

(c) preserve the railway organisation's investment and its structural assets.

6.4.1.5 Maintenance includes both reactive and preventative activities that preserve or restore the condition of a structure or its constituent parts. Restorative works are generally termed rehabilitation activities.

6.4.2 Repair Priorities

6.4.2.1 In assigning repair priorities, the following considerations shall be given:

(a) Location of the defect.

(b) Importance of the affected member.

(c) The degradation rate.

(d) The effect of multiple defects.

(e) The operating environment (type, speed and volume of rail, road or pedestrian traffic).

6.4.2.2 The initial response to a repair priority should include a risk assessment based on the considerations given in Clause 6.2.3

6.4.2.3 The initial action for a repair priority may include a risk management action, such as increased monitoring, installation of temporary supports or imposition of a speed or load restriction, pending final repair.

6.4.2.4 Defects that impose an immediate risk to the structure shall be reported to the RIM as soon as practical. Refer Appendix F for further information regarding defect categories and assessment.

6.4.3 Preventative maintenance

6.4.3.1 The RIM should ensure regular maintenance is carried out to reduce the deterioration of the integrity of the structure, and at a minimum the following items should be addressed:

(a) All protective coatings (paint, galvanising, etc.) are still performing a protective action.

(b) Vegetation is controlled and kept clear of structures.

(c) Debris is cleared from structures in waterways.

(d) All signage is in place and complies with visibility requirements.

(e) Drainage systems are effective.

(f) All moveable parts are still effective (e.g. bridge bearings, turntable gearing, expansion joints).

(g) Track clearance and track geometry is maintained.

(h) Honeycombing, cavities or blowholes found in concrete structures are repaired as soon as possible to minimize the risk of exposure and corrosion to reinforcement.

6.4.4 Rehabilitation and strengthening

6.4.4.1 All rehabilitation and strengthening works on structures shall be undertaken in accordance with the requirements of AS 5100 and other relevant Australian Standards.

7 Decommissioning and disposal

7.1 Decommissioning

7.1.1 Actions

7.1.1.1 The RIM shall ensure that the decommissioning plan includes the reduction or elimination of hazards and liabilities adjacent to and / or at the location of the structure at which the usage will change. These actions will be taken in compliance with Commonwealth, State, Territory, and industry regulations.

7.1.1.2 The process of decommissioning should involve a:

(a) initial site inspection;

(b) determination of assessment criteria;

(c) development of decommissioning technical specifications;

(d) decommissioning implementation;

(e) decommissioning documentation.

7.1.1.3 Part of the decommissioning plan shall include a risk assessment and appropriate change management processes.

7.1.2 Make safe

7.1.2.1 Each site with potential toxic materials to be disposed of should be identified, characterised and assessed for contamination.

7.1.2.2 Where applicable, contaminated soils (e.g. acid sulphates and asbestos) should be removed and replaced with clean fill, or remediated in place, in accordance with applicable regulations and standard industry practices in place at the time of actual decommissioning.

7.1.2.3 Where remediation and / or treatment methods are required, these should be selected based on proven and effective technologies, that will minimize or eliminate the potential for further contamination of the environment.

7.1.3 Monitor and maintain

7.1.3.1 Sites to be decommissioned and reclaimed should be restored so that the pre-disturbance vegetation can re-establish itself in a short period of time.

7.1.3.2 To facilitate revegetation, mitigation measures that could apply include fertilising and seeding, mulching, and surface texturing.

7.1.3.3 Close attention should be paid to areas where erosion potential is high.

7.1.3.4 Large plots of land, such as storage yards, borrow pits and main camp sites, should be revegetated and maintained until plant growth is established.

7.1.3.5 Where any components from decommissioned structures are to remain, the RIM shall ensure that these components are monitored and maintained in compliance with the requirements of Section 6 of this Standard and other relevant Australian standards.

7.2 Disposal

7.2.1 Demolition

7.2.1.1 Where appropriate, demolition work shall be carried out in accordance with AS 2601.

C7.2.1.1 Commentary

AS 2601 is not intended to apply to the demolition of road and railway bridges, or other specialized civil engineering structures.

7.2.1.2 If the work is not covered by or included in AS 2601, it must be done in a manner acceptable to the requirements of relevant work and health and safety legislation.

7.2.1.3 For the removal of railway bridges and / or other specialized railway structures, demolition work shall be carried out in accordance with RIM requirements and in a manner acceptable to the relevant Commonwealth, State and/or Territory regulatory safety requirements.

7.2.2 Removal

7.2.2.1 During the disposal of structures, a review shall be taken of the need to ensure and maintain assurance of public safety and environmental safeguards.

7.2.3 Registration of contaminated sites

7.2.3.1 Where applicable, the RIM shall record and, if appropriate, notify the relevant Commonwealth, State and / or Territory authority of all decommissioned sites that have been used for notifiable activity and / or have been contaminated by hazardous material.

Appendix A RISSB hazard register

Informative

This table provides guidance only by suggesting some hazards that are managed by this Standard.

Context	Percursor	Hazard
Loss of accreditation	Failure to maintain and service equipment, infrastructure and rolling stock	Lack of documented process
	Infrastructure failure leading to rail accident	Lack of implementation of the design and development processes
Rolling stock	Derailment or Collision, Human Error, Design Failure, Security Breach, Loads not Secure, and or Vandalism	Derailment causing tunnels / bridges / overpasses / building structures to collapse onto trains
		Earthquakes causing tunnels / bridges / overpasses / building structures to collapse onto trains
Infrastructure	Derailment or Collision, Human Error, Track Obstructions, Health and or Design Failure	Tunnels, bridges, overpasses or building structures collapsing onto trains
		Track failure at the interface to 'stiff' structures e.g. bridge ends

Appendix B Structure type classification

Normative

B.1 General

Table B:1 – Structure type Classification

Structure Asset Class	Structure Asset Definition	Structure Asset Types	Definition of Types
Bridge	A structure spanning over a river, road, railway, chasm or the like, carrying trains, road vehicles, pedestrians, native or domestic fauna, and/or providing support to other infrastructure (e.g. communication cables) over the span.	Overbridge	Bridge carrying road vehicles, livestock or other traffic over a track.
		Flyover	Bridging structure where one track passes over another track that is at ground level.
		Underbridge	A railway bridge supporting a track and passing over waterways, roadways, pathways, flood plains, pedestrian pathways, etc.
		Footbridge	Bridge carrying pedestrian traffic, mobility aids and/or cycles. May be freestanding or combined with another structure.
		Dive	Bridging structure where one track passes under another track that is at ground level.
Culverts	Arch, box, oval or circular shaped structure with integral walls, roof and / or floor which is used to carry a track or road over a waterway or drain. Refers to minor ballast-top openings comprising metal pipes, concrete pipes, concrete boxes, concrete arches, and brick and masonry arches. Minor bridges of	Large culvert	Large culverts have an opening span greater than or equal to 1.25 m in span.
		Small culvert	Small culverts have an opening span less than 1.25 m, but greater than or equal to 350 mm span. Structures less than 350 mm in span are considered as pipes and covered as part of track drainage.
		Livestock underpass	Culvert structure providing access under the railway for cattle or other livestock.

Structure Asset Class	Structure Asset Definition	Structure Asset Types	Definition of Types
	less than 2 m total span can be referred to as 'culverts'.	Subway	Culvert structure providing a pedestrian, cyclist and/or vehicular pathway (including cane rail).
Tunnels			Structures built primarily to enable the line to pass through a hill. Overbridges that accommodate wide or skewed roadways or railways below are not defined as tunnels.
Station platforms			Line-side structure built to provide public access to passenger trains.
Air space developments			A structure built over the rail track to support overhead offices, shops and accommodation.
Track slabs			A reinforced concrete slab supported by the ground that carries track.
Retaining walls and rock shelters		Retaining wall	A wall that holds back or supports soil when the natural ground level has been altered.
		Rockfall shelter	A structure installed over and beside a rail track to prevent loose material from adjacent cuttings falling onto the rail line.
		Dive	Soil retaining structure used to change the grade of track from ground level to below ground level (retaining wall).
		Access stairs, ramps and walkways	A structure providing access for pedestrians or others.

Structure Asset Class	Structure Asset Definition	Structure Asset Types	Definition of Types
Miscellaneous Structures		Buffer stop	Structure provided at the end of a rail line or siding to prevent rolling stock from running off the end of the track and/or colliding with an adjacent structure. Can be fixed or energy absorbing type.
		Cattle grids	A bridge over a ditch (consisting typically of parallel metal bars) which prevents passage of livestock and other animals.
		Loading and unloading facilities	A facility, usually located on a balloon loop, spur or siding, which comprises of bins/loading arms/hoses and other related equipment, to enable product loading and unloading of railway wagons.
		Overhead service crossings	A structure designed to carry utility services, such as water, sewer or telecommunications cable and associated equipment, over a defined span.
Miscellaneous Structures (cont)		Overhead wiring masts and gantry structures	Structures such as signal, lighting or electrical gantries (where a gantry is defined as a structure spanning one or more tracks and having two or more points of support), consisting of a mount adjacent to the railway, designed to provide support for signalling, electrical wiring, measuring and monitoring equipment or other, as required to be supported overhead of the track infrastructure.
		Noise barriers	Structures placed along the corridor to muffle the sound of traffic – typically constructed out of wood, plastic or concrete.
		Turntable	A deck, usually over a circular pit, onto which a locomotive is driven, and which pivots about its centre to turn a locomotive or allows it to run off onto other radiating tracks for storage.

Structure Asset Class	Structure Asset Definition	Structure Asset Types	Definition of Types
		Vehicle inspection pits and associated structures	A hole in the floor of a maintenance shed, and/or a series of pillars which can suspend a railway track, allowing the examination of railway vehicle from underneath the bogie.
		Water structures	Structures built to support and hold water (such as water tanks) and to direct water (such as inverts).
		Wingwall	Retaining walls adjoining abutments. E.g. piles and sheeting or concrete or masonry wall restraining embankment on each side of an abutment.
		Weighbridge	A mechanism for weighting rolling stock by means of a metal plate set into the underlying track.

B.2 Bridge diagrammatic examples

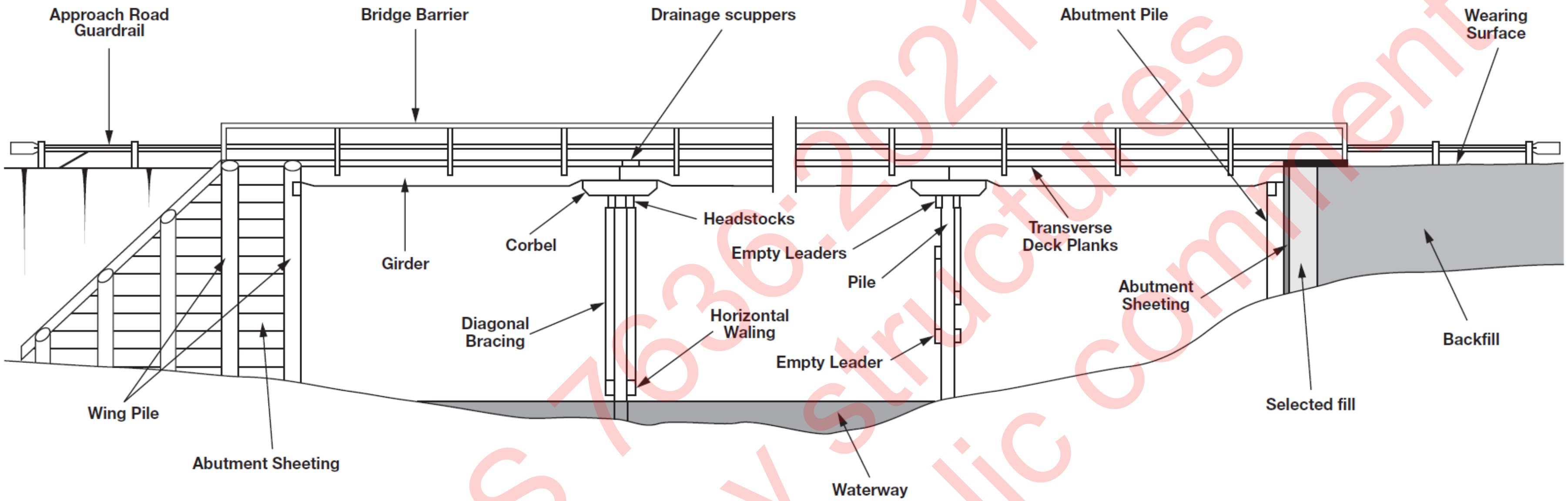

Figure B:1 – General terminology for bridges (timber)

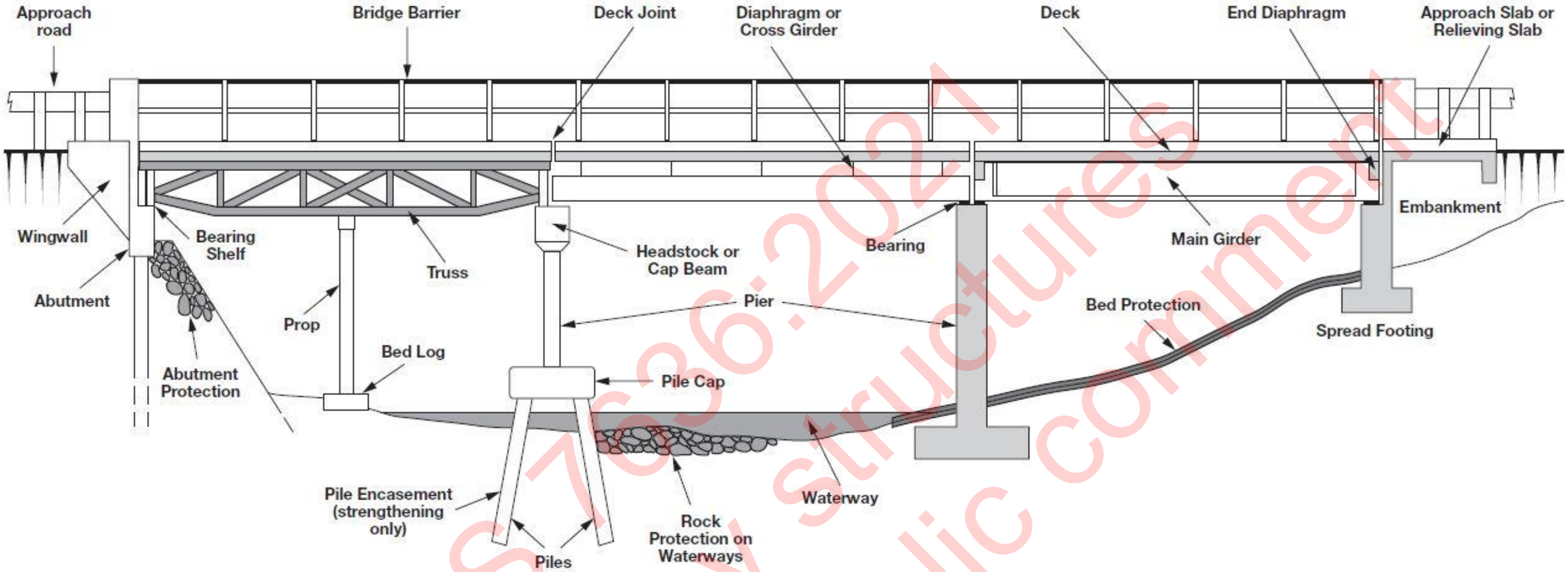

Figure B:2 – General terminology for bridges (steel or concrete)

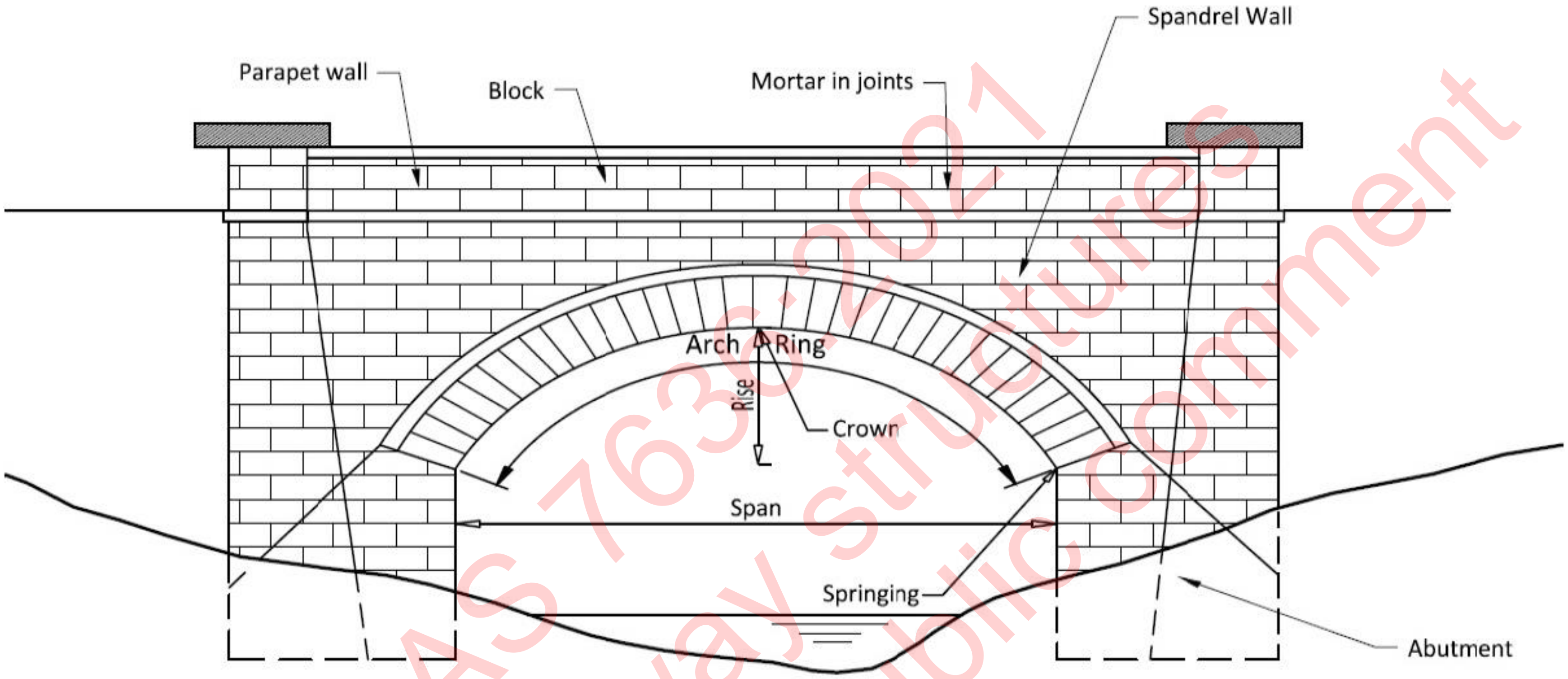

Figure B:3 – General terminology for bridges (masonry arch)

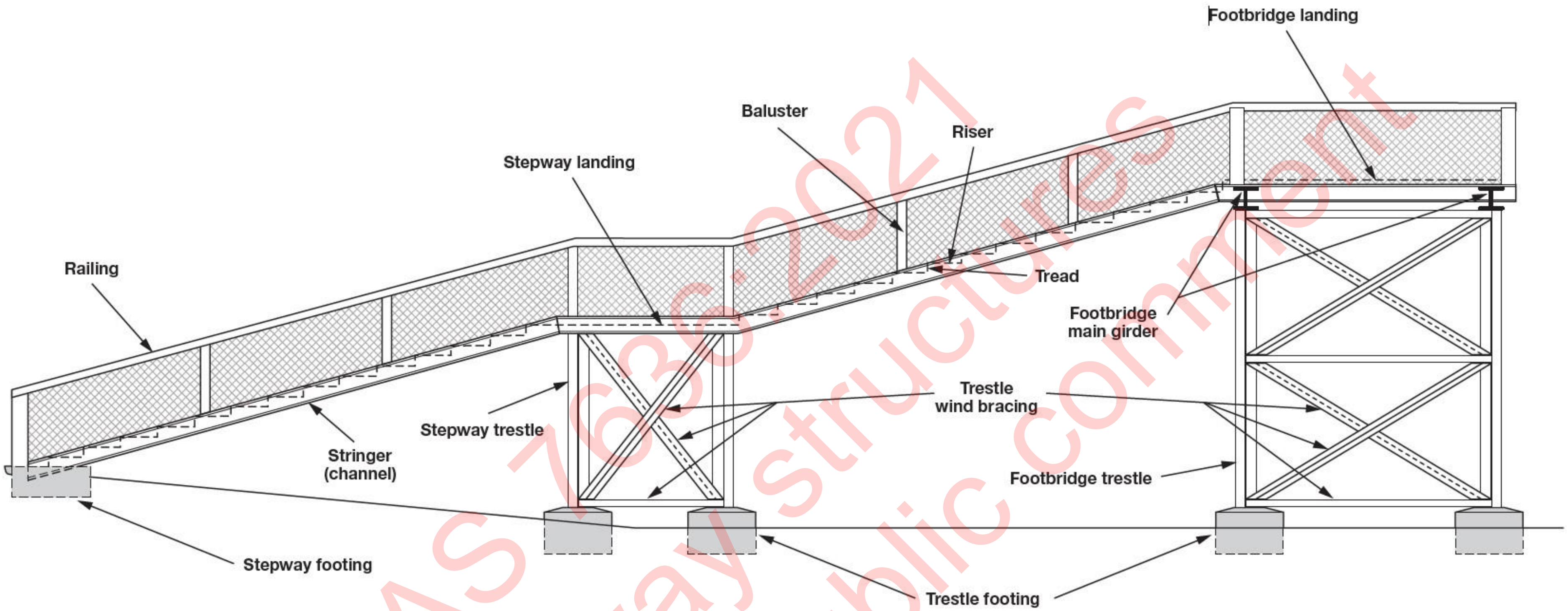

Figure B:4 – Typical footbridge with access stairs

B.3 Culvert diagrammatic examples

Typical culvert shapes include open-bottomed boxed culverts (typically installed on precast concrete slab), open-bottomed arched culverts (typically installed on concrete footings), boxed culverts (typically precast concrete), and arched elliptical culverts (steel, concrete or plastic)

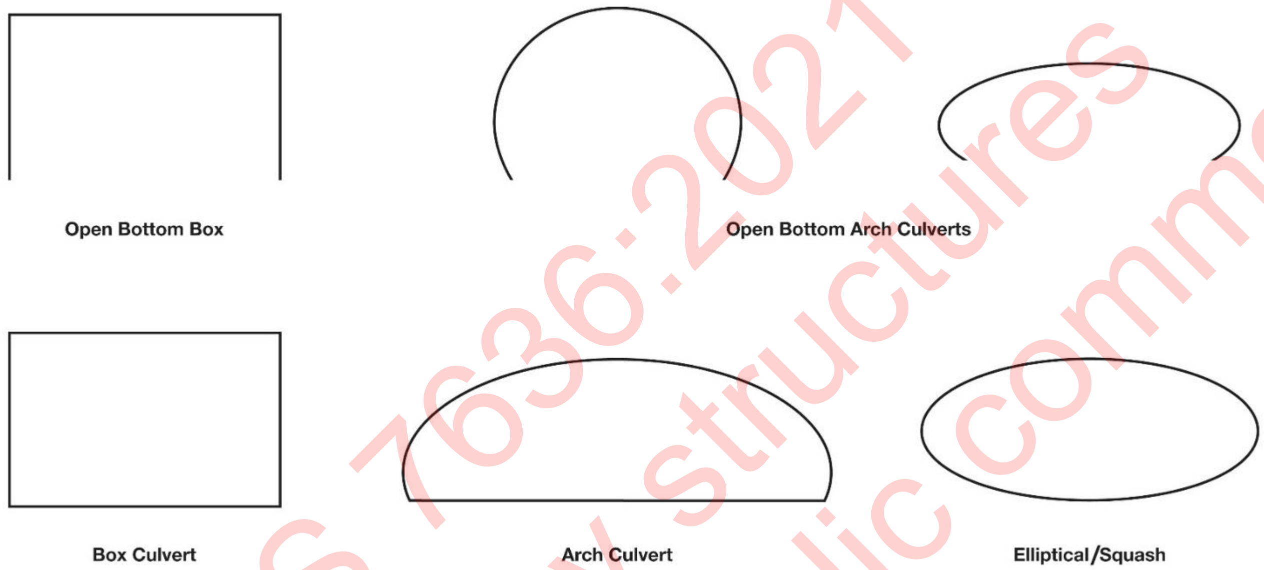

Figure B:5 – Typical culverts

Figure B:6 – Terminology for precast crown culverts

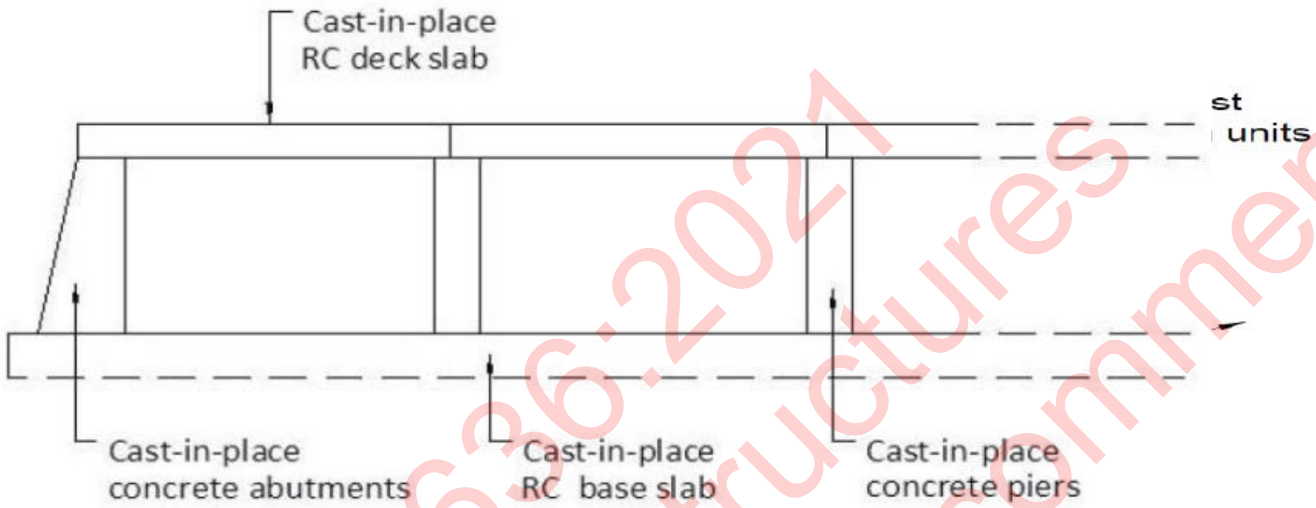

Figure B:7 – Terminology for modular culverts

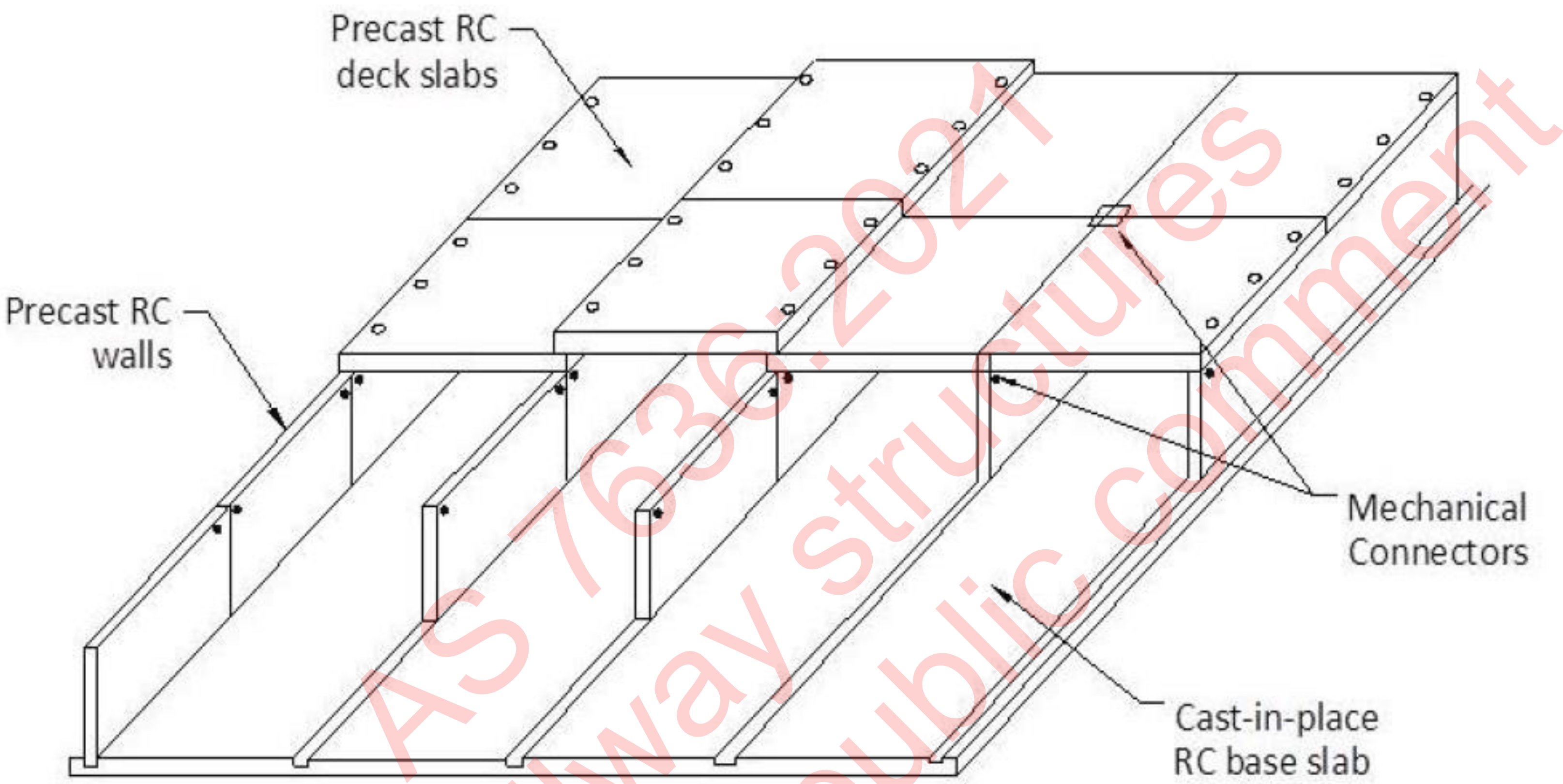

Figure B:8 – Terminology for modular culverts (cont.)

B.4 Bridge sections (diagrammatic examples and terminology)

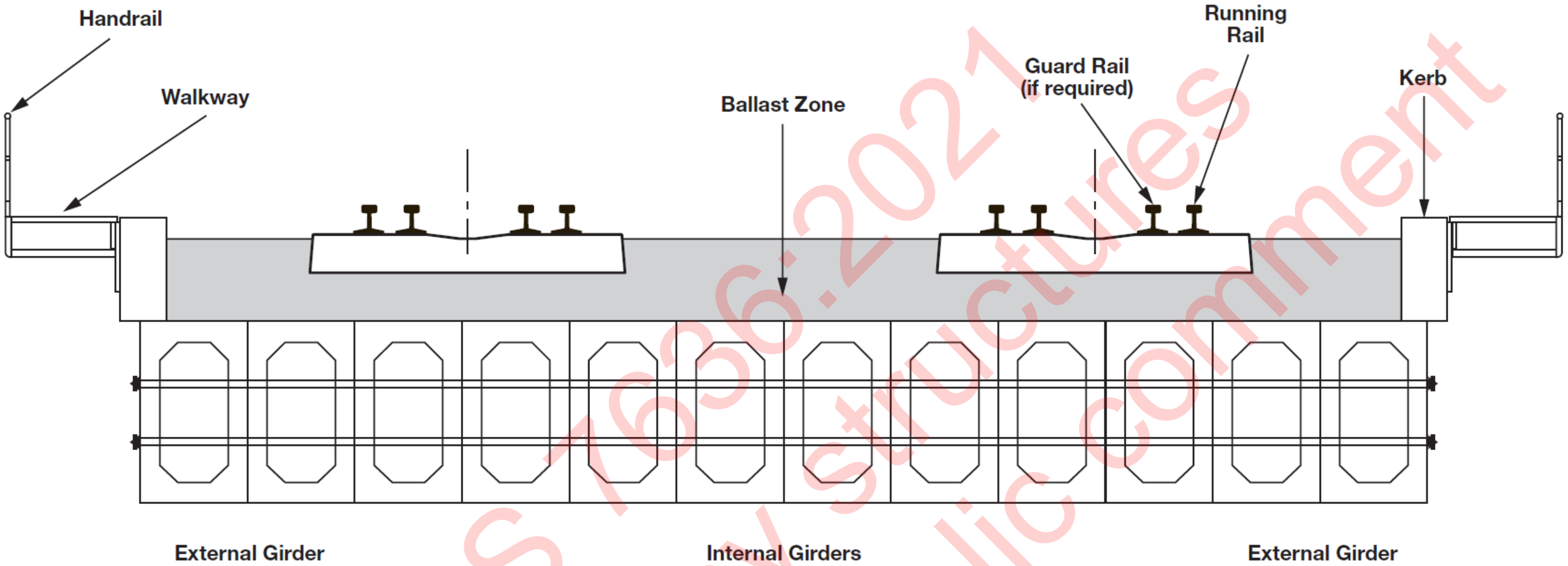

Figure B:9 - Ballast top underbridge (precast plank deck)

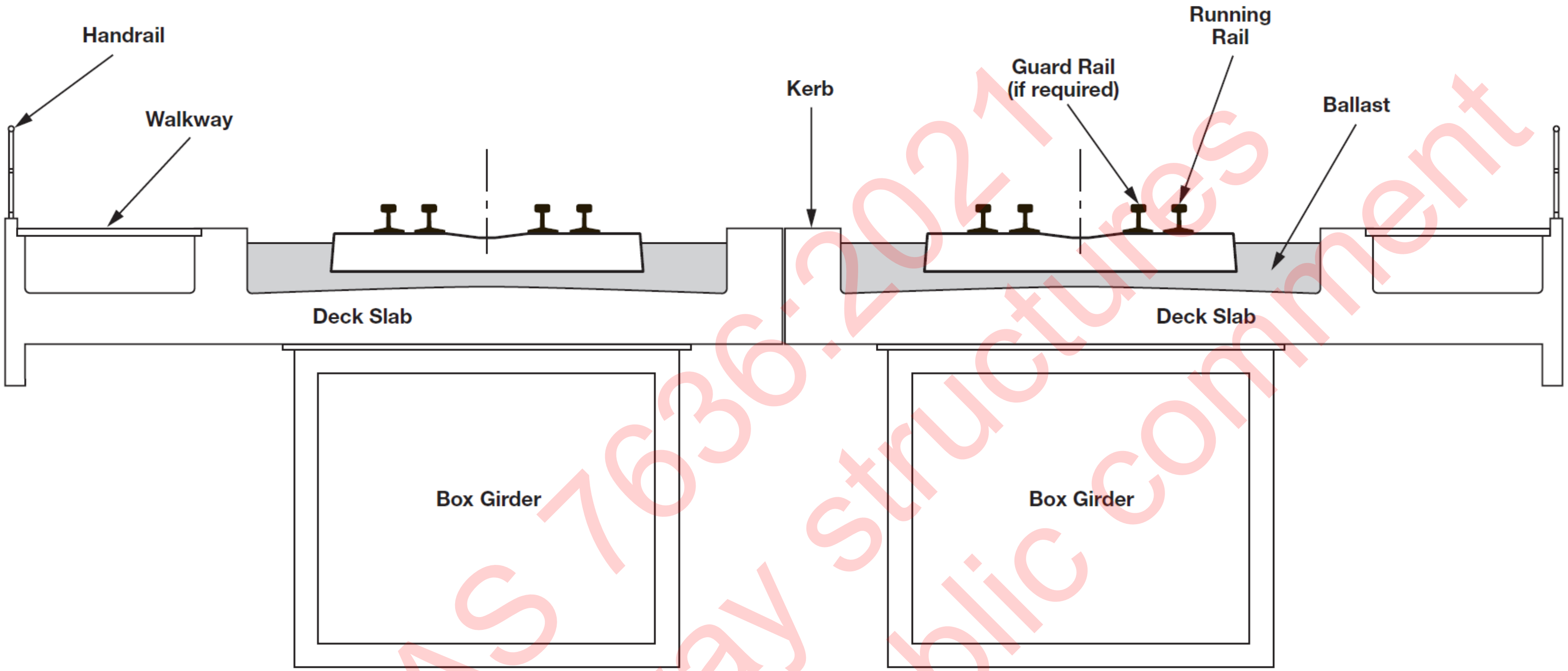

Figure B:10 - Ballast top underbridge (box girder)

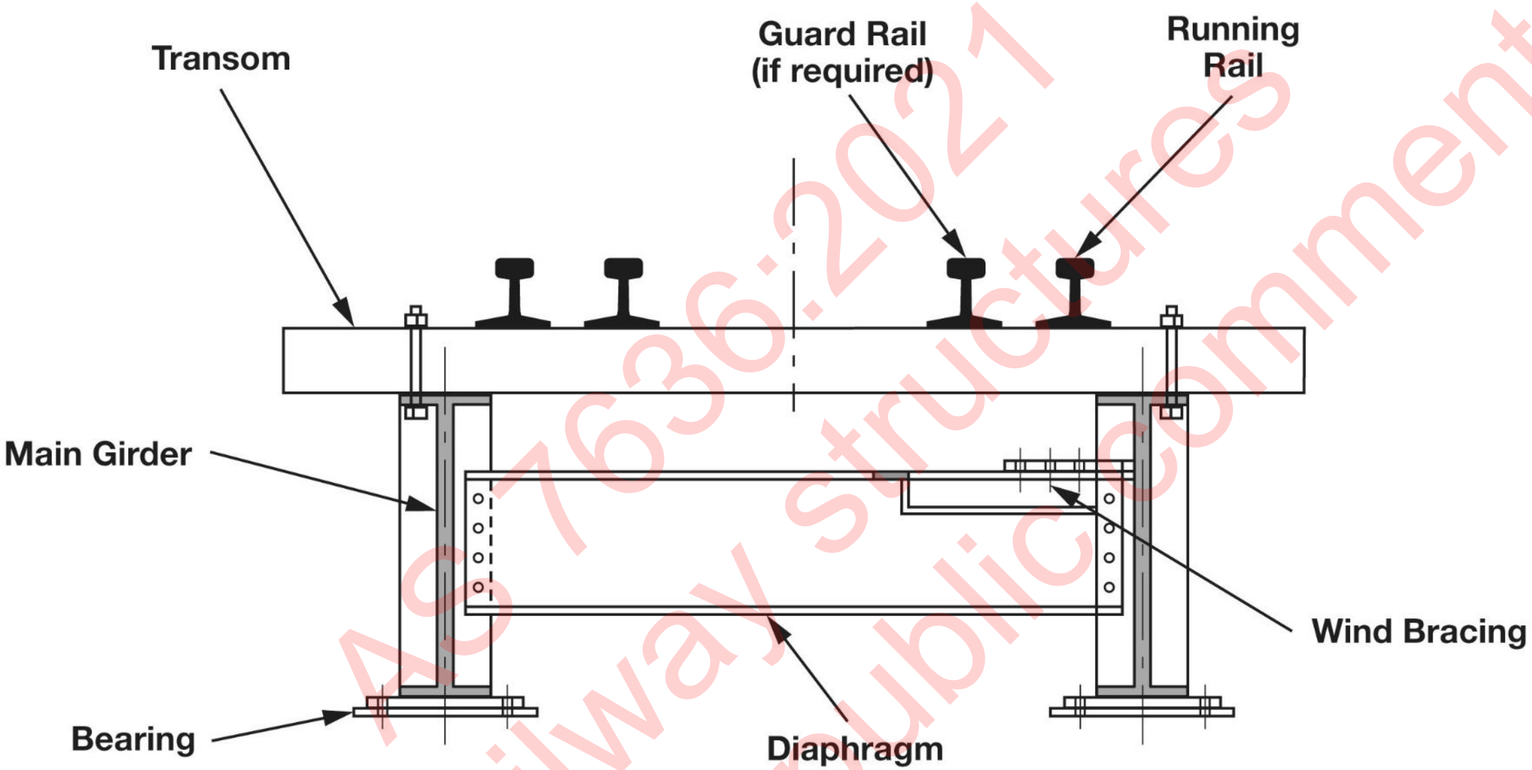

Figure B:11 – Transom section

Appendix C Design load and scour parameters

Normative

Table C:1 – Design load parameters - Bridges

Underbridge, flyovers, viaducts Structures carrying rail track over road and waterways	Overbridges	Footbridges
Structures supporting railway track over road, waterways or other shall be designed to accommodate axle configurations in accordance with AS 5100, in accordance for the various axle loads in the table below, unless otherwise notified by the RIM. Reference Load is 300LA. For the other loadings, all axles shall be proportioned by the ratio of the nominated LA load divided by 300. For loadings less than or greater than 300LA, future loading requirements need to be considered. Final approval of the design loads shall be obtained from the RIM. When designing through girders or truss bridges, secondary structural elements shall be incorporated in the structure to accommodate potential collision loading from a derailed vehicle, in accordance with AS 5100. These are required in order to protect the main structural elements of the bridge from damage. Where underbridges are designed for installation beneath track infrastructure and will extend beyond the existing tracks, they should be designed for the above loadings for the full extent of the rail corridor.	Structures located on highways, main roads and designated heavy haulage or road train routes could need to be designed for special heavy load vehicles or particular road train or long vehicle loadings. This shall be assessed and confirmed by the relevant authority/road manager. In the absence of design criteria, road structures will be designed to SM1600 loading in accordance with AS 5100. Structures which support railway access accommodation/ occupational/trackside access roads and/or public roads may be designed to T44 or R20, as verified by the RIM. The 'R' vehicle is a rigid truck with the same configuration as the prime mover portion (first 3 axles) of the 'T', vehicle and the numerical portion is the vehicle's weight in tonnes.	Normal loading wall be self-weight plus live load, as determined under the requirements of AS 5100; 5kPa live load equates to 300kg loading per metre length of 600mm wide walkway unless otherwise approved by the RIM.

Table C:2 – Scour design parameters – Bridges and culverts

Bridges	Culverts
Scour protection shall be incorporated in the design of new bridges where there has been a previous record of scouring or where a hydrological and hydraulical assessment indicates that there is a potential for scouring around the bridge. Scour protection shall be designed in accordance with Austroads' Waterway Design.	Scour protection is not normally required when any one of the following criteria apply: - calculated velocity of flow through the culvert opening at design flow is <1.5m/s; - bed and banks consist of sound rock or are protected by sound rock bars, and the toe of the embankment is protected; - the gradient of the channel downstream is flatter than 1%.

Table C:3 – Design parameters for consideration - tunnels

Tunnels	
General	Tunnels located within the rail corridor shall be designed to accommodate the train loadings as specified within the track classifications as given in AS 7630: The loading is based on the railway traffic load in AS 5100. The ‘referenced load’ is 300LA. For other loadings, all axles are to be proportioned by the ratio of the nominated LA divided by 300. Operating classes are as defined in track classification and as operated on the network. For loadings less than 300 LA, future loading requirements need to be considered. Final approval of the design loads shall be obtained from the RIM. The impact factor shall be in accordance with the DLA in AS 5100, with the characteristic length based on either deck slabs or direct rail fixation. Tunnels shall also be designed for the collision load requirements of AS 5100. Where tunnel walls are not continuous, for example where there is a crossover to the track adjacent tunnel, guardrails or concrete upstands should be provided in lieu of the collision load requirements at the discontinuity. Tunnels shall be designed for earthquake forces in accordance with AS 5100, and as per design category appropriate to the local region and environment.
Drainage and Waterproofing	The rate of inflow of groundwater into the tunnel is to be limited, in order to not adversely affect surrounding property and infrastructure caused by changes to the groundwater level and flow regime. The rate of inflow into the tunnel shall be controlled to avoid impact to any existing surface water courses. The seepage rate of water into the tunnel shall be limited to a maximum of 0.1 litres/second per any continuous 100m length of single track tunnel. Drainage systems shall be designed to collect and dispose of any seepage and surface water that enters the tunnel, in order that the track infrastructure is kept well-drained to minimize maintenance. The drainage system shall be configured so that in the event of a blockage, any overflow will not affect train operations or the reliability of the infrastructure. All drainage discharge from the tunnel shall be treated to be of such quality as to meet the requirements of the relevant authority for discharge to the stormwater system. The drainage system design and configuration shall consider the need for maintenance staff to access adjacent equipment without having to stand in the drain. No water seeping through the tunnel structure is to drip onto the track

Appendix D

Appendix E Frequencies of inspections

Informative

Table C:1 – Example inspection frequencies

Brief Description Table D:1	Example Frequency (Years)									
	Bridge					Culvert		Tunnels	Retaining Wall	Misc. Structure
	Underbridge				Overbridge	Large Culvert	Small Culvert		> 2m High	All Other Type
	Timber	Steel	Concrete	BFB Span	All Materials	All Materials	All Materials	All Materials	All Materials	All Materials
OPERATIONAL LINES										
GENERAL INSPECTION A general inspection is carried out to check the general serviceability of the structure for rail (or other) traffic. A general inspection assesses the physical condition of structures and whether the structure is safe for operational purposes.	2	2	2	See notes pg. 70	2	2	2	2	3	2
DETAILED INSPECTION A detailed inspection is an inspection carried out to assess the condition of each structure and its components. A detailed inspection assesses: • the physical condition and performance • the structural integrity • corrective and preventative management requirements.	4	6	6	See notes pg. 70	6	6	6	6	6	6
SPECIAL STRUCTURAL INSPECTION	As required									

Brief Description Table D:2	**Example Frequency (Years)**										
	Bridge					Culvert		Tunnels	Retaining Wall	Micl. Structure
	Underbridge				Overbridge	Large Culvert	Small Culvert		> 2m High	All Other Type
	Timber	Steel	Concrete	BFB Span	All Materials	All Materials	All Materials	All Materials	All Materials	All Materials
NON-OPERATIONAL LINES										
DETAILED INSPECTION As above	As per risk assessment by the RIM (see section 5.1.4)									
GENERAL INSPECTION As above	As per risk assessment by the RIM (see section 5.1.4)									

Further information provided in notes on page 70.

Notes for Table D1 and D2:
Underwater and groundwater components to have a detailed inspection undertaken at intervals of < 6 years. Underground untreated timber to have a detailed inspection undertaken at intervals < 4 years. Underground treated timber to have a detailed inspection undertaken at intervals < 8 years. A special structural inspection is conducted on a needs basis, to assess the structural condition behavior and capacity of the structure and appropriate management options. A special structural inspection can be undertaken outside of the prescribed inspection schedule of engineering and visual inspections. The reasons for special inspections are varied and include, but are not limited to: • monitoring specific defects reassessment of defects when the rectification date has been exceeded; • inspecting for anticipated hazards following an event, such as flooding, submerging, heavy rain, an earthquake, or fire; • following an unforeseen event, such as impact from a road vehicle or derailed rolling stock. Broad flange beams require additional inspection when spanning over roadways or subject to excessive force such as collisions. Common tests which could form part of any special structural investigation include: • magnetic particle testing/dye penetrant – undertaken in conjunction with visual/engineering inspections as required • ultrasonic • X-ray • Schmidt hammer test • acoustic emission • electrolysis test • structural health monitoring (remote sensing) • chloride test • carbonation test • chemical test • AAR test • material properties – tensile/compressive strength/elongation/Charpy's notch test • sampling and testing • dynamic testing • static test • liquefaction test • bearing capacity test – standard penetration testing

- standard compaction test – pocket penetrometers
- piling driving tests – numerous.
- geotechnical investigation
- durability investigation

Table C:2 – Inspection types and latitude

Inspection Type	Criteria for Latitude	Latitude (Weeks)
General Inspection	Frequency ≤ 18 months	4
	18 months > frequency ≤ 36 months	8
	>36 months	16
Detailed Inspection	Frequency ≤ 18 months	4
	18 months > frequency ≤ 36 months	8
	>36 months	16
Special Structural Inspection	Unscheduled Scheduled	As soon as practicable following trigger event

Notes:
Submission times will depend on the risk and required action times that the defect poses.

Appendix F Assessment methods (informative)

Table D:1 - Assessment methods

Assessment	Description of Assessment Method	Application	
		Material	Elements/Defects
Visual Inspection	Many problems in timber bridge structures could be detected firstly by sight. Visual inspection and appraisal shall be performed diligently, with particular attention to the following: cleaning of dirt, tar and other coverings from timber exposed in underground inspections; excessive checking of timber; splitting of timber; cracking of timber; shrinkage of timber; termite infestation (external termite galleries); discolouration of timber; damp areas of timber; decay and fungal presence, including fruiting bodies; and alignment of track on the bridge.	Timber	Elements joints behind abutments Timber decking Joinery bolts and holes Headstocks Transoms
	Most cracks in steel bridges are first detected by visual inspection. Once a crack is found, other non-destructive inspection methods, such as dye penetrant and magnetic particle, are used to further clarify the extent of the crack. The usual and most reliable sign of fatigue cracks is the oxide or rust stains that develop after the paint film has cracked. Experience has shown that cracks have generally propagated to a depth between one-fourth and one-half the plate thickness before the paint film is broken, permitting the oxide to form. This occurs because the paint is more flexible than the underlying steel.	Steel	Broad flange beams Loose structural fasteners Interface of the connecting elements

Assessment	Description of Assessment Method	Application	
		Material	Elements/Defects
	Visual inspection will detect most defects in concrete structural elements. The inspector is to look for signs of weathering or spalling of surfaces or mortar joints, cracking within elements or at joint stains; on surfaces indicating reinforcement corrosion; crushing, especially at bearings or at pre-stressing anchorage points; and changed alignment of elements.	Concrete	Vertically (e.g.abutments) Horizontally (e.g. deck camber) or Laterally (e.g. footings and culverts) Shrinkage or hairline cracks Cracking or crushing around pre-stressing anchorages seepage into unwanted areas
	Check if any distortions have occurred in the load bearing elements, such as walls, abutments, and piers, as well as retaining structures. Check verticality with a plumb line and measure any out-of-plumb distortion. Check bulging in both horizontal and vertical directions using a 3 m long hardwood straight edge. If there are signs of efflorescence, leaching and percolation of water through masonry, assess the deterioration of masonry units and jointing mortar by fretting. Investigate if the earth fill behind abutments and retaining walls, and fills between spandrel walls of the arches are properly drained. Check if the weepholes (if provided) are functioning. Dry weepholes indicate they could be blocked.	Masonry	Walls Abutments Piers Barrel

Assessment	Description of Assessment Method	Application	
		Material	Elements/Defects

	Check if any distortions have occurred in the load bearing elements, such as walls, abutments, and piers, as well as retaining structures. Check verticality with a plumb line and measure any out-of-plumb distortion. Check bulging in both horizontal and vertical directions using a 3 m long hardwood straight edge. If there are signs of efflorescence, leaching and percolation of water through masonry, assess the deterioration of masonry units and jointing mortar by fretting. Investigate if the earth fill behind abutments and retaining walls and fills between spandrel walls of the arches are properly drained. Check if the weepholes (if provided) are functioning. Dry weepholes indicate they could be blocked.	Masonry	Walls Abutments Piers Barrel
	Observe members under load and note any excessive movement in members or fastenings.	Steel	Girders Bracing Web stiffeners
Observation of members under load	Measuring deflection of structural members under known applied loads.	Concrete	Girders Decks
	Ascertain if the cracks are 'live' (i.e. their width changes under thermal or structural loading). This can be detected with a mechanical strain gauge held on gauge discs glued to the concrete surface. Cracks that are due to applied load will move immediately the load is changed (e.g. under traffic passing over a bridge). Cracks due to thermal movement shift when the temperature of the element alters. Measurements made three or four times a day should establish whether a crack is live or not.	Concrete Masonry	Girders Decks Abutments Piers
Strain gauge	Ascertain if the cracks are moving by fixing special strain gauges across them at suitable locations, which will be used to tell if a crack has grown. Cracks that are due to applied load will move immediately when the load is changed (e.g. under traffic passing over a bridge). Cracks may also move under temperature variations. Measurements should be made with and without traffic loads, and for four or five times in a day, to establish whether a crack is live or not.	Masonry	Walls Abutments Piers Barrel

Assessment	Description of Assessment Method	Application	
		Material	Elements/Defects
Hammer testing	Hammering, or sounding, a timber element gives an indication of internal deterioration. The presence of rot or termite attack may cause a hollow sound when struck by the hammer, indicating boring is required.	Timber	Girders All transoms on both sides Fasteners including spikes, screws and bolts
	When steel elements are tapped lightly with an inspector's hammer, it will help to identify loose plates and fastenings, the extent of corrosion, and effectiveness of corrosion protection. Care must be taken that hammering does not cause unnecessary destruction of protection systems.	Steel	Loose pates and fastenings The extent of corrosion Effectiveness of corrosion protection
	Hammer testing, where surfaces are tapped lightly with an examination hammer, can indicate drumminess and potential spalling areas.	Concrete	Girders Corbels Headstocks Piles Sills
Bore and probe	Test boring is carried out with a 10mm auger, in order to locate internal defects, such as pipes, rot or termites.	Timber	Girders Corbels Headstocks Piles Sills
Bore and probe	Test boring is carried out with a 10mm auger, in order to locate internal defects, such as pipes, rot or termites.	Timber	Girders Corbels Headstocks Piles Sills

Assessment	Description of Assessment Method	Application	
		Material	Elements/Defects
Deflection test	A deflection test gives an indication of girder condition and riding quality.	Timber Steel	Girders
Measurements	Check for section loss using an ultrasonic thickness metre to measure section thickness.	Steel	Girders Bracing Web stiffeners
	Check thickness of paint using a dry fill thickness gauge.	Steel	
	Estimate the concrete cover to reinforcement using electromagnetic cover meters or by actual measurement where concrete is broken and reinforcement is exposed. Check if the cover provided is adequate for the exposure conditions, or is as per drawings (if the drawings are available).	Concrete	Girders Decks Abutments Piers
Test methods	Magnetic particle testing (MPI) or flaw detection penetrant dye will detect suspected cracking not clearly visible. The local area is to be cleaned back to bare metal to perform the testing. The bare metal shall be reprimed with an appropriate paint system if no crack is found.	Steel	Girders Bracing Web stiffeners
	Test for carbonation: Break off small pieces of concrete from different areas of the structure using a hammer and cold chisel, and test freshly exposed concrete surfaces by spraying with 2 % solution of phenolphthalein in alcohol. This pH indicator solution will change colour according to the alkalinity of the concrete. The solution remains pink and is easily visible on concrete that has retained its alkalinity, but becomes colourless on concrete that has lost its alkalinity by carbonation. The test will thus indicate the depth to which the concrete has been carbonated from the surface.	Concrete	Girders Decks Abutments Piers

Assessment	Description of Assessment Method	Application	
		Material	Elements/Defects
	Test for chloride contamination: To determine the chloride content of concrete, samples are obtained by drilling holes in the concrete and collecting the dust produced (NB: If there is any surface salt build-up, it must be removed before drilling.) The dust samples are collected at a range of different depths (e.g. 0 - 10 mm, 10 - 25 mm, 25 - 50 mm, etc.), to determine how the chloride content changes with depth from the surface. It also helps to establish whether the chloride was present in the concrete when it was cast, or whether it penetrated the concrete from the surroundings . The concrete samples are treated with acid to dissolve the cement, and the chloride content is determined by titration against silver nitrate.	Concrete	
Advanced inspection techniques	Where the cause of cracking or bulging of an element cannot be explained by visual inspection, specialist testing (e.g. X-ray, ultrasonic or acoustic emission) can be used to examine the internal condition of structures and the underlying cause of the observed defects.	Steel	Girders Bracing Web stiffeners Cracking
	Listed below are additional tests that require special equipment and significant skills and experience to obtain usable results. Such testing methods would have to be undertaken by specialist personnel skilled in the field of diagnostic testing: • half-cell potential measurements to assess corrosive activity in concrete and the probability of corrosion in steel reinforcement • ultrasonic pulse velocity measurements to locate areas of delamination and honeycombed concrete • electrical resistivity measurements to assess the rate of corrosion qualitatively • permeability tests to measure the water absorption of concrete	Concrete	Girders Decks Abutments Piers

Assessment	Description of Assessment Method	Application	
		Material	Elements/Defects
	• in situ compressive strength measurements using Schmidt hammer test • core sample testing for strength, permeability, contamination, composition and density • scanning concrete for confirming reinforcement availability and arrangements.		
	Listed below are additional tests that require special equipment and significant skills and experience to obtain usable results. Such testing methods would have to be undertaken by specialist personnel skilled in the field of diagnostic testing: • Shigometer • Ultrasonic • X-rays.	Timber	Girders Corbels Headstocks Piles Sills
Footings, piles and below ground / water structures	Assessments should include: • Misalignment of track • Abnormal rotation of piers • Abnormal closure of deck joints and bearing movements • Excessive scouring and exposure of footings / piles • Periodic underwater inspections should be carried out. • Inspections should also be carried out following a significant flood event.	All	All

Appendix G Example category tables for defect categorization

Normative

G.1 Defect categories and actions

The below table is an example only. Further information provided in section 6.3.6 of this Standard.

Table E:1 – Example categories and actions

Category	Action
Defect category A	The RIM should immediately stop trains in the case of an underbridge, or close access if an overbridge or footbridge. Experienced structural personnel are to be advised and the structure assessed immediately.
Defect category B	The RIM should impose a 20km/hr speed restriction in the case of an underbridge. Experienced structural personnel are to be advised and the structure is to be assessed within 24 hours.
Defect category C	For footbridges and overbridges, the RIM should barricade the area, and a report should be provided to experienced structural personnel. The structure is to be assessed within 24 hours.
Defect category D	Experienced structural personnel are to be advised and the structure is to be assessed within 24 hours.
Defect category E	Experienced structural personnel are to be advised appropriately and the structure is to be assessed within seven days.
Defect category F	The RIM should ensure that the defect is reported and assessed as part of the inspection management process.

G.2 Defect categories for specific structures

The below table provides indicative historical values for defect size categorization only. The RIM shall assess each defect based on the individual circumstances and the RIM defect assessment policies. Further information provided in section 6.3.6 of this Standard.

Table F:2 – Example category tables

Member	Defect Type	Defect Size	Defect Category	Mandatory Repair Priority*
A. Underbridges – steel and wrought iron				
For steel, wrought iron and broad flange beam (BFB) underbridges, items in the table are defined as follows: **Main structural members** are main girders, cross girders, stringers, truss chords, diagonals and verticals, columns, trestle legs, and headstocks. **Secondary structural members** are bracing, bearing/bed plates, gusset plates, bearing and web stiffeners, tie bars, etc. An **element** of a member is typically a flange or web and may consist of multiple plates and/or angles. For piers, abutments, wingwalls and reinforcement see 'Underbridges – concrete'.				
Main member (excluding BFBs)	New crack or extension of previously assessed crack	> 80 mm long (total if old and new)	A	
Main member (excluding BFBs)	New crack or extension of previously assessed crack	50 mm – 80 mm long (total if old and new)	B - 20km/h speed Observe underload	
Main member (excluding BFBs)	New crack or extension of previously assessed crack	10 mm – 49 mm long (total if old and new)	B	
Main member (excluding BFBs)	New crack	0 mm – 9 mm long	C	
Main member (excluding BFBs)	Missing	Any	A	
Main member	Crack at bearing zone	> 300 mm long	C	
Main member	Corrosion loss	Perforation to any level element	C	

Member	Defect Type	Defect Size	Defect Category	Mandatory Repair Priority*
A. Underbridges – steel and wrought iron				
Main member	Corrosion loss	> 60% section loss	C	
Main member	Corrosion loss	30-60% section loss	D	
Main member	Corrosion loss	< 30% section loss	E	
Secondary member	Crack	Any	D	
Secondary member	Missing	Any	B	
Secondary member	Corrosion loss	Perforations to any element	D	
Main member fastenings (at connections)	Bolts/rivets missing	> 60%	A	
Main member fastenings (at connections)	Loose	> 60%	B	
Main Member Fastenings (at connections)	Loose/missing	40-60%	B	
Main member fastenings (at connections)	Loose/missing	20-39%	C	
Main member fastenings (at connections)	Loose/missing	10-19%	D	Ry2
Main rivets	Corroded away in any 600mm length of girder	> 50% of rivet heads	C	

Member	Defect Type	Defect Size	Defect Category	Mandatory Repair Priority*
A. Underbridges – steel and wrought iron				
Main rivets	Corroded away in any 600mm length of girder	≤ 50% of rivet heads	D	Ry2
Secondary fastenings	Missing	> 75%	B	
Secondary fastenings	Loose	> 75%	C	
Secondary fastenings	Loose/missing	50-75%	D	
Secondary fastenings	Loose/missing	25-49%	E	Ry2
Segmental bearings	Locked over		D. Reset, but only after structural/ geotechnical investigation into abutment stability	
Bed or bearing plate HD bolts	Missing/broken	> 50%	D	
Bed or bearing plate HD bolts	Missing/broken	≤ 50%	E	Ry2
Bed plate	Broken		D	
Bearing pads	Broken/missing mortar	> 25%	D	
Bearing pads	Broken/missing mortar	≤ 25%	E	
Painting – any member	Flaking paint	Any	D	

Member	Defect Type	Defect Size	Defect Category	Mandatory Repair Priority*
A. Underbridges – steel and wrought iron				
Impact damage				
Track	Out of alignment (bridge has moved)	> 50 mm	A	
Track	Out of alignment (bridge has moved)	30 mm – 50 mm	B	
Track	Out of alignment (bridge has moved)	≤ 30 mm	D	
Main member	Major structural damage	Structure likely to be unable to carry load	A	
Girder flange	Flange outstand deformed vertically	> 60 % of outstand width	B	
Girder flange	Flange outstand deformed vertically	30-60 % of outstand width	C	
Girder flange	Flange outstand deformed vertically	20-29 % of outstand width	D	
Girder flange	Flange outstand deformed vertically	< 20 % of flange outstand width	E	
Girder flange	Flange deformed horizontally within bracing bay	> 60 mm	B	

Member	Defect Type	Defect Size	Defect Category	Mandatory Repair Priority*
A. Underbridges – steel and wrought iron				
Girder flange	Flange deformed horizontally within bracing bay	30 mm – 60 mm	C	
Girder flange	Flange deformed horizontally within bracing bay	20 mm – 29 mm	D	
Girder flange	Flange deformed horizontally within bracing bay	< 20 mm	E	
Girder flange	Notched	> 30 mm	B	
Girder flange	Notched	≤ 30 mm	C	
Trestle	Column deformed in any direction	> 100 mm	A	
Trestle	Column deformed in any direction	50 mm – 100 mm	B	
Trestle	Column deformed in any direction	25 mm – 49 mm	D	
Trestle	Column deformed in any direction	< 25 mm	E	
Main rivets	Sheared off in any 600 mm length of girder length	> 50 % of rivets	D	
Main rivets	Sheared off in any 600 mm length of girder	≤ 50 % of rivets	E	

Member	Defect Type	Defect Size	Defect Category	Mandatory Repair Priority*
Main rivets	Sheared off in any 600mm length of girder	≤ 50 % of rivets	E	
Any joint fastenings	Rendered ineffective	> 50 %	B	
Any joint fastenings	Rendered ineffective	≤ 50 %	D	
B. Underbridges – broad flange beams				
All the above limits for steel and wrought iron under bridges apply to BFB underbridge, except for the 'main girder/truss' and 'new crack' items, which are to be replaced with the following.				
Unplated BFB spans				
BFB flange	Crack	> 25 mm	A	
BFB flange	Crack	10 mm – 25 mm	B - Observe under load. Stop road traffic during passage of each train	
BFB flange	Crack	5 mm – 9 mm	B	
BFB flange	Crack	< 5 mm	C	
Plated BFB spans				
Both BFB flange and flange plate	Crack	> 2 5mm	A	
Both BFB flange and flange plate	Crack	10 mm – 25 mm	B - Observe under load. Stop road traffic during passage of each train	

Member	Defect Type	Defect Size	Defect Category	Mandatory Repair Priority*
B. Underbridges – broad flange beams				
Both BFB flange and flange plate	Crack	10 mm – 25 mm	B - Observe under load. Stop road traffic during passage of each train	
		5 mm – 9 mm	B	
		< 5 mm	C	
		> 50 mm	A	
Either BFB flange or flange plate	Crack	20 mm – 50 mm	B - Observe under load. Stop road traffic during passage of each train	
		10 mm – 19 mm	B	
		< 10 mm	C	

Member	Defect Type	Defect Size	Defect Category	Mandatory Repair Priority*
C. Underbridges – timber				
The following maintenance limits are based on nominal 300 mm x 300 mm timber section.				
Girder/corbel	Pipe / trough in any girder or corbel	> 250 mm	A	
		226 mm – 250 mm	B	
		200 mm – 225 mm	C	
		151 mm – 199 mm	D	
		50mm - 150mm	E	
	Crushing		B	
Solid headstock	Pipe / trough	> 250 mm	A	
		226 mm – 250 mm	B	
		200 mm – 225 mm	C	
		151 mm – 199 mm	D	
		50 mm – 150 mm	E	
	Crushing	Any	B	
Girder	Mid-span deflection	4.27 m span > 8 mm 4.57 m span > 9 mm 7.32 m span > 20 mm 7.92 m span > 22 mm	B	

Member	Defect Type	Defect Size	Defect Category	Mandatory Repair Priority*
C. Underbridges – timber				
Girder / corbel small section 250 mm x 150 mm	Rotted out		B	
Waling headstock	Rotted out		B	
Waling Sill	Rotted out		C	
Body bolts	Loose	> 25 %	D	
	Loose	≤ 25 %	E	
Corbel bolts	Loose	> 25 %	D	
	Loose	≤ 25 %	E	
Trestle bolts	Loose	> 25 %	D	
	Loose	≤ 25 %	E	
Piles	Section loss in more than 50% of piles in any trestle or abutment	> 75 %	A	
	Section loss in more than 25% of piles in any trestle or abutment	> 75 %	B	
	Section loss in any pile	> 75 %	C	
	Section loss in any pile	50 - 75 %	D	
	Section loss in any pile	40 – 49 %	E	
	Pumping	Any	D	
Decking	Split or rotted out	> 20 %	D	

Member	Defect Type	Defect Size		Defect Category	Mandatory Repair Priority*
C. Underbridges – timber					
Abutment and wingwall sheeting	Broken, decayed, missing or displaced	Any		D	
Any timber section	Termite infestation	Any evidence of damage		C	
D. Underbridges – timber transoms					
		Track class			
		1, 2, 3	5		
Transoms	Ineffective	3 adjacent	4 adjacent	B	
		2 adjacent	3 adjacent	C	
		2 in 3	2 adjacent	D	
		One isolated		E	
Transom bolts	Missing	3 adjacent transoms	4 adjacent transoms	B	
		2 adjacent transoms	3 adjacent transoms	C	
		One transom (2 bolts) isolated	2 adjacent transoms	D	
	Loose	Any		E	Ry2

Member	Defect Type	Defect Size	Defect Category	Mandatory Repair Priority*
E. Underbridges – concrete				
Main-PSC or RC	Differential deflection between units under live load	Visible	C	
Main-PSC	Crack	Other than shrinkage (surface) crack > 0.3 mm	B	
Main-RC	Crack	> 3 mm wide	C	
Main-RC	Crack	1 mm –3 mm wide	E	Ry2
Main reinforcing bar	Section loss in one bar	> 30 %	D - Undertake diagnostic testing	
Stirrup reinforcing	Section loss in one bar	> 60 %	D - Undertake diagnostic testing	
Pre-stressing ducts/tendons	Exposed	Any	C	
Piers/abutments	Crack	> 5 mm wide and 1 m long, especially under bearings	C	
Piers/abutments	Crack	3 mm – 10 mm wide	E	
Wingwall	Crack	> 5 mm wide and 2 m long	C	
		3 mm – 10 mm wide	E	
	Lateral dislocation	> 20 mm	D	
Member	Defect Type	Defect Size	Defect Category	Mandatory Repair Priority*
E. Underbridges – concrete				
Piers/abutments	Crack	3 mm – 10 mm wide	E	

Wingwall	Crack	> 5 mm wide and 2 m long	C	
		3 mm – 10 mm wide	E	
	Lateral dislocation	> 20 mm	D	
Deck	Spalling	> 1 square metre with exposed reinforcing	D - Undertake diagnostic testing	
		300 mm x 300 mm and no reinforcing exposed	E - Undertake diagnostic testing	Ry2
Deck – joint between slabs	Fouling with ballast/debris	Any	D	
Impact damage				
Main	Deformation	Any	A	
Main-PSC or RC	Crack	Other than shrinkage (surface) crack more than 0.3 mm	A	

Member	Defect Type	Defect Size	Defect Category	Mandatory Repair Priority*
F. Underbridges – masonry and concrete arch				
For piers, abutments, wingwalls and reinforcement see 'Underbridges – concrete'.				
Arch ring	Brickwork dislocation	> 50 % in any square metre missing or unbonded	B	
		20-50 % in any square metre missing or unbonded	D	
	Longitudinal cracking (along arch barrel)	> 3 mm wide, through and across full arch width Visible differential movement under live load	B	
		2 mm – 3 mm and not through and across	D	
		< 2 mm and not through and across	E	
	Circumferential cracking (along arch profile)	> 6 mm wide and > 2 m long along arch	C	
		3 mm – 6 mm wide, or > 6 mm wide and < 2 m long along arch	D	
	Distortion of profile	> 50 mm – detectable by undulations in top line of spandrel walls/parapets or track	D	
		20 mm – 50 mm	E	
Other than arch	Brickwork dislocation	> 50 % in any square metre missing or unbonded	D	
		20-50 % in any square metre missing or unbonded	E	

Member	Defect Type	Defect Size	Defect Category	Mandatory Repair Priority*
F. Underbridges – masonry and concrete arch				
Spandrel wall	Displacement	Longitudinal > 30 mm, or > 20 mm longitudinal + 20 mm tilt	D	
		15 mm – 30 mm	E	
Culvert floor	Heaving	> 50 mm	D	
		25 mm – 50 mm	E	
Any other	Brickwork dislocation	Nil	D	
Brickwork mortar	Missing or loose	More than 30 % in any square metre missing or loose	D	
		10-30 % in any square metre missing or loose	E	
G. Underbridge – bearings				
Bearings		Any degradation	D	
H. Culverts and pipes				
For reinforcement, see 'Underbridges – concrete'.				
Culvert, corrugated metal pipe or timber box drain	Collapse	Subsidence of formation/ballast	A	
		No subsidence of formation/ballast	C	
	Blocked	75-100 %	C	
		50-74 %	D	
		20-49 %	E	Ry2

Member	Defect Type	Defect Size	Defect Category	Mandatory Repair Priority*
G. Culverts and pipes				
Culvert	Cracked barrel	> 50 mm	B	
		10 mm – 50 mm	D	
		< 10 mm	E	
Corrugated metal pipe	Joint broken	-	D	
	Out of round / distortion	> 50 mm	D	
Headwall/wingwall	Cracked	> 50 mm wide	B	
		10 mm – 50 mm wide	D	
		< 10 mm	E	
Apron	Scouring under	> 2 m	C	
		Any	D	
Floor	Heaving	> 50 mm	D	
		25 mm – 49 mm	E	
Adjacent waterways	Blocked - Geotechnical risk site	> 25 %	C	
	Blocked	> 25 %	D	

Member	Defect Type	Defect Size	Defect Category	Mandatory Repair Priority*
H. Overbridges – timber				
The following maintenance limits are based on nominal 300 mm x 300 mm timber section. The restrictions are to be applied to the road across the overbridge.				
Girder/corbel	Pipe/trough in any girder or corbel	> 250 mm	A – Close bridge	
		226 mm – 250 mm	B	
		200 mm – 225 mm	C	
		151 mm – 199 mm	D	
		50 mm – 150 mm	E	
	Crushing		B	
Solid headstock	Pipe/trough	> 250 mm	A – Close bridge	
		226 mm – 250 mm	B	
		200 mm – 225 mm	C	
		151 mm – 199 mm	D	
		50 mm – 150 mm	E	
	Crushing	Any	B	
Girder	Mid-span deflection	4.27 m span > 8 mm 4.57 m span > 9 mm 7.32 m span > 20 mm 7.92 m span > 22 mm	B	
Girder/corbel small section 250 mm x 150 mm	Rotted out		B	Girder/corbel small section 250 mm x 150 mm

Waling headstock	Rotted out		B	Waling headstock
Waling sill	Rotted out		C	Waling sill
Body bolts	Loose	> 25%	D	

Member	Defect Type	Defect Size	**Defect Category**	**Mandatory Repair Priority***
H. Overbridges – timber				
Body bolts	Loose	≤ 25 %	E	
Corbel bolts	Loose	> 25 %	D	
		≤ 25 %	E	
Trestle bolts	Loose	> 25 %	D	
		≤ 25 %	E	
Piles	Section loss in > 50 % of piles in any trestle or abutment	> 75 %	A - Stop trains	
	Section loss in > 25 % of piles in any trestle or abutment	> 75 %	B	
	Section loss in any pile	> 75 %	C	
		50-75 %	D	
		40-49 %	E	
Decking planks (transverse)	Broken or missing, bolts protruding	2 or more adjacent planks have collapsed	B	
		Isolated planks have collapsed	C	
Decking planks (longitudinal)	Rotted out or loose, bolts protruding	2 or more adjacent planks have collapsed	B	
		Isolated planks have collapsed	C	
Wearing surface	Holes or lifting	Any	C	

Member	Defect Type	Defect Size	Defect Category	Mandatory Repair Priority*
I. Footbridges and overbridges				
In addition to the following, underbridge defect limits also apply where applicable.				
Brick parapets	Horizontal crack	> 3 mm wide and > ½ of parapet width and > 2 m long	D	
Brick parapets	Vertical crack	Any crack full height and full width of parapet	D	
Pedestrian safety aspects				
The bridge and stepway maintenance triggers described are of a structural nature, and intentionally do not cover defects in walking surface finishes (e.g. tiles) and associated anti-slip requirements.				
Pedestrian barriers	Missing / broken	Any	B - Seal off area	
	Missing / displaced chain wire infill	Any	B - Seal off area	
	Missing vertical balusters	Any	B - Seal off area	
	Missing displaced metal sheet	Any	B - Seal off area	
	Loose	Any	D	
	Missing bolts	Any	D	
Traffic barriers	Missing / broken / loose	Any	C	
Deck	Walkway planks	Broken, decayed, missing or displaced	B - Seal off area	
	Cracks in AC / FC sheets	Any	B - Seal off area	

Member	Defect Type	Defect Size	Defect Category	Mandatory Repair Priority*
I. Footbridges and overbridges				
Deck-nails, screws	Protrusion above deck	> 10 mm	C	
		≤ 10 mm	D	
Safety screens	Missing/broken	Any	C	
Safety screen fixings	Defective	> 50 %	C	
		25-50 %	D	
Timber railing, posts	Section loss	> 25 %	D	
Protection screens	Missing/broken/ loose	Any	D	
	Missing bolts	Any	D	
Stepways (also includes balustrade and handrail references above)				
RC stepway tread	Broken front edges	> 150 mm long and 35 mm deep	C	
		> 50 mm long and 15 mm deep	D	
	Cracked	> 2 mm wide	D	
RC stepway landing	Cracked	> 2 mm wide	D	
		≤ 2 mm wide	E	
Stepway reinforcing	Protruding at toe	Any	C	
Stepway tread	Rocking between heel and toe	> 5 mm	C	
		2 mm – 5 mm	D	
	Slope heel to toe	> 15 mm	D	
		5 mm – 15 mm	E	

Member	Defect Type	Defect Size	Defect Category	Mandatory Repair Priority*
J. Underbridge walkways and refuges				
Walkway and refuge handrails	Missing/broken	Any	B - Seal off area	
Walkway and refuge handrails	Broken, decayed, displaced or missing	Any	B - Seal off area	
Walkway fastenings	Loose or missing	Any	D	
K. Underbridge guardrails				
Guardrail	Missing	-	D	
	Undersize	-	D	
Vee section	Missing/end not closed	-	D	
Fastenings	Missing/loose	-	D	
L. Underbridge road / pedestrian safety aspects				
Clearance signs	Missing	-	D	
	Not legible	-	D	
Ballast	Falling	-	D	
M. Underbridge ballast logs/walls				
Ballast log	Missing/rotted out	-	D	
Ballast wall	Decayed, displaced or missing	-	D	

Member	Defect Type	Defect Size	Defect Category	Mandatory Repair Priority*
N. Tunnels				
Roof/wall	Brickwork dislocation	> 30 % in any square metre missing or unbonded	C	
		10-30 % in any square metre missing or unbonded	E	
	Longitudinal cracking (along tunnel)	> 5 mm wide and more than 5 m long	B	
		2 mm – 5 mm and more than 5 m long	C	
		≤ 2 mm and more than 5 m long	D	
	Circumferential cracking (along tunnel profile)	> 5 mm wide and > 2 m long along tunnel profile	D	
		> 5 mm wide and ≤ 2 m long along tunnel profile	E	
	Seepage	Causing corrosion of track fastenings	D	Ry1
		Any	E	
	Spalling	Through the lining or of whole bricks	D	
Portal	Crack	> 50 mm wide	B	
		10 mm – 50 mm wide	D	
		≤ 10 mm	E	

Member	Defect Type	Defect Size	Defect Category	Mandatory Repair Priority*
O. Retaining walls and platform walls				
Retaining wall	Crack	> 10 mm wide and > 2 m long	C	
		> 10 mm wide and ≤ 2 m long	D	
		5 mm – 10 mm wide	E	
	Lateral dislocation	> 20 mm	C	
		10 mm – 20 mm	E	
Platform wall	Crack	> 50 mm wide	C	
		10 mm – 50 mm wide	D	
		< 10 mm	E	
Platform coping	Separation from platform surface and / or wall	Visible	D - Check clearances for possible infringement	
	Broken edging	Any	D	
P. Gabion walls				
Gabion baskets - bridges	Damaged	Loss of tension/rocks spilling out	D	
	Lateral dislocation	> 100 mm	D	

G.2.1 Repair priority table

Informative

Table E.3 – Repair priority table

Repair class	Timeframe	Applicable defect category
Rm1	Repair within 1 month	Applies to Defect Categories A to D
Rm6	Repair within 6 months	Applies to Defect Categories A to D
Ry1	Repair within 1 year	Could apply to any Defect Category
Ry2	Repair within 2 years	Could apply to any Defect Category
Ry5	Repair within 5 years	Applies to Defect Category E only
Ryxx	No repair for 5 years	Applies to Defect Category E only
Mm1	Monitor monthly	Applies to Defect Categories A to D
Mm6	Monitor half yearly	Applies to Defect Categories A to D
My 1	Monitor yearly	Applies to Defect Categories A to D
Axx	Assess/inspect next inspection	Applies to Defect Category E only

Appendix H Structurally critical members

Informative

Table F:1 – Structurally critical members

Span Type	Structurally critical member	Details of critical areas
A: Steel and wrought iron underbridges		
Plate web deck, RSJ and BFB	Main Girders	Bottom flange: middle third of span and at any changes in flange plates
		Top flange: middle third of span and over intermediate piers
		Flange and web splices
		Web: at support
Plate web through		Bottom flange and end connectors
		Flange and web splices
	Cross girders	Web: at support
	Stringers	Bottom flange: middle half of span, at any changes in flange plates and end connections
		Web: at support
Lattice girders	Top chord	Over intermediate piers and buckling at mid-spans (arches)
	Bottom chord	Middle third
	Arches / portal frames	Mid-span arches at end connections
	Stringers (2nd generation)	Bottom flanges and splices: middle third
	Cross girders	Connections to bottom chord: Middle third of bottom flange
	Diagonal lattice bars	Whole member, including chord connections, especially in the vicinity of supports

Span Type	Structurally critical member	Details of critical areas
A: Steel and wrought iron underbridges		
Trusses (Pratt)	Top / bottom chord	Whole member including connections
	Web verticals / diagonals	Whole member including connections
	Portal frames	All frames including end connections
	Cross girders	Bottom flange and end connections, flange and web splices
	Stringers	Middle half of span, at any changes in flange plates and end connections, flange and web splices.
B: Timber bridges		
All spans	Girders	Middle third (bending) and over corbels (shear)
	Corbels	Over headstocks (shear)
	Headstocks	Nil
	Piles	At ground level, and 500 mm above and below ground level
	Transverse decking	Middle third (bending)
C: Concrete bridges		
All spans	Pre-stressed and reinforced concrete girders	Middle third of span
		Over supports (shear)

Appendix I Steel materials properties

Normative

Table H:1 Steel material properties

Material	Yield (MPa)	Ultimate (MPa)	Elongation (%)	Capacity factor (f)
Wrought iron (1) (2)	190 longitudinal 150 transverse	300	10	0.85
Steel < 1910 (2)	210		20	
Steel 1910 – 1940 (2)	230		20	
Steel 1941- 1969 (2)	240		20	
Steel after 1970 (2)	250		20	0.9
Rivets (3)				
Wrought iron	Use same properties as plate			0.8
Steel	Use same properties as for plate of relevant period			0.8

Notes:

1. *Plastic properties not to be used if elongation <5%.*
2. *Reduce yield by 5% where sections >20mm thickness are used.*
3. *Field/hand-driven rivets are assumed to be equivalent to shop rivets. All rivets, irrespective of installation method, have demonstrated satisfactory performance over the years.*

Appendix J Specification of steel fabrication of sections

Normative

Materials	Specifications
Rolled Sections	AS / NZS 3679.1
Flange and web plates	AS / NZS 3678
Other plates and flats	AS / NZS 3678, AS/NZS 1594
Hollow sections	AS 1163
High-strength structural bolts, nuts, and washers	AS / NZS 1252 for manufacture AS 1214 for galvanizing AS 4100 for assembly AS / NZS 5131
Product Grade C bolts, nuts, and washers	AS 1112.3, AS 1111.1 & AS 1237 for manufacture AS 1214 for galvanizing AS 4100 for assembly AS / NZS 5131

Note: Also refer to RIM specifications as required

Appendix K Load rating results table

Informative

The bridge load summary table below provides a sample template that can be used to capture load rating data.

<table>
<tr><th colspan="16">Load rating results table</th></tr>
<tr><td colspan="3">Bridge and type:</td><td colspan="7">Central Road underbridge[1]</td><td colspan="3">Km:</td><td colspan="3">M 270</td></tr>
<tr><td colspan="3">Location:</td><td colspan="7">Central station</td><td colspan="3">Design drawing load capacity:</td><td colspan="3"></td></tr>
<tr><td colspan="3">Route and tracks:</td><td colspan="7">Main suburban: up and down main</td><td colspan="3"></td><td colspan="3"></td></tr>
<tr><td colspan="3">Load Rating Reference Vehicle</td><td colspan="7">300LA</td><td colspan="6">Designed train load (DTL)</td></tr>
<tr><td colspan="3">Critical design components</td><td colspan="2">As new</td><td colspan="5">As is</td><td colspan="2">As new</td><td colspan="4">As is</td></tr>
<tr><td>Bridge member / connection / critical section</td><td>Design action</td><td>As-is section loss (% thickness loss and element)</td><td>Rating factor</td><td>Rated load</td><td>Rating factor</td><td>Rating load</td><td>Rating load without DLA</td><td>Reduced speed for RF=1 (if applic.)</td><td>Reduced live LF for RF=1 with full DLA (if applic.)</td><td>Rating factor</td><td>Rated load</td><td>Rating factor</td><td>Rating load</td><td>Rating load without DLA</td><td>Reduced speed for RF=1 (if applic.)</td></tr>
<tr><td>Main girder (end)[1,2]</td><td>Shear</td><td>20% web thickness</td><td>1.00</td><td>300LA</td><td>0.91</td><td>273LA</td><td>335LA</td><td>41 km/h</td><td>1.2</td><td>1.4</td><td>1.4DTL</td><td>1.3</td><td>1.3DTL</td><td>1.6DTL</td><td>N/A</td></tr>
</table>

[1] Heading and data in italics for demonstration purposes only.
[2] Add rows for additional structure sections.

Appendix L Bibliography

Informative

The following referenced documents are used by this Standard for information only:

(a) AS 1012: Methods of Testing Concrete Series
(b) AS 1085.1: Railway Track Material, Part 1 Steel Rails
(c) AS 1379: Specification and Supply of Concrete
(d) AS 1449: Wrought Alloy-steels – Stainless and Heat-resisting Steel Plate, Sheet and Strip
(e) AS 1530.4: Methods of Fire Tests on Building Materials, Components and Structures
(f) AS 1604: Specification for Preservative Treatment Series
(g) AS 1680: Interior Lighting
(h) AS 1684: Residential Timber Series
(i) AS 1720.1: Timber Structures – Design Methods
(j) AS 1726: Geotechnical Site Investigations
(k) AS 1851: Maintenance of Fire Protection Systems and Equipment
(l) AS 1939: Degrees of Protection Provided by Enclosures for Electrical Equipment
(m) AS 2293: Emergency Escape Lighting and Exit Signs
(n) AS 2870: Residential Slabs and Footings
(o) AS 3000: Electrical Installations (known as the Australian / New Zealand Wiring Rules)
(p) AS 3013: Electrical Installations – Classification of the Fire and Mechanical Performance of Wiring System Elements
(q) AS 3700: Masonry Structures
(r) AS 3735: Concrete Structures Retaining Liquids
(s) AS 3818.1: Timber – Heavy Structural Products – Visually Graded, Part 1 General Requirements
(t) AS 3818.2: Timber – Heavy Structural Products – Visually Graded, Part 2 Railway Track Timbers
(u) AS 4600: Cold-formed Steel Structures
(v) AS 4678: Earth Retaining Structures
(w) AS 4997: Guidelines for the Design of Maritime Structures
(x) AS 5604: Natural Durability Ratings
(y) AS 7639: Track Structures & Support Systems
(z) AS 7640: Rail Management
(aa) AS 7664: Railway signaling cable routes, cable pits, and foundations
(bb) AS 7702: Rail equipment type approval

(cc) AS / NZS 1050: Methods for the Analysis of Iron and Steel Series
(dd) AS / NZS 1080: Timber – Methods of Testing Series
(ee) AS / NZS 4063: Characterisation of Structural Timber Series
(ff) AS / NZS 4455.3, Masonry Units, Pavers, Flags and Segmental Retaining Wall Units – Segmental Retaining Wall Units
(gg) AS / NZS 4671: Steel Reinforcing Materials
(hh) AS / NZS 5313 Structural steelwork - Fabrication and erection
(ii) AS / NZS 15288: Systems Engineering
(jj) AS ISO 354: Acoustics – Measurement of Sound Absorption in a Reverberation Room
(kk) AS ISO 13822 Basis for Design of Structures – Assessment of Existing Structures
(ll) ISO 14837-1: Mechanical Vibration – Ground-borne Noise and Vibration Arising from Rail Systems, Part 1 General Guidance
(mm) EN 10168 Steel Products – Inspection Documents – List of Information and Description
(nn) EN 10204 Metallic Products – Types of Inspection Documents
(oo) RISSB Code of Practice - Derailment Containment and Protection for Rail Underbridges
(pp) Australian Rainfall and Runoff – Geoscience Australia
(qq) Bridge Waterway Manual
(rr) National Construction Code 2019 Volume 1 and 2
(ss) Waterway Design – Austroads
(tt) WorkCover code of Practice – Tunnels under Construction

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