

Structures

Section 9

Applicability

ARTC Network Wide SMS

Publication Requirement

Internal / External

Primary Source

Document Status

Version #	Date Reviewed	Prepared by	Reviewed by	Endorsed	Approved
3.6	22 September 2017	ARTC Technical Standards	Stakeholders	Manager Standards	A/General Manager Technical Standards 22/09/2017

Amendment Record

Amendment Version #	Date Reviewed	Clause	Description of Amendment
3.0	24 Nov 09		Updated to reference use of existing NSW Standards for Walkways and Guard Rail requirements
3.1	27 Apr 10	9.2.1; 9.2.2; 9.2.4; 9.4.4; Various	Specific positions within ARTC structure added; Clause on maintenance work added; Word bridge(s) replaced with structures and minor reformatting
3.2	18 Jun 10	9.4.2; 9.4.4; 9.4.5; 9.5.2	Title changed to Temporary Work for Construction; Maintenance Work requirements updated; Requirements for As-Built Drawings updated; Nosing load requirements updated. Banner added regarding mandatory requirements in other documents and alternative interpretations.
3.3	24 Oct 11	9.3.3; 9.3.5; 9.3.11;	Certification – third party verification added; Design Loads – Hunter heavy haulage design load 350LA added; Transom Design – Timber

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		9.3.12; 9.3.13; 9.4.4; 9.5.2	properties added; Walkways/Refuges/Handrails – Introduction of new Walkway policy in NSW; Guard Rails – Introduction of new Guard Rails policy in NSW; Maintenance Work – reference number updated; Loads and Loading Factors – Wind Load – further clarified. Minor editorial change to remove CRN applicability box.
3.4	10 Feb 14	Various	Updates and clarifications on competency levels for structures staff, culvert design reference, EGP-03-01 reference to certification of drawings, use of bridge approach slab as transition approach, walkway/refuge/handrail requirements, re-badged BSS 01 made obsolete, guard rail maintenance, road traffic barrier requirements, service duct location, nosing load deleted as covered in AS 5100, clarification on when an inspection is 'compliance', inspection and maintenance of third party structures and redundant structures. Other minor editorial updates throughout. Further updates to Clause 9.3.2 Competency Requirements and Clause 9.7.5 Redundant Structures following OSERG review 8/09/2014.
3.5	03 Jul 17	Various	Minor editorial changes. Communication towers added to structures discipline. The roles of structures personnel removed. "Safety in Design" added. Transom design section revised completely to include Australian Standards and transom thickness for steel spans with 4 girders. Load rating for road bridges revised to include new load limit signage.
3.6	22 Sept 2017	9.5.2	LL factor specified as 1.4

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Mandatory requirements also exist in other documents.

Where alternative interpretations occur, the Manager Standards shall be informed so the ambiguity can be removed. Pending removal of the ambiguity the interpretation with the safest outcome shall be adopted.

9 Section 9: Structures

9.1 General

Structures generally include bridges, culverts, tunnels and miscellaneous structures, as shown in Table 9.1 below;

Asset Class	Structure Type
Bridges	Underbridge
	Overbridge
	Footbridge
Culverts	Large Culvert
	Small Culvert
Tunnels	Tunnel
Miscellaneous Structures	Access (i.e. stairs, walkways)
	Buffer stop (includes "Stop block")
	Culvert non-track
	Communication Towers
	Flood structure
	Lighting Gantry
	Lighting Tower
	Loading Structures (e.g. Loading Bank)
	Overhead Service crossing
	Small Retaining wall
	Large Retaining wall (> 2m in height)
	Signal gantry
	Sound barrier (including fencing)
	Turntable
Water Structures	
Weighbridge	

Table 9.1 – Asset Class and Structure Type

9.2 Responsibilities

Business Unit management is responsible for delegating and documenting responsibility for each function of the management of structures assets, as described by this section of the Code of Practice. All functions must be delegated to and carried out by competent rail industry workers.

The National Bridge and Structures Engineer supports Business Unit Management by providing subject matter expert (SME) advice in the management of structures assets; to ensure that risks to rail safety and operations are maintained at an acceptable level.

9.3 Design

The Code of Practice sets out the requirements for the design of railway, road and pedestrian bridges, culverts and other significant structures. It defines requirements specifically or by reference to relevant Australian Standards.

“Safety in Design” is mandated by statutory requirements and shall be incorporated into the design.

The safety in design process shall identify potential hazards and the potential risks to persons during construction, future operation, maintenance and eventual decommissioning of an asset. During the design phase, risks shall be eliminated or minimised. Residual risks shall be documented in accordance with ARTC’s risk management procedures.

9.3.1 Basis of Design

Bridge design shall be carried out in accordance with the Australian Bridge Design Standard AS 5100 and RISSB’s Australian Railway Infrastructure Standard AS 7636 Railway Structures.

AS 5100 sets out the requirements for the design, using limit states principles, of the following:

- Bridges that are required to support road traffic loads
- Bridges that are required to support railway loads, e.g. railway bridges
- Bridges that are required to support tramways (light rail loads)
- Pedestrian bridges, including bicycle and wheelchair access
- Other structures that are required to support road and railway traffic, e.g. culvert and structural components related to tunnels, except those covered specifically by other Standards
- Structures, other than bridges, that are required to support or resist road or railway traffic loads, e.g. retaining structures, deflection walls and sign gantries
- Structures built over or adjacent to railways, or both

Culvert design shall be carried out in accordance with the Precast Reinforced Concrete Box Culverts Standard AS 1597, Design for Installation of Buried Concrete Pipes Standard AS 3725, Precast Concrete Pipes Standard AS 4058, Buried Corrugated Metal Structures Standard AS 2041 and Long-span Corrugated Steel Structures AS 3703.

Design of all other structures shall be carried out in accordance with relevant Australian Standards.

9.3.2 Competency Requirements

The designs and design approvals shall only be carried out by persons holding the appropriate competency to undertake design and design approval in the field of structures, as per the ARTC Rail Safety Worker Competence Matrices.

9.3.3 Acceptance by ARTC

ARTC Acceptance of Drawings:

- All drawings shall be accepted on behalf of ARTC by the applicable discipline competent project or maintenance engineer
- The drawings shall be accepted as complying with the engineering requirements of the project

9.3.4 Certification

All "Issue for Construction Drawings" shall be signed by the Design Engineer, and counter signed by the Design Check Engineer. Third party independent verification certificate for all construction drawings must be provided unless ARTC waives this requirement.

All design changes shall comply with the requirements of Rail Network Configuration Management Procedure EGP-03-01.

9.3.5 Requirements of other Authorities and Government Departments

ARTC is responsible for obtaining all statutory approvals for all new design and rehabilitation work as necessary.

9.3.6 Design Loads

All structures shall be designed for the loading effects prescribed in AS 5100 and/or AS 7636 unless otherwise loading is specified by the ARTC.

For rail traffic load other than 300LA design load, the load shall be taken as the proportion of the 300LA design load.

As a minimum, when rail traffic loading is not specified:

- Rail bridges and culverts shall be designed to 300LA
- Rail bridges and culverts on the NSW Hunter heavy haulage lines between Newcastle and Muswellbrook, Muswellbrook and Ulan and, Muswellbrook and Narrabri shall be designed to 350LA design load
- Road bridges shall be designed to SM1600 and W80 wheel loads
- Walkways and Footbridges shall be designed for 5kPa

9.3.7 Clearances

Horizontal and vertical clearances for structures (adjacent to and over the track) shall comply with Section 7 of this Code of Practice (or as approved by the ARTC).

All structures over road traffic access with less than the regulated vertical clearance shall have overhead road clearance signs posted on them.

9.3.8 Waterways

ARTC can set the return precipitation event for a particular waterway or drainage system. As a minimum, when the return precipitation event is not specified by the ARTC, the flood openings shall be designed to accommodate the following:

- Major under track structures (discharge equal to or greater than 50m³/sec): 100 year precipitation event;
- Minor under track structures (discharge less than 50m³/sec): 50 year precipitation event;
- Structures not under track: 50 year precipitation event.

Refer to AS 7636.

9.3.9 Abutment Transition Approach

Reinforced soil transition approach, ballast trough 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.

Approach slab with one end seated on abutment is not to be used for a transition approach unless the slab is designed as an integral structural component for the stability of abutment or to square off a skewed abutment. The design must ensure that there is no uplift on abutment that could cause track misalignment due to any differential settlements at opposite end of the slab.

Refer to AS 7636.

9.3.10 Transom Design

9.3.10.1 Transom

Transoms are now available in a variety of materials. ARTC still uses hardwood timber transoms extensively.

Transoms manufactured from fibre composite materials or any other materials shall be designed, manufactured and supplied by ARTC approved supplier.

Specific requirements for timber transoms are as follows:

- Timber stress grade shall be F22 or higher.
- Structural grade and timber species shall comply with the requirements of Table 9.2 below.
- Timber must be free of loose knots, unsound knots and knot holes.
- Want, wane and sapwood, individually or in aggregate, shall not exceed one seventh of the cross-section nor two fifths of the wide face on which it occurs.

All other requirements for transom timber must comply with the following standards:

- AS 1720.1 – “Timber structures – Design methods”.
- AS 2082 – “Timber Hardwood - Visually Stress - graded for structural purposes”.
- AS 2878 – “Timber classification into strength groups”.
- AS 3818.1 – “Timber – Heavy structural products – Visually graded, Part 1: General requirements”.

AS 3818.2 - "Timber – Heavy structural products – Visually graded, Part 2: Railway track timbers".

Groups	Common Name	Visual Stress-grade		Botanical Name(s)
		Structural Grade No 1	Structural Grade No 2	
Group 1	Grey Ironbark	F27	F22	E. siderophloia E. drepanophylla E. paniculata
	Red Ironbark	F22	N/A	E. fibrosa E. crebra E. sideroxylon
	Grey Gum	F27	F22	E. punctata E. propinqua
	Tallowwood	F22	N/A	E. microcorys
	White Mahogany	F22	N/A	E. acmenoides
	Woollybutt	F22	N/A	E. longifolia
Group 2	Spotted Gum	F22	N/A	C. maculate C. citriodora C. henryi

Table 9.2 – Transom Timber

9.3.10.2 Transom Size

Transom dimensions and tolerances shall be as stated in Table 9.3 below.

	Dimensions (mm)	Tolerance (mm)
Length	2800, 3000, 3200	+50, -0
Width	250 nominal	+25, -0
Thickness	As per Table 9.3 below	+6, -0

Table 9.3 – Transom Dimensions and Tolerances

9.3.10.3 Transom Thickness and Holding Down Bolt

Some of the transom top steel span rail bridges in Victoria have 4 girders, compared to 2 girders in NSW. It is also relevant that some transom top bridges in Victoria were originally for Broad Gauge track whereas they are now Standard Gauge tracks

Transoms for steel spans with 2 girders or timber spans with 3 girders

For transom top steel and timber rail bridges with span main girders at 2m centres maximum, the transom thickness shall be provided in accordance with Table 9.4 below.

AXLE LOAD & SPACING	TRANSOM SPACING (mm)	MAX SPEED (km/h)	JOINT STRENGTH GROUP ³	HD BOLT SIZE (min) ⁴	TRACK HORIZ. ALIGNMENT	MIN. TRANSOM THICKNESS (mm) ⁵
30t axles as per AS5100 - 300LA Railway Loading	600	115	J1	M30	Straight	190
					Curved	210 ^{1,2}
	500 - 550	80	J1	M30	Straight	185
					Curved	205 ^{1,2}
		115	J1	M30	Straight	170
					Curved	185 ¹ /200 ²
80	J1	M30	Straight	165		
			Curved	180 ¹ /190 ²		
30t axles at ≥1500 centres (120t NHRN Wagons)	500 - 600	115	J1 or J2	M24 (J1)	Straight	150
				M30 (J2)	Curved	165 ¹ /170 ²
		80	J1 or J2	M24 (J1)	Straight	150
				M30 (J2)	Curved	160 ¹ /165 ²
25t axles at ≥1500 centres (100t CHS Wagons)	500 - 600	115	J2	M22	Straight	150
					Curved	150 ¹ /160 ²
		80	J2	M22	Straight	150
					Curved	150 ^{1,2}

Table 9.4 - Minimum Timber Transoms thickness and Holding down Bolt for 2 girder spans

Transoms for steel spans with 4 girders

For transom top steel rail bridges with span main girders at 610, 910 and 610 mm centres maximum, the transom thickness shall be provided in accordance with Table 9.5 below.

AXLE LOAD & SPACING	TRANSOM SPACING (mm)	MAX SPEED (km/h)	JOINT STRENGTH GROUP ³	HD BOLT SIZE (min) ⁴	TRACK HORIZ. ALIGNMENT	MIN. TRANSOM THICKNESS (mm) ⁵
25t axles at ≥1500 centres	400 - 600	115	J1 or JD2	M22	Straight	110
					Curved	120 ^{1,2}
	80	J1 or or JD2	M22	Straight	110	
				Curved	120 ^{1,2}	

Table 9.5 - Minimum Timber Transom thickness and Holding down Bolt for 4 girder spans

Notes on Table 9.4 and 9.5;

Maximum superelevation on curved track = 125 mm

1. Max. track offset in relation to span centreline = 30 mm
 2. Max. track offset in relation to span centreline = 70mm
 3. J groups as specified in Table 2.2 of AS1720.1
 4. Swage Bolts shall be grade 8.8S bolts with reduced tension to suit timber application. All other bolts shall be commercial Grade 4.6.
-

9.3.11 Walkways / Refuges / Handrails

All new walkways / refuges / handrails on rail bridges or in tunnels or on any other structures shall comply with the requirements of AS 5100 and AS 1657;

- The walkways or suitable alternative access shall be provided along both sides of each track across structures where train crews regularly work on the ground for shunting, train inspections, etc.
- The ARTC shall perform a risk assessment to assess if walkways, refuges and/or handrails are required
- Where walkway or wall is within the 3m DANGER ZONE then “safety refuge” shall be provided at 20m intervals, one side for a single track and staggered for multiple tracks
- “Safety refuge” must be located outside of 3m DANGER ZONE unless it is protected against;
 - A flapping tarp / rope or a container door that is open
 - Leaking material from a wagon
 - Fumes and heat from locomotives in tunnels
 - Any other issues identified at risk assessment
- Minimum clear space for refuge shall be 2m in height, 1.5m wide and 0.7m in depth
- Handrails on (or at) structures shall not infringe track clearances specified in CoP Section 7
- Refuge is not required for structures less than 20m in length
- Where walkway, wall or refuge is within 3m DANGER ZONE and unprotected from the above hazards then warning signs as follows must be displayed at;
 - Each end of walkway, retaining wall and tunnel
 - Every 50m along long walkway, retaining wall and tunnel
 - Each refuge



9.3.12 Guard Rails

Guard rails are not required on rail bridges. All the existing guard rails, until removed, shall be safely maintained by Civil Team in accordance with Code of Practice Section 1: Rail.

9.3.13 Road Traffic Barrier

The road traffic barriers for all new road bridges over the interstate rail network and Hunter coal lines shall be designed to minimum standard of **Medium Performance Level** in accordance with AS 5100.

For all other new road bridges, the performance level of road barrier shall be determined in accordance with AS 5100 and approved by ARTC.

For bridge rehabilitation, the existing road barriers to be upgraded to performance levels specified above.

9.3.14 Services

Services, utilities and service ducts shall be designed and fixed to structures so as to allow safe and unimpeded access to the structure for inspection and maintenance.

No services to be installed under bridges or through culverts or attached to structures without prior approval of ARTC.

Where service ducts are attached to a bridge walkway they must be positioned so that they do not encroach on the safe working area or create a trip or other safety hazards.

9.4 Construction and Maintenance Work

9.4.1 General

All construction and contract maintenance shall be performed in accordance with individual contracts.

Refer to AS 7636.

9.4.2 Maintenance Work

All maintenance work on existing structures shall be carried out in accordance with approved construction drawings or on a like-for-like basis or EHG-09-01 Structures Repair Guideline. Where the guideline is used the applicable repair methodology shall be subject to approval by structures representative or competent structures engineer. Any changes to as-designed structures configuration or structurally critical elements shall be approved by a competent structures engineer and accompanied by relevant risk assessment, any additional active inspections and signed off by a competent structures representative. All work shall be carried out in accordance with EGP-03-01 Rail Network Configuration Management and EGN-03-01 Configuration Management Manual.

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

9.5 Load Rating

9.5.1 Structure Load Rating

All existing bridges and culverts shall be assigned "As New" and "As Is" load ratings and fatigue assessment in accordance with AS 5100 Part 7 and AS 7636.

For road bridges, the vehicle mass and/or speed shall be reduced to attain a Rating Factor greater than unity (i.e. $RF > 1.0$). All deficient road bridges shall be sign posted with R6-17 sign in accordance with AS 1742.2 and AS 1743.

9.5.2 Loads and loading factors

The loads and factors are to be in accordance with AS 5100 except as modified/clarified below.

Dead Loads

The combined un-factored dead load of running rails, any existing guard rails and transoms of the track together with/without steel walkway(s) can be taken as 5kN/m unless otherwise more refined analysis is required.

Live Loads

In addition to the standard 300LA design vehicle and RAS vehicles (refer Structures Inspection Procedure, Train Consists). Ratings will normally be required in terms of current trains operating over the structure as nominated by the ARTC.

Load Factors

The value for Live Load factor shall be 1.4 for all current and RAS train consists unless otherwise nominated by the ARTC. All other factors shall be as specified in Table 12.2 (B) AS 5100.7:2017

Wind load

The Serviceability Wind Speed in AS 5100 is 37m/sec. The lower 20m/sec is to be used on Ultimate Limit State live loads with load factor of 1.0 because of the short-term nature of the train loading on the structure.

9.5.3 Fatigue Rating

Where ARTC requires a fatigue analysis to be undertaken, the minimum theoretical remaining fatigue life across all structural elements shall be assessed in accordance with AS 5100.

9.6 Inventory

Structures Management System shall have a minimum set of inventory information for all Structures listed in Table 9.1.

9.7 Inspection and Assessment

9.7.1 Purpose

The purpose is to identify the requirements for systematic inspections so that;

- All structures are fit for purpose to meet operational needs
- The responsibility and accountability for the structures management, inspection and maintenance is identified
- The safety of all operators is ensured
- The need for unplanned downgrading of service conditions is avoided for all structures
- The inspections are carried out in accordance with the approved program, in the correct format and by competent inspectors
- Data is provided for the development of structure management plans including strategic maintenance and replacement programs
- Adequate structural integrity is maintained to an acceptable engineering Standard
- Routine maintenance works are being effectively implemented

The requirements of current AS 4292.2 – Rail Safety Management – Track, Civil and Electrical Infrastructure are being met.

9.7.2 Scope

ARTC shall establish a comprehensive, systematic, condition monitoring and load rating program for structures nominated in Table 9.1. ARTC shall establish a comprehensive, systematic load rating program for structures, as prescribed by ETE-09-01. The program shall comprise the following inspection types:

- Engineering Inspections
- Visual Inspections
- Special Inspections Track Patrol Inspections

9.7.3 Compliance

An inspection is deemed compliant once the inspector has completed on-site inspection of a structure and signed off Maintenance Scheduled Task to certify the structure is safe for the operational purposes.

9.7.4 Third Party Structure

Inspection and maintenance of third party structures shall conform to the requirements of Road-Rail Interface Agreement and/or Infrastructure License Agreement between the parties.

9.7.5 Redundant Structures

Where possible and reasonable to do so, redundant structures and fittings shall be removed or isolated from the public and railway workers. Isolation actions can include filling in, entry barricading, fencing and signage. Some structures may be partially removed, leaving some residual elements in place. Until total removal or isolation, redundant structures, structural elements and fittings shall be subject to inspections called out by Inspection Standard ETE-09-01 and the minimum maintenance assessed as necessary to prevent an increased risk to the public and workers above that considered necessary SFAIRP during the structure's service life. Such inspection and maintenance actions of redundant structures and fittings shall be described in Maintenance Schedules Tasks (MST), and scheduled in Ellipse until such time as the structures are removed or isolated.

ARTC will endeavour to maintain a training package and 2 year refresher course for all ARTC Project Managers and contractor Project Managers in relation to the accurate assessment of any risks to workers or the public arising from unauthorised access to ARTC access tracks, including any risks associated with redundant infrastructure.

9.7.6 Operational Safety

All personnel involved with inspections shall not cause danger, delay, obstruction or stoppage to railway traffic and not interfere with the general business of the ARTC or its operators.

9.7.7 Work Health and Safety

All inspection personnel shall comply with the ARTC's Work Health and Safety procedures.

All inspection personnel shall be appropriately accredited for work on or within rail corridors in accordance with network operational and safe working requirements.

9.7.8 Environment

All inspection procedures shall comply with ARTC's environmental procedures.