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Section 9: Structures

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1.0	20 Mar 23		Document renumbered to ETS-09-00 Minor editorial changes

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9 Section 9: Structures

9.1 General

9.1.1 Reference Documents

- ETS-09-01 Structures Inspection Standard
- ETP-09-01 Structures Inventory Procedure
- ETP-09-02 Structures Inspection Procedure
- EGP-04-01 Engineering Drawings and Documentation
- EGP-03-01 Rail Network Configuration Management
- Section 1 Track and Civil Code of Practice: Rail
- Section 7 Track and Civil Code of Practice: Clearance.

9.1.2 Definitions

The following terms and acronyms are used within this document:

Term or acronym	Description
ARTC	Australian Rail Track Corporation Ltd.
Significant track work	Major work changing the alignment of the track, including track lowering. Does not include alignment changes resulting from routine track maintenance.
Equivalent Standard	A suitable alternative standard approved by the Manger Standards.

Table 9-1 Asset Class and Structure Type

Asset Class	Structure Type
Bridge	Underbridge Overbridge Footbridge
Culvert	Culvert
Tunnel	Tunnel
Miscellaneous Structures	Access (i.e. stairs, walkways) Buffer stop Culvert non-track Communication Towers Flood structure Lighting Gantry Lighting Tower Disused Loading Structures (now acting as retaining walls next to tracks) Overhead Service crossing Retaining wall (including old loading banks) Signal gantry (including cantilever structure) Sound barrier Turntable Water Structures

9.2 Design and Load Rating

The Section 9 of the ARTC Track and Civil Code of Practice sets out the requirements for the design of new railway, road and pedestrian bridges, culverts and other significant structures and for the load rating of existing structures. It defines requirements specifically or by reference to relevant Australian Standards.

"Safety in Design" is mandated by statutory requirements and must 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 must be eliminated or minimised so far as is reasonably practicable. Residual risks shall be documented in accordance with ARTC's risk management procedures.

9.2.1 Basis of Design

Bridge design shall be carried out in accordance with the Australian Bridge Design Standard AS (AS/NZS) 5100, RISSB's Australian Railway Infrastructure Standard AS 7636 Railway Structures, RISSB Code of Practice 'Derailment containment and protection for rail underbridges' and RISSB's guideline 'Refuges – Bridges and Tunnels'. Where there is a conflict among aforementioned documents, the requirements of this Code of Practice shall take precedence.

AS (AS/NZS) 5100 series 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 rail traffic.
- Bridges that are required to support light rail traffic.
- Pedestrian bridges and walkways, including bicycle and wheelchair access.
- Other structures that are required to support road and rail 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 rail traffic loads, e.g. retaining structures, deflection walls, signal gantries and sign gantries.
- Structures built over and/or adjacent to railways.

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 Buried Flexible Pipelines – Part 1 Structural Design AS/NZ 2566.1.

Top of drainage pipes under tracks shall not be less than 1.2m below top of rail level unless otherwise approved by ARTC.

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

Design of any structures utilising materials not currently covered by any Australian Standards shall only be undertaken following “Type Approval” by ARTC.

9.2.2 Matters for Resolution

All relevant matters for resolution listed in AS 5100 shall be confirmed as accepted by ARTC prior to commencement of the design and load rating processes for all internal and 3rd Party projects.

All risk assessment workshops for design, construction, maintenance and disposal of structures within ARTC corridor shall have in attendance ARTC subject matter experts to ensure all ARTC concerns are addressed properly unless otherwise waived by ARTC.

9.2.3 Design Loads

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

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

As a minimum, when loading is not specified:

- Rail bridges and culverts shall be designed to 300LA design rail traffic load with applicable dynamic load allowance.
- Rail bridges and culverts on the NSW Hunter heavy haulage lines shall be designed to 350LA design rail traffic load with applicable dynamic load allowance.

- Only design rail traffic axle loads, nosing load and derailment loads (AS 5100.2 Clause 11.5.1) shall be proportioned to suit nominated design or load rating loads. All other rail traffic loads shall be in accordance with AS 5100.2.
- Minimum strength for reinforced concrete or fibre reinforced pipe under track shall be Class 4 (equivalent to 300LA design rail traffic).
- High Density Polyethylene (HDPE) pipes shall comply with the above design loads and the requirements of AS 2566. In bush fire prone areas, the pipe suitability shall be risk assessed.
- All ballast top rail bridges shall be designed for 600mm maximum and 300mm minimum ballast depth below sleepers. (Plaque(s) shall be clearly displayed on top of ballast kerb in each span indicating maximum designed low-leg rail height above plaque).
- The height of ballast kerb above concrete deck shall be 600mm minimum unless otherwise approved by ARTC.
- Road bridges shall be designed to SM1600 wheel design loads with applicable dynamic load allowance.
- Walkways and Footbridges shall be designed for 5kPa.

9.2.4 Collision from Rail Traffic

9.2.4.1 New bridges

Unless otherwise approved by ARTC, the design of all the new bridges shall comply with all the minimum requirements of AS 5100 for the protection against rail traffic collision loads in conjunction with the following additional requirements:

1. As per AS 5100, all new bridges over tracks shall be designed to:
   a. Avoid collapse of structures over rail due to impact from derailed trains.
   b. Reduce the severity of impacts with structures to reduce the probability of injury to occupants of derailed trains.
2. A risk assessment acceptable to ARTC shall be carried out to determine the requirements for protection of bridge piers, abutments and the ends of the through girder, arch or truss.

   The head-on collision loads on a deflection wall can be much higher than minimum collision loads of 4,000kN parallel to rails and 1,500kN normal to rails specified in AS 5100.2. Designer shall use rational method, taking into consideration train axle configuration, train mass, train speed, car stiffness (K = 1200kN/m [Note]), track alignment, etc. for determination of collision loads. These loads shall not be less than minimum collision loads specified in AS 5100.2.
3. All piers, abutments and the ends of the through girder, arch or truss shall be protected against head-on collision from derailed trains by deflection walls at both city and country ends of the tracks.
4. Piers and abutments shall be a continuous concrete wall aligned parallel to the adjacent tracks and the minimum height of wall shall be subject to site specific risk assessment but not less than height specified in AS 5100.
5. Deflection wall shall be designed as a continuous wall and the minimum height of wall shall be subject to site specific risk assessment but not less than height specified in AS 5100.

Note: Extracted from Texas Transportation Institute report, Analysis and Design of Metrorail - railroad Barrier System, T.J.Hirsch, May 1989

The vehicle stiffness of 1200kN/m can be taken as a design criterion unless a more rigorous stiffness analysis is undertaken by the designer.

9.2.4.2 For significant track work below existing bridges for tracks carrying double stacked rolling stock

1. A risk assessment acceptable to ARTC shall be carried out to determine the requirements for protection of bridge piers and abutments.
2. Deflection walls shall be provided for the protection of existing piers and abutments and shall comply with the above requirements in 9.2.4.1 and AS 5100.
3. Deflection walls shall be provided on the track approach side to the existing substructure.
4. The deflection wall shall be designed for loads specified in 9.2.4.1.The wall shall be separated from the existing structure and shall not rely on the existing substructure for support.
5. Barrier protection shall be provided alongside the existing substructure adjacent to the rail track, unless otherwise approved by ARTC.
6. The barrier shall be designed for loads specified in AS 5100.2 Clause 11.4.4.2
7. The superstructure of existing bridges shall not be assessed to resist a minimum collision load of 500kN.

9.2.4.3 For new bridges above rail tracks carrying double stacked rolling stock

AS (AS/NZS) 5100 (Part 1 & Part 2) is silent on the requirements for protection of bridge superstructures above rail tracks carrying double stacked rolling stock.

1. For any part of the structure within 7m vertically of the centreline of the nearest track carrying double stacked rolling stock shall be designed to resist a minimum collision load of 500kN. Above 7m and up to 12m vertically above the rail track level, this load shall vary linearly from 500kN to zero at 12m.

9.2.4.4 Underground rail, air space developments and similar situations

1. The supports for all underground rail and air space developments shall be designed for the train collision loads specified in AS 5100.2.

9.2.5 Bridge Earthquake Design Category

The bridge earthquake category for new bridges shall be determined as specified in AS 5100.2.

The classification of a new bridge shall be BEDC-4 unless otherwise approved by ARTC based on a site-specific cost benefit analysis.

The minimum classification for new bridge shall be BEDC-3.

9.2.6 Derailment Kerb

A derailment kerb shall be provided for new bridges. It shall extend 200mm above the top of the adjacent running rail without infringing maximum kinematic envelope plus 200mm from the centreline of the nearest track.

9.2.7 Bridge Bearing

The requirements for rail bridge bearings shall be as follows:

- For new steel spans, the bearings shall be spherical bearings or bearings approved by ARTC.
- For new concrete spans, the bearings shall be spherical bearings, elastomeric bearings or bearings approved by ARTC.
- All spherical bearings shall be designed with 100year design life.
- All other bearing types shall be designed with 50year minimum design life.
- All bearings shall be designed for rail traffic loading specified in Clause 9.2.3 Design Loads.
- All bearings and fixing details shall be arranged to permit removal of the fasteners without jacking the bridge at all and removal of the bearing by jacking the bridge by no more than 5mm.
- Bearings shall be tested in accordance with requirements of AS5100.4. The tests shall be carried out in Australia in a test facility, suitably accredited by NATA. The test frequency shall be in accordance with Table 9.2;
- For testing purposes, the bearing group is defined as bearings of the same type, with the same sliding pad and spherical surface geometry and with similar load capacity. Bearings within a group may have different translational movement ranges.

Table 9.2 Bearing Test Frequency

<table>
<tr><th rowspan="2">Type of Test</th><th colspan="3">Bearings per group</th></tr>
<tr><th>Up to 10</th><th>10 to 25</th><th>>25</th></tr>
<tr><td>Vertical Load test</td><td rowspan="3">1 per group (2 min)</td><td rowspan="3">2 per group</td><td rowspan="3">3 per group</td></tr>
<tr><td>Lateral Load Test</td></tr>
<tr><td>Rotational Capacity Test</td></tr>
<tr><td>Geometrical Verification</td><td colspan="3">All</td></tr>
<tr><td>Coefficient of Friction Test</td><td colspan="3">1 per stainless steel and sliding material batch combination</td></tr>
</table>

Only Spherical Bearings comprising Ultra High Molecular Weight Polyethylene (UHMPE) as the sliding material shall be used and shall comply with European Technical Approval ETA-08/115 or similar and shall demonstrate below minimum performance characteristics

- Maximum Friction Coefficient: 0.0267 (g) ≥ 30 MPa
- Minimum Friction Coefficient: 0
- Minimum Accumulated Sliding Distance (To ensure adequate Abrasion resistance): ≥ 75Km
- Minimum Short Term Compressive Strength (To ensure No Damage to Sliding Surfaces for short term high temperatures and any accidental impacts): 240 MPa @ 48 °C
- Bearing attachment plates shall be detailed and supplied by the bearing manufacturer.

Where use of pot bearings cannot be avoided, only pot bearings that use Polyoxymethylene (POM) or Carbon Filled Polytetrafluoroethylene (PTFE) as internal sealing elements complying with current version of CEN-EN1337-5 Structural Bearings – Part 5: Pot Bearings shall be used.

For all other bridge types, the design of the bearings shall comply with AS (AS/NZ) 5100.

Detailed shop drawings with design loads of all bearings shall be provided for ARTC review prior to commencement of manufacture of any bearings.

All bearing test reports and final drawings shall be provided with delivery of bearings.

9.2.8 Protection Screen

Protection screens shall be provided to prevent objects falling or being thrown from overhead bridges.

1. Protection screens shall be provided unless otherwise approved by ARTC.
2. Screen shall have a minimum height of 3m above the roadway, walkway surface or ledge that people can stand on. Road traffic barrier and barrier railing can act as ledge. Where height is not taken from ledge but from road surface then ledge shall be screened off to prevent people from climbing onto it.
3. Preference is for screen to curve inwards facing road as per Figure 16.4 in AS 5100.1.
4. Screen shall not tilt outwards more than 10º from vertical position where it is impractical to curve it towards road.
5. Screens shall extend across full length of road bridge or full width of railway boundary or 9m minimum as per AS 5100 unless otherwise approved by ARTC.

9.2.9 Clearances

Horizontal and vertical clearances for structures (adjacent to and over the track) shall comply with the ARTC Code of Practice: Section 7 ‘Clearance’ unless otherwise approved by ARTC.

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

9.2.10 Waterways

ARTC can set the annual exceedance probability (AEP) for a particular waterway or drainage system. As a minimum, when the AEP 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): 1% AEP (as defined in Australian Rainfall & Runoff guideline, previously defined as 100year precipitation event).
- Minor under track structures (discharge less than 50m3/sec): 2% AEP (previously defined as 50year precipitation event).
- Structures not under railway track: 2% AEP (previously defined as 50year precipitation event).

For rail bridges, the flood immunity and serviceability limit state Average Recurrence Interval shall be 100years as set out in AS (AS/NZ) 5100 unless otherwise specified by ARTC.

9.2.11 Abutment Slabs

9.2.11.1 Approach Slab

The requirement to use an approach slab shall be determined by the design. The approach slab designed as an integral structural component for the stability of the abutment or to square off a skewed abutment shall not to be used for a transition approach. The approach slab seated on an abutment shall be adequately piled at the opposite end. The design of slab shall ensure that there is no uplift on the abutment that could cause track misalignment due to any differential settlements at the piled end of the slab. Adequate drainage on each side of slab (lateral to track) shall be provided to ensure there is no entrapment of water on the approach slab or no water drains off the slab structure onto the formation under the track.

9.2.11.2 Transition Slab

The transition slab shall be provided for all new rail bridges. The slab shall not be seated on the abutment. The length of slab across the rail track shall suit the width of the bridge approach embankment and the slab shall be at least 5m wide in direction parallel to running rails or as approved by ARTC. Where slab is comprised of 2 or more smaller units then these units shall be mechanically interlocked to form a single rigid transition slab. Adequate drainage on each side of slab (lateral to track) shall be provided to ensure there is no entrapment of water on the slab or no water drains off the transition slab onto the formation under the track.

9.2.12 Walkways / Refuges / Handrails

All new walkways / refuges / handrails on rail bridges, culverts or in tunnels or on any other structures shall comply with the requirements of AS (AS/NZS) 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.

In other cases, a risk assessment shall be performed to assess if walkways, refuges and/or handrails are required.

“No Safe Place” sign, as per Figure 9-1 below, shall be posted at each end of structure where any walkway, refuge or wall is within 3m horizontally from nearest running rail. It shall also be attached at locations along the wall where access is available to the track adjacent to the structure. Signage shall be attached such that it is clearly visible to authorised staff.

The following requirements shall apply to refuges that could be used in emergency situations:

- For bridges and culverts, refuges shall not infringe the Kinematic Envelope (KE) + 200mm from the centreline of the nearest track.
- For wall structures such as tunnels and retaining walls, refuges shall not infringe the KE + 500mm from the centreline of the nearest track.
- Refuges shall not exceed 20m intervals, one side for a single track and staggered for multiple tracks.
- Refuge is not required for structures less than 20m in length.
- Minimum dimensions of refuge shall be 2m in height, 1.5m wide and 0.7m in depth.
- Handrails on (or at) structures shall not infringe the KE + 200mm from the centreline of the nearest track.

Figure 9-1 below illustrates the general configuration of the ‘No Safe Place’ sign.

Figure 9-1 'No Safe Place' sign

The requirements for danger signage are set out in AS 1319.

9.2.13 Road Traffic Barrier

The road traffic barriers for all new road bridges over the ARTC network shall be designed to minimum standard of **Medium Performance Level** in accordance with AS (AS/NZS) 5100.

For bridge rehabilitation, the existing road barriers to be upgraded to performance level specified above or unless otherwise approved by ARTC.

9.2.14 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 bridge walkway, refuges or handrails they shall be positioned so that they do not encroach on the safe working area or create a trip or other safety hazards.

9.2.15 Survey Control Markers

Survey controls shall be established on all bridges and major culverts as follows:

1. Brass triangle control markers.
2. All markers are intervisible with ease of access and occupiable.
3. All markers are properly coordinated with reduced level.
4. A marker be installed on each abutment and no more than 150m apart on long bridges/viaducts
5. Permanent control(s) installed within ARTC corridor or on public land such as public roadway but no more than 150m from structure unless otherwise there is already a permanent marker nearby.
6. All markers, coordinates and reduced levels are clearly specified on “As Built” drawings.

9.2.16 Construction Specification

Specifications shall comply with the following requirements:

1. All specifications shall comply with all relevant ARTC Standards and Australian Standards.
2. All specifications shall be logically, concisely and without any ambiguity presented on construction drawings.
3. References to include all relevant ARTC Standards, ARTC drawings and/or Australian Standards, if applicable.

9.2.17 Competency Requirements

The designs, design approvals and verification shall only be carried out by persons holding the appropriate competency level in accordance with ARTC competency certification, details available on ARTC web site - EGP0103F-01 Engineering Design & Project Management Matrix

ARTC shall select the designers, design checkers and independent verifiers based on their demonstrated skills and experience with the construction materials (concrete, steel, timber, masonry, composites) and structure type (including but not limited to bridges, tunnels, communication towers).

9.2.18 Certification

All “Issued for Construction Drawings” shall be signed by the Design Engineer, and counter signed by the Design Check Engineer, Approver and Independent Verifier. Third party independent verification certificate for all construction drawings shall be provided unless ARTC waives this requirement. Third party here implies a competent engineer from another engineering consultancy.

All design changes shall comply with the requirements of Rail Network Configuration Management Procedure EGP-03-01 Engineering, Design and Project Management Identification of Competence Procedure

9.2.19 Acceptance by ARTC

All drawings shall be accepted as per EGP-04-01 Engineering Drawings and Documentation.

9.3 Construction and Maintenance

9.3.1 General

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

9.3.2 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 EGH-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 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 shall be adequately maintained and monitored until the structure is upgraded to safe operating condition.

9.3.3 Guard Rails

Guard rails are not required on rail bridges. Where fitted, existing guard rails shall be safely maintained by the local ARTC maintenance team in accordance with Code of Practice Section 1: Rail

9.3.4 Bridge Transom

9.3.4.1 Transom Material

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 only be utilised following “Type Approval” by ARTC.

9.3.4.2 Timber Transom

9.3.4.2.1 Timber Material

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 below.
- Timber shall 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 shall 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”.

Table 9-3 Transom Timber

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
Group 2	Spotted Gum	F22	N/A	C. maculate C. citriodora C. henryi

9.3.4.2.2 Timber transom Size

Open deck rail bridges with steel span lengths greater than 20m have built in camber. The thickness of transoms shall not be increased at ends of span to remove camber.

Transom dimensions and tolerances shall be as stated in below.

Table 9-4 Transom Dimensions and Tolerances

	DIMENSIONS (mm)	TOLERANCE (mm)
Length	2800, 3000, 3200	+50, -0
Width	250 nominal	+25, -0
Thickness	As per Tables 9.4 and 9.5 below	+6, -0

9.3.4.3 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 to note that some transom top bridges in Victoria were originally designed for Broad Gauge track whereas they are now standardised to Standard Gauge track.

9.3.4.3.1 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 below:

Table 9-5 Minimum Timber Transom thickness and Holding down Bolt for 2 girder spans

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 AS5100.2 - 300LA design rail traffic loading	600	115	J1	M30	Straight	190
					Curved	210[2]
		80	J1	M30	Straight	185
					Curved	205[2]
	500 - 550	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 coal wagons)	500 - 600	115	J1	M24	Straight	150
					Curved	165[1]/170[2]
		80	J1	M24	Straight	150
					Curved	160[1]/165[2]
25t axles at ≥1500 centres (100t general freight wagons)	500 - 600	115	J2	M22	Straight	150
					Curved	150[1]/160[2]
		80	J2	M22	Straight	150
					Curved	150[2]

9.3.4.3.2 Transoms for steel spans with 4 girders

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

Table 9-6 - Minimum Timber Transom thickness and Holding down Bolt for 4 girder spans

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[2]
		80	J1 or or JD2	M22	Straight	110
					Curved	120[2]

Notes on Tables 9.5 and 9.6:

Bolt thread not to protrude into holding down bolt hole more than 10% of transom thickness.

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 C1 of AS 3818.1*
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.*
5. *Any localised reduction in thickness of a transom shall be achieved by a maximum 1 in 8 bevelling and rounded change of direction away from the reduced section.*

9.3.4.4 FFU transom

Fibre-reinforced foamed urethane (FFU) transoms are intended for use as underbridge transoms only. FFU transoms shall not be used for spot re-transoming as they may lead to potential track problems associated with the effects of differences in elastic modulus between timber and FFU.

Structures representative shall verify design input data provided on FFU TRANSOM DESIGN CONDITION form and also, design data used by manufacturer to derive transom depth prior to proceeding with procurement. If necessary, seek engineering advice.

9.3.4.4.1 FFU Material

The FFU components provide an alternative material to hardwood timber for transoms for steel bridges on the ARTC network. They have equivalent material characteristics to that of timber and they are specifically designed for individual axle loads and bridge configurations with up to 50year design life.

9.3.4.4.2 FFU Transom Size

The minimum length of transom shall be the length between holding down bolt holes plus 400mm and the width shall be 250mm nominal unless otherwise approved by the corridor manager. The 200mm length beyond HD bolt at each end of transom is for a worker to put a foot there whilst installing transom HD bolts, sleeper plates and/or rails.

9.3.4.4.3 FFU Transom Thickness

FFU transoms are designed and manufactured by Sekisui Chemical Co. Ltd of Japan. FFU transoms shall be designed and supplied in accordance with ‘JIS E 1203 (JRCEA/JSA) Synthetic Sleepers– Made from fibre reinforced foamed urethane’ and the manufacturer's requirements. FFU transoms are designed to mimic the physical and material characteristics of hardwood timber transoms.

Open deck rail bridges with steel span lengths greater than 20m have built in camber. The thickness of transoms shall not be increased at ends of span to remove camber.

Project Manager shall provide supplier with fully completed FFU TRANSOM DESIGN CONDITION form available from supplier. Details required on the form are axle load, train speed, rail offsets, track alignment, transom length and width, girder spacing, girder flange width, packer sizes and non-slip surface coating if required and holding down bolt size and locations if they are required to be pre-drilled by manufacturer.

FFU products are designed to achieve a high level of manufacturing precision that can eliminate the need for onsite modifications. They can be cut to specified precision, predrilled, pre-cut and prepacked. To facilitate this, Project Manager shall provide supplier with accurate survey and rail alignment data.

Where the gaskets (packers) are necessary, they can be ordered from Sekisui. The order shall include the correct dimensions (shall be greater than 3mm thick), shape and quantity of gaskets. Where the gaskets are to be positioned over rivets, the supplier shall be provided with rivet positions on drawing and required hole or groove sizes over rivets.

Axle load for specific track classification shall comply with the requirements of below.

Table 9-7 – Axle Loads for FFU transoms

TRACK CLASSIFICATION	AXLE LOAD (t)	SPEED (kph)
Hunter heavy haulage lines (New bridges)	35	>80
Hunter heavy haulage lines (Existing bridges)	30	>80
All other lines	25	>80
Lines requiring specific approval of Corridor Manager	23	>80

9.3.4.4.4 Holding Down Bolt and Screw Spike

The holding down bolt sizes shall be as specified in Table 9- 5

Recommended screw spike and hole dimensions for rail plate installation are given in below:

Table 9-8 – Recommended screw spike and hole dimensions for rail plate installation

SCREW SPIKE DIMENSION	HOLE DIMENSION	NOTE
22 dia x 150mm long	17 dia x 140mm deep	Standard screw spikes with Fe6 washer
24 dia x 150mm long	19 dia x 140mm deep	Standard screw spikes with Fe6 washer
24 dia x 165mm long	19 dia x 150mm deep	Standard screw spikes with Fe6 washer

9.3.4.4.5 Traceability of FFU Transoms

FFU products are manufactured from non-naturally occurring materials. The manufacturing process and conformance testing records for each batch of FFU transoms shall be supplied by the manufacturer and retained by the corridor manager. The corridor manager shall maintain traceability records of all FFU transoms used in the corridor.

9.3.4.5 Transom Holding Down Assembly

All transoms on steel girder spans shall be seated on rubber pads to reduce impact loading on steel superstructure and if required packers shall be used to achieve required rail level.

Specific requirements for rubber pads under transoms are as follows:

- Pad shall be SA47 rubber pad or equivalent.
- Nominal pad thickness 5mm.
- Total thickness of pad(s) shall not be greater than 32mm.
- No steel plate or any other packer type to be inserted between layers of rubber pads.

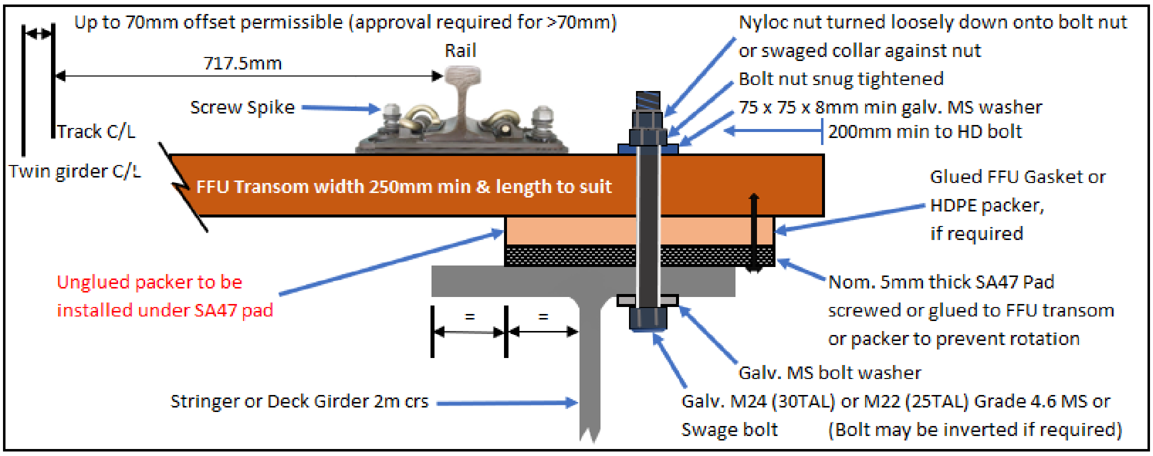
Specific requirements for packers under transoms are as follows:

- Open deck rail bridges with steel span lengths greater than 20m have built in camber. The thickness of packers shall not be increased at ends of span to remove camber.
- Packer(s) shall be installed below rubber pad unless packer, especially FFU gasket, is glued to transom.
- Packers to be steel plates, High Density Polyethylene (HDPE) sheets, FFU gaskets or equivalent to suit required thicknesses.

- Packer thickness shall not be greater than 50mm in total unless otherwise approved by ARTC.
- Conical spring is not required for non-shrinking FFU transom.
- Conical spring with flat washers can be installed either under bolt nut or head (spring expands as timber shrinks).
- No more than 2 flat washers shall be used under bolt head and 1 either side of conical spring

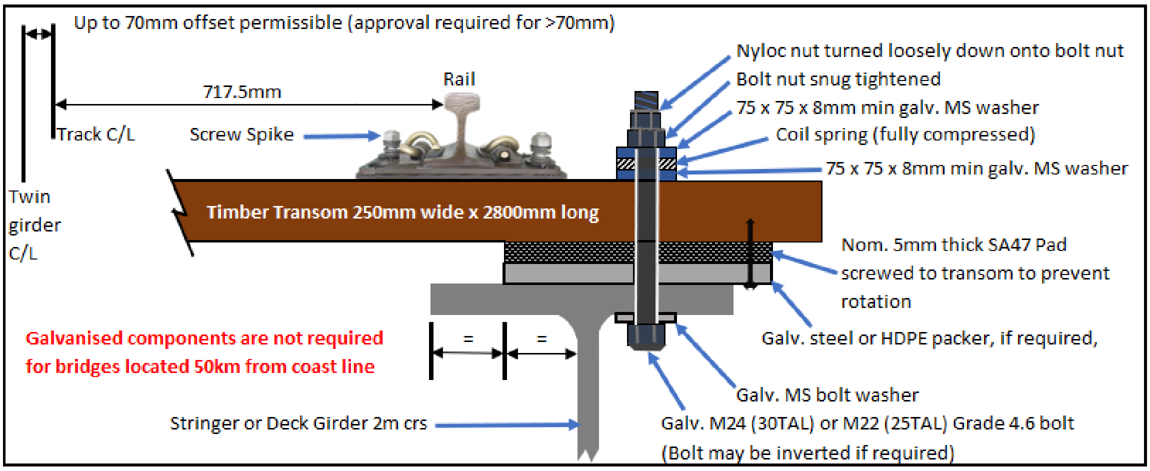
Typical transom holding down assembly is shown in Figure 9-2 below.

- Conical spring with washers can be installed either under collar or head of bolt (spring expands as timber shrinks).
- No more than 2 flat washers shall be used under bolt head and 1 either side of spring washer.



FFU Transom Assembly (Bolted)

Note: For FFU transoms, swage bolt with threaded nut and swage collar is an alternative option to mild steel bolt provided tension in swage bolt is less than 40kN.



Timber Transom Assembly (Bolted)

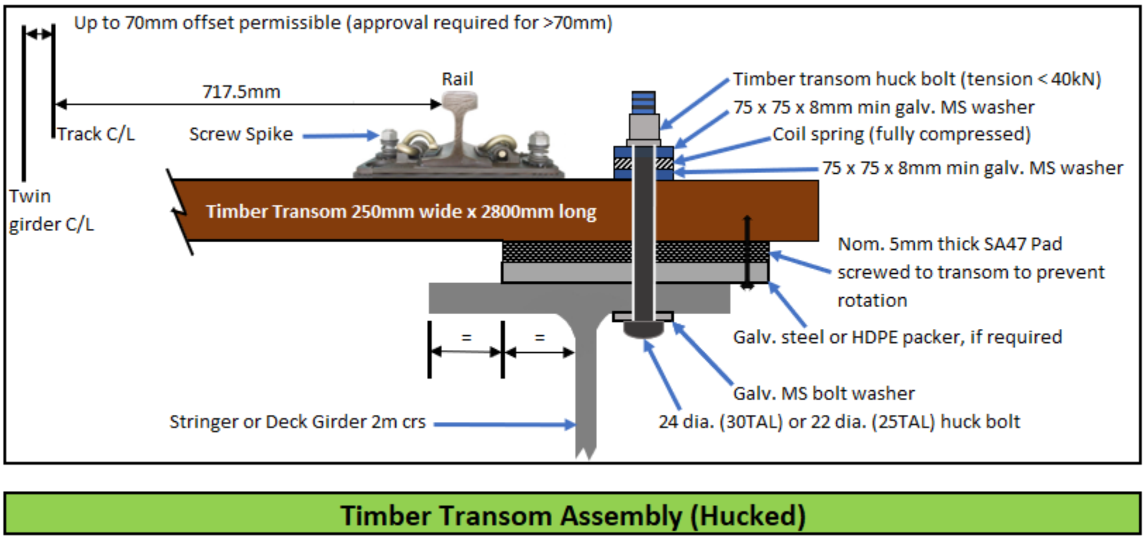


Figure 9-2 Transom holding down assembly details (typical)

9.4 Inspection and Assessment

9.4.1 Inspections

9.4.1.1 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 structures 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.

9.4.1.2 Scope

ARTC shall establish a comprehensive, systematic, condition monitoring and load rating program for all nominated structures selected from Table 9.1. The program shall comprise the following inspection types:

- Engineering Inspection.
- Visual Inspection.
- Special Inspection.
- Track Patrol Inspection.

9.4.1.3 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. Third party structures here imply structures not owned or managed by ARTC.

9.4.1.4 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 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 implemented until the structures are removed or isolated.

9.4.1.5 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.

9.4.1.6 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.

9.4.1.7 Environment

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

9.4.2 Load Rating

9.4.2.1 Structure Load Rating

All existing bridges (and large culverts, if required) 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.

9.4.2.2 Loads and loading factors

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

9.4.2.2.1 Live Loads

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

There is a potential risk of rail breaking, failure of deteriorated transoms and ballasted timber planks or existence of loose transom/plank holding down bolts in bridges. For this particular reason, their small contribution towards load carrying capacity of span members shall be disregarded unless otherwise approved by ARTC.

9.4.2.2.2 Dead Loads

The combined un-factored superimposed dead load such as 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.

9.4.2.2.3 Load Factors

The value for Live Load factor shall be 1.4 for live load and all loads induced by live load such as centrifugal, nosing, braking and traction forces for all current and RAS train consists unless otherwise nominated by ARTC. All other factors shall be as specified in AS 5100.7.

9.4.2.2.4 Dynamic Load Allowance (DLA)

The DLA value for load rating of existing bridges shall be as per AS 5100.2 and shall not be increased by 50% for existing bridges without any transition slab as required by AS 5100.2 for new bridges.

9.4.2.2.5 Nosing Load, Wind Load and Centrifugal Force

Nosing load, wind load and centrifugal force induce axial stresses in members bracing the flanges of stringer, beam and girder spans, axial stresses in the chords of truss spans and in members of cross frames of such spans, and stresses from lateral bending of flanges of longitudinal members having no bracing system. The capacity of sway and wind bracing shall undergo detailed analysis. If this methodology produces the rating factors below permissible values, then Finite Element Analysis shall be carried out as per AS5100.6. If the aforementioned methodologies produce unfavourable results, then the effects of lateral bending between braced points of flanges, axial forces in flanges, vertical forces and forces transmitted to bearings shall be disregarded as per American Railway Engineering and Maintenance-of-Way Association *Manual for Railway Engineering*.

9.4.2.2.6 Braking and Traction Forces

The following characteristics of coal and freight trains shall be used to determine braking and traction forces when using Rational method in AS (AS/NZ) 5100:

Table 9-9 Braking and Traction Forces

PARAMATER	VALUE
Rail traffic	Nominated main line or heavy haulage freight traffic.
Train length	1800m unless otherwise nominated by ARTC
CoG above rail	2.1m for single stack container wagon and 2.65m for double stacked container wagon
Traction acceleration	0.5m/s^2
Traction Length	60m (for 3No. 20m long locomotives) unless otherwise nominated by ARTC
Braking deceleration:	1.2m/s^2.
Braking length:	1800m (for 3No. 20m long locomotives + 100No. 100t general freight wagons) unless otherwise nominated by ARTC

Note: Where necessary, track-bridge interaction should be assessed to ensure the rails and the bridge components are not subjected to any anomalies, guidance provided in UIC Code – 774-3R.

9.4.2.2.7 Wind load

The Serviceability Wind Speed in AS (AS/NZS) 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.

9.4.2.3 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 (AS/NZS) 5100. The Section 13 “Fatigue” in Part 6 of AS (AS/NZ) 5100 (2017) contains numerous discrepancies. Wherever applicable, the 2004 version of the bridge code should be used for fatigue assessment until the 2017 version is updated. Detail Categories shall be in accordance with the 2017 version of the Bridge Code. Detail Category for the assessment of normal stress for existing riveted bridge members that are in a reasonable condition should be 112 for shop driven rivets and 90 for field driven rivets, unless otherwise approved by ARTC. Where shop and field driven rivets cannot be distinguished then detail category should be 90.