UGL REGIONAL LINX

STRUCTURES GENERAL

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CRN CM 301

LINKING COMMUNITIES. CONNECTING CUSTOMERS.

Table of Contents

Document Control

Function	Position	Name	Date
Approver	A&E Manager	Lucio Favotto	24.01.2022

Revision	Issue Date	Revision Description
1.2		Baseline Document received from TfNSW
2.0	January 2022	UGLRL template applied, first approved and issued UGLRL version
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Summary of changes made from previous version

Section	Summary of change
All	This document is based on the previous rail infrastructure maintainer (RIM). Full revision history is available on request from UGLRL. Updated some job titles

Chapter 1 General

C1-1 Purpose

This Manual outlines miscellaneous requirements for installing and maintaining structures. It includes relevant information from the Structures Design Standards.

The Manual covers:

- General requirements such as structural bolts, excavation works, and the operation of the ballast stabilising machine near structures
- Collision protection of existing structures
- Safety refuges, handhold devices and limited clearance signs
- Guard rails
- Structures including underbridges, overbridges, footbridges, signal gantries, tunnels, retaining walls, platforms and miscellaneous structures
- Typical structures configurations.

C1-2 Context

The manual is part of UGLRL CRN's engineering standards and procedures publications. More specifically, it is part of the CRN Engineering suite that comprises standards, installation and maintenance manuals and specifications.

Manuals contain requirements, process and guidelines for the management of track assets and for carrying out examination, construction, installation and maintenance activities.

The Manual is primarily intended for use by staff and contractors undertaking construction and maintenance work on structures or in the vicinity of structures, but includes some requirements for personnel involved in track work and platform upgrading work

It also contains management requirements for the District Engineer, Area Manager and Maintenance Superintendents needing to know what they are required to do to manage structures repair activities on their area, and Production Superintendents needing to know what they are required to do to manage the renewal activity their teams are undertaking.

C1-3 How to read the manual

The best way to find information in the manual is to look at the Table of Contents starting on page 3. Ask yourself what job you are doing? The Table of Contents is written to reflect work activities.

Throughout this manual reference is made to the following levels of Engineering Authority:

- Principal Track and Civil Engineer
- District Engineer
- Area Manager
- Superintendent
- Supervisor

These are general descriptors only. For an explanation of the positions in the UGLRL CRN organisation that perform these functions, refer to CRN Engineering Manual CRN CM 001 “Civil Technical Competencies and Engineering Authority”

C1-4 References

C1-4.1 Australian and International Standards

AS 1252 High strength steel bolts for structural engineering

AS 1449 Wrought alloy-steels – Stainless and heat-resisting steel plate, sheet and strip

AS 1657 Fixed platforms, walkways, stairways and ladders – Design, construction and installation

AS 1720.1 Timber Structure – Design methods

AS 3600 Concrete structures

AS 4100 Steel structures

AS 4292 Railway safety management

AS 4678 Earth-retaining structures

AS 5100 Bridge design

C1-4.2 CRN Documents

CRN CS 215 – Transit Space

CRN CS 310 – Underbridges

CRN CM 001 – Civil Technical Competencies and Engineering Authority

CRN CM 221 – Rail Installation and Repair

CRN CM 421 – Track Drainage

CRN CP 213 – Trackside Signs

CRN CP 301 – Structures Construction

C1-4.3 Other

RMS Bridge Technical Direction – Bridge Safety Screens

RMS Guidelines

Austroads Guidelines

C1-5 Definitions, abbreviations and acronyms

Site Supervisor: A qualified civil engineer or a competent person with delegated engineering authority for civil construction supervision.

Terms used in the design, construction and maintenance of bridges and structures on the CRN network are provided in Appendix 1 of this Manual.

Chapter 2 Management requirements

C2-1 District Engineer

The District Engineer shall establish systems to ensure:

- Compliance with the Railway Bridge Policy detailed in Chapter 4.
- Compliance with the requirements for bridges and structures detailed in this Manual.

C2-2 Area Manager

The Area Manager shall establish systems to ensure that Installation, inspection and maintenance tasks detailed in this manual are undertaken by people who have the required competencies.

C2-3 Renewals Manager/Project Manager

Renewals Manager/Project Managers shall establish systems to ensure:

- Construction and installation tasks are undertaken by people who have the required competencies.
- Approved designs are used for the replacement and refurbishment of bridges and structures.

C2-4 Superintendent/Site Supervisor

Superintendents/Site Supervisors shall ensure that construction, installation, and maintenance tasks are undertaken by people who have the appropriate competencies.

Chapter 3 Competencies

The construction and installation of bridges and structures shall be carried out by persons with the appropriate civil construction competencies and under the supervision of a Site Supervisor.

Competencies for various installation and maintenance activities are documented in CRN CM 001.

Chapter 4 Railway bridge policy

C4-1 Purpose

This chapter defines UGLRL CRN's policy for managing the bridge assets on the CRN network.

C4-2 Policy statement

- To provide and maintain bridges for CRN network that are safe, reliable and fit for purpose;
- Maintain a robust framework of Engineering Standards and Technical Maintenance Plans for CRN bridges;
- Implement management systems that can both enforce compliance to CRN Engineering Standards and be supported by regular auditing;
- Recognise the NSW Railway's unique heritage

This Bridge Policy is supported by the following underlying management principles:

- Safety for both users and maintainers is paramount and will not be compromised ;
- Management must show leadership in ensuring the safe operation of CRN bridge assets;
- All bridges must be built, maintained and inspected in accordance with CRN Engineering Standards;
- Accountability for bridge assets is clearly defined;
- Bridge safety and maintenance decisions will only be made with the appropriate Engineering Authority;
- Qualified and technical expertise must be sought and made available for all bridge safety decisions;
- Bridge Asset Management Plans must be financially responsible; and
- All decisions and actions in managing CRN bridge assets will be conducted in accordance with this policy.

Chapter 5 General requirements for bridges and structures

C5-1 General

Bridges shall be managed in accordance with the Railway Bridge Policy.

Bridges and structures within the CRN network shall be designed, installed and maintained in a condition appropriate to the traffic task and safe operations, at the lowest overall life-cycle and operational cost.

Bridges and structures will be generally designed for a design life of 100 years, in accordance with AS 5100 “Bridge design”. Major assets in service such as steel truss bridges, long viaducts and tunnels will, however, be maintained and preserved for an indefinite service life.

Work shall be done in accordance with relevant CRN Engineering Manuals. Work shall be done by persons with appropriate technical competencies and engineering authority as detailed in CRN CM 001.

C5-2 Heritage

All construction and maintenance personnel are required to be aware of any heritage restrictions or requirements before undertaking maintenance work on an existing structure, where the configuration or components are being materially altered.

A Certificate of Heritage Status shall be obtained before major alterations are carried out or before a redundant structure is demolished.

C5-3 Clearances

Horizontal and vertical clearances for bridges, structures and services attached to bridges and structures shall comply with CRN Engineering Standard CRN CS 215 “Transit Space”.

The area extending one metre below design rail level of Normal Structure Gauge 1994 as detailed in CRN CS 215 Figure 1 shall be kept clear of structures and structure footings.

The design of trackside structures shall also provide clearances for safe places as detailed in Chapter 7 of this manual.

Clearances from the track to piling equipment when constructing substructures shall take account of transit space, safeworking and construction requirements. The minimum clearance is the kinematic envelope (out-of-gauge load) plus 200 mm.

C5-4 Approved materials

Approved construction materials for main structural elements are steel and concrete.

Apart from transoms, timber materials shall not be used as structural elements in the design of new structures.

Masonry is approved for existing structures and for cladding of new structures where this is required in special circumstances such as for heritage reasons.

Materials and finishes should be chosen to minimise future maintenance due to the close proximity of the structure to the tracks and commuter usage. Stainless steel fasteners shall be specified where access for inspection and replacement purposes is difficult.

In locations that are vulnerable to vandalism and graffiti, appropriate measures shall be taken to prevent access to the adjoining rail infrastructure. Anti-graffiti paints should be specified in areas where there is a high risk of graffiti.

Trackside structures shall not be painted in safeworking colours of red, orange and green.

C5-5 Services

Services and service ducts shall be located so as not to impede access to the structure and to the services for inspection and maintenance.

No services shall be attached to bridges and structures without the approval of the Principal Track and Civil Engineer. Proposals shall include a risk assessment of the impact on the structure and other CRN infrastructure in the area.

No services shall be carried in an open channel drainage system.

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

When approval is given to place a pipe under a bridge the trench shall be excavated no closer than 3m to the footings of any abutment or pier. The excavation shall not undermine the bridge footing or lead to instability due to sliding of the abutment or pier. The stability of the abutment or pier shall be checked for the temporary open trench condition and it shall be demonstrated that the requirements of AS 5100 have been met.

When approval is given to install a pipe through a concrete culvert, the pipe shall be located close to the culvert wall and as close to the soffit as possible. The pipe shall be located by grouting under and over the pipe to present a smooth surface to the water passing through the culvert. The pipe shall return underground at each end of the culvert as quickly as practical.

C5-6 Structural bolts and anchors

C5-6.1 Structural bolts

Most of the connections for bridges and structures on the CRN network comprise bolts, designated 4.6 or 8.8, of snug tight, friction or bearing type or huck bolts, in accordance with AS 1252 “High strength steel bolts for structural engineering”.

Structural connections are generally the weakest elements of a bridge or structure. To reduce the risk of structural failure due to inadequate connection capacity, the following policies shall be followed by construction and maintenance personnel:

- The preference is to use huck bolts;
- High strength bolts (8.8TF or TB) can be used provided a certificate of compliance is available from an Agency acceptable to the Principal Track and Civil Engineer for the batch of bolts;
- If a certificate of compliance (for the bolt and particular batch) is not available, one of the following options shall apply:
  - Bolts of the same batch shall be tested in accordance with AS 1252 by a NATA registered laboratory. It shall be permissible to demonstrate compliance with AS 1252 up to one month after installing the bolts;
  - With prior engineering design approval, it shall be permissible to increase the bolt size (e.g. M20 to M24).

Upon completion of the works, the Structures Superintendent or equivalent shall appropriately file all certificates of compliance.

C5-6.2 Tensioning of bolts

Structural bolts shall be tensioned in accordance with the requirements of CRN Engineering Specification CRN CP 301 “Structures Construction” S26 “Erection of Structural Steel”.

Direct-tension indication devices may be used provided they conform to the requirements of AS 4100 “Steel structures” - Clause 15.2 and they are used strictly in accordance with the manufacturers’ instructions.

C5-6.3 Anchors

Both mechanical and chemical anchors are commonly used to attach minor structures such as traffic barrier posts to bridges and other major structures.

A number of proprietary products such as ‘Chemset’ and ‘Dynabolt’ anchors are available for a range of applications. The load carrying capacity of these products is normally based on concrete strength. The manufacturers, however, do not accept any liability for their anchors if they are not installed properly in the right type of material in accordance with the manufacturer’s written instructions.

There have been many cases of failures of anchors installed in aged structures or in unsatisfactory materials, e.g. aged concrete or fragmented brickwork. As such if there is any doubt as to the quality of the material into which the anchors shall be installed or type of anchor to be used, reference should be made to the Principal Track and Civil Engineer.

C5-7 Structure footings

When excavating adjacent to structures, there is a risk that the footings may be undermined or the structure destabilized, resulting in structural failure and potential collapse.

Excavations in the vicinity of structure footings are therefore not permitted unless documented engineering advice and approval are obtained.

No excavation should be made within this 5m distance without prior analysis of structure stability with respect to the effects of the excavation.

No excavation shall be made below the base of the footings of any structure (for example bridges, retaining walls and station platform walls) without prior analysis of structure stability with respect to the effects of the excavation.

The approval will be in the form of a certification by a competent geotechnical/ structural engineer with relevant engineering authority, based on the results of an appropriate geotechnical and/or structural investigation.

This requirement extends to the footings of all structures such as bridge piers, abutments, wingwalls, tunnels, retaining walls, platform walls, signal gantries and towers.

C5-8 Clearances to electrical services

Electrical services within the rail corridor may include aerial lines and exposed low voltage equipment.

Bridges and structures shall be designed and constructed to ensure that minimum clearances are observed to electrical power lines as laid down within the Australian Standards and the regulations of the relevant electrical authorities.

Where high voltage aerial lines are located above the bridge, measures shall be taken to ensure that the risk of transferred potential associated with fallen conductors is mitigated.

C5-9 Advertising signs

Fixing details shall be in accordance with design codes and practices. They shall not impact on the structural integrity of the bridge. They shall only be made into existing structural members with the approval of the Principal Track and Civil Engineer. They shall not create an obstruction that causes water to pond or debris to accumulate on the bridge structure.

Fixings and ladders for the sign shall not impinge on the clear walking space of footbridges and pedestrian walkways.

Signs and fixings shall not prevent access for inspection and maintenance of the bridge, including the structure immediately behind the sign.

C5-10 Ballast stabilising machine

C5-10.1 Operating restrictions

Vibrating forces generated by dynamic ballast stabilizing machines can be quite powerful and under certain conditions may excite critical vibration frequencies in nearby structures. Fortunately, most structures have critical frequencies in the low portion of the stabiliser's vibration range. For these reasons, the stabiliser must not be operated at frequencies below 40Hz over ballast top underbridges.

When starting the vibration units they MUST be engaged onto the rails and brought up to the required vibrating frequency as fast as possible. Conversely when stopping the vibration units they MUST be stopped as fast as possible. This will prevent any possible critical vibration frequency ranges from being prolonged. Starting and stopping the vibration units MUST occur only when the machine is moving.

The dynamic stabilising machine must finish its run-out ramp, i.e. at zero pressure and vibrators turned off whilst moving, no closer than 10 metres to the nearest extremity of a bridge abutment or return wingwall. The reverse shall apply at the start of the operation, i.e. when moving away from the structure.

The dynamic stabilising machine can operate over:

- Brick or masonry underbridge spans over 5 m long where the parapets directly contain the ballast (concrete bridges are OK);
- A masonry or any other type of culvert less than 5 metres span and only if the culvert has a minimum of 1 metre fill between the top of the culvert and the underside of the ballast bed and only if free of structural defects.
- A modern pre-stressed concrete reinforced concrete or steel underbridge, only with concrete piers and abutments and only where these substructure elements have been constructed/renewed at the time of the deck construction.

In order to avoid possible damage to structures or the machine itself, the stabiliser must NOT be used in the following circumstances:

- On any track with heavily fouled or cemented ballast;
- On transom top or open top bridges;
- On ballast top timber bridges;
- On ballast top steel trough bridges;
- In tunnels;
- On track which is within 5m of multi-storey buildings;
- On concrete slab track;
- Over pits;
- Over any level crossing that has not been recently tamped;
- At locations near old or fragile signalling equipment as specified by a Signalling Engineer;
- Through turnouts, crossovers and diamonds and similar locations where the track has not been recently tamped and then only with care and with the roll clamps open;
- Through platforms where the ballast between sleeper ends and the platform wall is heavily fouled.

The above operating procedures and restrictions assumes that bridge components are free of structural defects. If this is not the case, reference should be made to the District Engineer for further direction.

Chapter 6 Collision protection of existing structures

C6-1 General

Supporting structures (including bridges, airspace developments, lift structures) within the rail corridor require some form of protection against damage from a derailed vehicle, which in turn could result in collapse of the structure onto the train. This requirement is now taken into consideration during the design of all new structures, in accordance with the provisions of collision protection and loading in AS 5100.

C6-2 Assessment of damage potential

Existing supporting structures (including temporary structures) may not be adequately protected from a derailed vehicle. The District Engineer is responsible for the assessment of potential damage and the implementation of appropriate protection to these structures where warranted, in accordance with the guidelines below.

In general, only those structures carrying vehicular or pedestrian traffic over the track shall be included in the assessment.

The risk assessment shall be performed in accordance with UGLRL CRN's Safety Risk Management System and should take into account the following parameters:

- Site condition, cutting, embankment etc.
- Derailment history
- Type of structure, i.e. potential for collapse damage to trains
- Track geometry
- Track speed
- Type of rolling stock
- Future usage and growth in patronage.

The risk analysis shall also consider any other relevant site specific criteria.

For those structures determined by the risk assessment as requiring additional protection, an appropriate device should be installed. The preference is to use deflection walls, however lower order protection devices such as earth mounds, gabions or guard rails etc. may be used if approval is obtained from the Principal Track and Civil Engineer.

Specific locations may be referred to the Principal Track and Civil Engineer for guidance and design input.

C6-3 Deflection walls

Deflection walls shall comply with the structural configuration and geometric requirements of AS 5100.1. In addition, they shall have the leading faces rounded or vee-shaped.

In the case of retrofitting a deflection wall to an existing vulnerable pier or column, as well as infill walls, end walls shall extend parallel to the track, 3 metres on the approach side of the pier or column.

C6-4 Guard rails

Where guard rails are determined to be the most appropriate device for providing protection at a specific location, they shall be installed in accordance with the standard design and configuration detailed in Chapter 8.

Chapter 7 Safety refuges

C7-1 Provision of safe areas

Provision shall be made for a 'safe area' adjacent to trackside structures for infrastructure and other authorised staff to stand during the passage of a train.

Trackside structures include: bridges, tunnels, retaining walls.

The principles adopted for the determination of clearance requirements are as follows:

- a 'safe area' will be a place where no part of a person or piece of equipment encroaches closer to the track than the kinematic envelope plus a safety margin of 200mm;
- the minimum depth for a safe standing area is 400mm;
- the kinematic envelope is the widest swept path of the rollingstock. Where out-of-gauge loads normally operate or are capable of operating, this outline shall be used;
- the basic premise is that a location is deemed to be safe unless otherwise indicated.

A 'safe area' must be provided along wall structures where the wall is longer than 20 metres.

In lieu of calculating kinematic envelopes, the default clearances to the front of the 'safe area' are:

- 2230mm on tangent track
- 2500mm on curved track.

C7-2 Locations with limited clearances

C7-2.1 Clearance less than kinematic plus 600mm:

When the clearance dimension from the track centreline to the structure is less than kinematic plus 600mm, refuges shall be provided for wall structures longer than 20 metres.

C7-2.2 Clearance between kinematic + 600mm and kinematic + 1200mm

When the clearance dimension from the track centreline to the wall structure is between kinematic plus 600mm and kinematic plus 1200mm, handhold devices as specified in Section C7-6 shall be provided for wall structures longer than 20 metres.

C7-2.3 Limited clearance sign

Owing to physical constraints, it may not always be possible to provide refuges or handhold devices along new or existing wall structures.

Where refuges or handhold devices are required but are not provided, wall structures shall have warning signage attached. The sign is shown in Section C7-7.

Warning signs should be considered for wall structures less than 20metres in length where clearance is less than kinematic plus 1200mm.

The sign is a warning that there is insufficient clearance to stand safely when trains are passing.

C7-3 Locations with adequate clearances

When the clearance dimension from the track centreline to the wall structure is greater than kinematic + 1200mm, no physical protection or signage is required.

C7-4 Location of refuges, handhold devices and limited clearance signs

The spacing of safe areas/ refuges/ handhold devices along a wall structure is not to exceed 20 metres. The spacing at each location shall be determined by a risk assessment, taking account of factors such as train speed, available sighting distances and existence of warning light systems.

Refuges/ handhold devices shall be provided on one side only of a single track where there are structures closer than the clearances for safe places on both sides of the track.

Where clearances are restricted on only one side of a single track, refuges/ handhold devices are not required. Limited clearance signage is required on the side of the obstruction.

Where refuges/ handhold devices are required on multiple tracks, they shall be provided in a staggered pattern on both sides of the track group.

The limited clearance sign is attached to the wall structure so as to be clearly visible to personnel standing on or adjacent to the track. The sign is required at access points to the limited clearance area.

The sign shall be attached at each end of the wall structure e.g. ends of retaining walls, tunnel portals, entrance to cuttings etc., and at locations along the structure wall where access is available to the track adjacent to the structure.

If access is only available from the end of the structure, no signs are required along the wall.

If access is continuously available, for instance the structure is on one side only, signs shall be installed at maximum 20 metre intervals along the structure.

C7-5 Refuge details

The floor of the refuge shall be at cess level or with a maximum step up above the cess level of 200 mm.

The minimum dimensions of refuges shall be:-

Height:	2000 mm
Width:	1500 mm
Depth:	700 mm

If the refuge is to contain telephones, fire extinguishers or other essential items, the width shall be increased to provide the same clear floor area.

The floor of the refuge shall be level. The refuge shall be kept clear of cables, pipes or other obstructions.

Handrails must be installed in all refuges to assist staff in keeping their balance during the passage of a train.

C7-6 Handhold device details

A schematic layout for a handhold device is shown in Figure 1 below.

It comprises two vertical pipe handrails 40 mm diameter, located 1000 mm apart and each protruding 400 mm from the fixing point on the structure.

The pipes shall be manufactured from galvanised steel.

Each handrail extends vertically from 900 mm above cess level to 1800 mm above cess level.

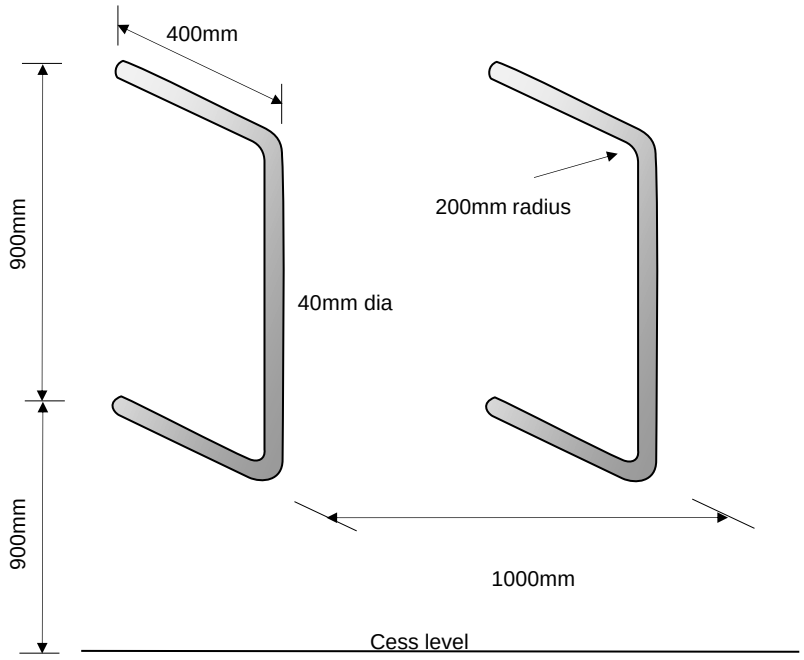

Figure 1 – Handrail device

The horizontal and vertical elements of each handrail are connected by a 200 mm radius bend.

A level standing area at cess level shall be provided between the handhold devices.

C7-7 Limited clearance sign details

The sign shall be as shown in Figure 2 below:

Figure 2 – Limited clearance sign

Chapter 8 Guard rails

C8-1 Functional purpose

The prime purpose of guard rails on underbridges is to keep derailed or derailing bogies/wheels tracked parallel to and in close proximity to the running rails. This action prevents a derailed train from falling over the side of the bridge.

In the case of through girder and through truss type underbridges, the guard rails prevent impact with key structural supporting elements.

For through girder, through truss and direct fix bridges concrete upstands may be provided in lieu of guard rails. The upstands shall be designed for a 80 kN lateral load. The design shall take account of cross drainage requirements. The upstand shall comply with the relevant configuration requirements for guard rails.

In addition, the guard rails, by way of a baulking effect, provide additional support to the track at the bridge ends.

C8-2 General requirements

Guard rails shall be installed on the following underbridges:

- Through span bridges and their approach spans.
- Transom top bridges on Class 1 and 2 lines > 3m long.
- Transom top bridges on Class 3, 3G and 5 lines > 3m long and on a curve or within 100 metres of the trailing end of a curve.
- Ballast top bridges > 20m long.

For ballast top bridges ≤ 20m on Class 1 or 2 lines and box culverts > 20m on all line classes, a risk assessment shall be undertaken to determine whether guard rails are required. The risk assessment should be in accordance with the UGLRL CRN Safety Management System, and consider the following criteria:

- Height of bridge;
- Bridge span;
- Probability and consequence of a derailment;
- Track alignment and configuration;
- Train speed, density and type of traffic.

Existing underbridges not complying with the guard rail requirements will need to be identified, risk assessed and added to a prioritised upgrading program.

In addition, guard rails may be provided to protect columns on overbridges and air space developments where the columns do not meet the collision protection requirements of AS 5100.

C8-3 Guard rail details

C8-3.1 Configuration

Guard rail installations shall comply with the following requirements:

- Guard rail shall be new rail or recycled rail Category 1 (White rail).
- Guard rail section shall be the same as the running rail or one section size less than the running rail.
- Top of guard rail shall be no higher than the adjacent running rail and no more than 50 mm below the running rail.

- Each guard rail shall be fastened on both sides to every transom/sleeper
- On timber ties, guard rails may be directly fixed to the timber with no plates
- For underbridges, guard rails shall extend parallel between the abutments
- For overbridges, guard rails shall extend parallel for a minimum 20 metres in advance of the vulnerable support on the train approach side.
- Guard rails shall extend parallel for a minimum of 3 metres beyond the abutment or vulnerable support on the train departure side.
- Where rail traffic is bi-directional, the guard rail shall extend parallel for 20 metres beyond the vulnerable support on both approach and departure sides of overbridges.
- A tapered nose section (“vee”), shall extend for a minimum of 3.6 metres beyond the abutment on the train approach side of the bridge. The design of the vee shall be in accordance with Drawing Number 785-570. The nose of the vee shall be bolted.
- Where traffic is bi-directional, the tapered guard rail section shall be installed at both ends of the bridge.
- Clearance between gauge face of running rail and adjacent face of guard rail shall be a minimum of 200mm and a maximum of 380mm.

The maximum clearance is preferred. The District Engineer may approve a reduction to a minimum of 200mm based on an assessment of

- requirements for tamping ballast top bridges,
- requirements for tamping bridge ends,
- the potential for derailed wheels to strike holding down bolts on transom top bridges
- and the use of resilient baseplates for mitigating noise and vibration

and the implementation of an effective maintenance regime for bridge ends

Block-out holes for guard rail fastenings in concrete sleepers shall be grouted with an approved high strength grout.

For fixing details, dimensional set-out and componentry detail and sizes, standard guard rail drawings are available:

785-568	Bridge guard rails Ballast top bridge Arrangement for concrete sleepered track
785-569	Bridge guard rails Details of concrete guard rail sleepers Concrete sleepered track
785-570	Bridge guard rails Ballast / Transom top bridge Arrangement for timber sleepered track
785-571	Bridge guard rails Timber sleepered track Details of special plating for tapered nose

C8-3.2 Special installations

Where expansion joints exist, specific design details of guard rail installations will be required. Approved track fixings shall be used. The design shall be certified by a competent design engineer.

Where noise and vibration limiting track fixings are used and there is a mismatch in height between the bridge ties and the end treatment ties, the guard rail and vee shall be supported on all ties with approved products such as rubber pads and fastened to all ties with approved track fixings.

C8-3.3 Signalling interface

Suitable isolation arrangements shall be made, where required, in track circuited areas.

The tapered nose section (“Vee”) shall be insulated with an approved component - refer to Figure 3. Generally one insulated joint is satisfactory. This insulation requirement applies to new installations and where refurbishment of the guard rails is undertaken.

Figure 3 - Insulated guard rails

Where guard rails exceed 50 metres in length, additional insulation and bonding arrangements may be required. Design drawings shall specify that insulation and bonding arrangements shall be in accordance with the requirements of the Principal Signal Engineer.

C8-4 Joints in guard rails

Whilst no joint is permitted in running rails on bridges, guard rails may have minimal joints with at least two bolts on each side.

If standard fishplates are used, six bolts are required.

If modified fishplates are used, the four bolts shall all have the nuts on the inside. Fishplates shall be modified by machining, not by oxy-acetylene cutting.

No joints are permitted in the vee.

Chapter 9 Underbridges

C9-1 Underbridge walkways, refuges and handrails

C9-1.1 Functional purpose

Walkways serve the following purposes:

- protect authorised personnel from falling when crossing a bridge;
- provide a safe pathway for train crew in the event of a train having stopped or failed on a bridge;
- facilitate track inspection;
- facilitate the replacement of transoms, sleepers and other track components.

Refuges serve the following purpose:

- provide a safe area on a bridge for authorised personnel to stand clear of a passing train.

Note: Standard width walkways do not provide a safe area or refuge.

Handrails serve the following purpose:

- protect authorised personnel and train crew from falling off the side of the bridge and approaches.

C9-2 Walkways

C9-2.1 General

The requirements for walkways and/or handrails shall be applied to all new and existing underbridges. These requirements may also be applied to significant multi-barrel culverts which are similar in safety risk level to underbridges.

Existing structures must be risk assessed to ascertain compliance to these requirements. Where compliance is not achieved, appropriate controls must be implemented until the existing structure is upgraded or renewed.

Walkways and/or handrails shall be installed on underbridges where the height from bridge deck to the lowest invert level is greater than 2 metres. Where the height is less than or equal to 2m a risk assessment must be carried out if walkways and/or handrails are not proposed to be installed.

When designing the location of walkways on underbridges, consideration shall be given to particular site characteristics such as flood issues (e.g. afflux and debris), track curvature, sighting distances and train lengths.

On single tracks where walkways are required, they should be installed in the following order of preference:

- downstream side of a bridge over water where flood levels are high;
- on the ‘outside’ of a bridge on a curve;
- on the same side of the track on adjacent bridges spaced less than one train length apart, with the ‘worst’ safety access bridge governing the side.

One walkway shall be provided on single track bridges and on double track bridges less than 15m long. Two or more walkways are required on double track bridges longer than 15m and on multiple track bridges. Refer to the typical configurations for walkways, refuges and handrails as shown in CRN CS 310 Underbridges Appendix 2.

Where provided, walkways shall be extended with suitable detailing at each end of the bridge to provide a safe transition to the approaches and adjoining rail embankments. Particular attention

shall be given to the detail where the last walkway panel abuts the face of the abutment, to ensure that adequate support is provided to the walking surface.

C9-2.1.1 Design criteria

The following design criteria shall apply to walkways on underbridges:

- Normal loading shall be self-weight plus 5 kPa live load, i.e. when no special storage bays are provided;
- On major bridges where special storage bays, designated by signage, may be provided, general walkway loading may be reduced to 3 kPa live load. The reduced walkway loading shall also be designated by signage;
- On transom top bridges, there should generally be no gap between the end of the transoms and the walkway deck;
- Where a grating is required in the 4-foot or on the transom ends, a proprietary material shall be used that will not lift or deform. Products such as expanded metal are not to be used where they are prone to deformation and lifting at the ends, thereby creating a trip hazard or the risk of being picked up by a passing train;
- On excessively wide ballast top deck bridges, i.e. 3 metres and greater from centreline of track to edge of bridge, no discrete walkway is required. In this case a handrail shall be provided up to 4 metres from the centreline of track, irrespective of deck to invert height;
- For through truss/girder bridges, structural elements are permitted to locally infringe clearance requirements when fitting internal walkways subject to a waiver being obtained from the Principal Track and Civil Engineer. This is preferred to the provision of external walkways, from which a track patroller could not effectively inspect the track;
- The minimum clear walking space shall be 600 mm. Consideration may be given to providing a wider walkway that affords a ‘continuous refuge’, where the particular circumstances (e.g. sighting distances, traffic volumes, bridge length) warrant such provision;
- For transom top bridges, the surface of the walkway shall be at or below underside of transom and ≤ 300mm below top of transom;
- On ballast top bridges, the normal standard is to set the walking surface of the walkway level with the top of the kerb;
- Walkway components shall comply with Australian Standards AS 3600, AS 4100 and AS 1657.

C9-2.1.2 Walkway storage

No walkway shall be loaded beyond the design value. If storage requirements exceed this value, storage bays shall be provided and designated by signage. 5kPa live load equates to 300 kg loading per metre length of 600 mm wide walkway.

C9-2.1.3 Services

Services and utilities for UGLRL CRN and external parties shall be located so as not to infringe on the walking or standing areas.

They shall be located to the outside of the walkway and extra width of walkway shall be provided to achieve the minimum walking space specified above.

C9-2.2 Refuges

Refuges shall be provided on underbridges over 20 metres in length.

Refuges may be required on bridges less than 20 metres long where site conditions warrant their installation.

The distance between refuges shall not exceed 20 metres over the length of the bridge. The spacing at each location shall be determined by a risk assessment, taking account of factors such as train speed, available sighting distances, the existence of warning light systems.

Refuges shall have a minimum clear space of 700 mm depth and 1500 mm width.

To establish the need for refuges and/or signage, the default clearances from the centreline of the nearest track to the front of a refuge are:

- 2230 mm on straight track
- 2500 mm on curved track

Where circumstances prevent the installation of refuges and the clearance from the track centreline to the back of a walkway is less than the kinematic envelope (out-of-gauge load) plus 600 mm, warning signs shall be installed as detailed in C9-2.5 below.

C9-2.3 Handrails

Handrails shall be provided on the outside of walkways and refuges and also on the opposite side of a ballast top underbridge where the height from deck to invert exceeds 2 metres.

Handrails shall consist of vertical posts together with a top rail and intermediate rail. Specific layouts shall be in accordance with the proprietary specifications of approved suppliers. The height of the top rail shall not be less than 950mm above the deck surface.

C9-2.4 Configurations

Typical configurations for walkways, refuges and handrails on underbridges are shown in CRN CS 310 Underbridges Appendix 2.

In most situations, walkways will be cantilevered on the outside of both transom top and ballast top structures. In addition, a walking area by way of a grating may also be required on transom top bridges in the 4-foot and on the transom ends.

The Principal Track and Civil Engineer may approve alternative configurations to the typical configurations shown in CRN CS 310 Underbridges Appendix 2 subject to a review of the usage, locality, requirements and any controls in place to reduce potential hazards. Examples of alternative configurations may include but are not limited to

- ballast top or direct fix bridges ≤ 15m with handrails installed on both sides to prevent fall risk, walkways not provided.
- ballast top or direct fix bridges >15 m with handrails and individual refuges installed, full length walkway not provided.

If usage or operation of an underbridge changes in the future then the walkway configuration may need to be reviewed.

Walkways shall generally comply with the layout, fixing and componentry detailed on the following drawings:

CV 0041442	Standard Steel Walkway (With Refuge) to suit 9m to 15 m Fabricated Steel Girder Spans
CV 0042333	Standard 1500 Wide Steel Walkway (Without Refuge) to suit 9 m to 15 m Fabricated Steel Girder Spans

C9-2.5 Safety marking and signage

C9-2.5.1 Safety marking

Delineation of the ‘safe areas’ to walk and stand on a walkway/ refuge shall be provided by a line 75mm wide and painted in Safety Yellow.

C9-2.5.2 Restrictions on use

Each walkway shall display a sign at each access end showing ‘Authorised Persons Only’. An ‘Authorised person’ is a person authorised by UGLRL CRN or its agents to enter onto and cross rail bridges.

The sign shall also incorporate a warning regarding the restriction on loading.

Details of a typical sign are provided in Figure 2. The sign shall be manufactured in accordance with CRN Engineering Specification CRN CP 213 “Trackside Signs”.

Figure 4 – Authorised persons sign

C9-2.5.3Location

The sign shall be attached to the handrail with lettering facing along track (must be placed so that staff approaching the bridge become aware of Danger)

The attachment to the handrail shall be such that inner edge of sign does not project into the walkway space beyond the inner edge of the handrail

C9-2.5.4Limited clearances

An additional sign shall be attached to all underbridges with walkways where the clearance from track centreline to the walkway handrail is less than the kinematic envelope plus 600mm. The sign, shown in Figure 5, shall be manufactured in accordance with CRN CP 213. Where similar signs have previously been provided, they should be replaced with the new sign when due for replacement.

Figure 5 – Limited clearance sign

C9-3 Bearings and deck joints

Bearings and joints shall be designed to provide sufficient access for the inspection, maintenance and replacement of the bearings and joints.

The minimum vertical distance between the underside of the main beams and the bearing shelf shall be 500mm.

Jacking points shall be provided on the bearing shelf.

C9-4 Track structure requirements

C9-4.1 General

Mechanical rail joints are not permitted on bridges. Anchoring of track and provision for expansion switches shall be in accordance with CRN Engineering Manual CRN CM 221 “Rail Installation and Repair”.

The noise emitted from the underbridge should be the same level (within □2 dBA) as that emitted from the track on the approach and departure from the bridge. This requirement applies to bridges in urban areas only. Ballast top structures are deemed to meet this requirement.

New bridge decks, except transom top, shall be structurally continuous without gaps or open joints to prevent matter and debris penetrating the deck within the spans. Where precast beams with gaps are used, there shall be a continuous deck slab rather than joints at the top surface.

Bridge decks installed during refurbishment/replacement of existing bridges shall, wherever possible, be structurally continuous.

C9-4.2 Ballast top

Ballast top underbridges are preferred to transom top due to ease in maintaining the track and provide for a significant reduction in track degradation adjacent to bridge ends.

The distance between the inside face of the ballast kerb and centre line of track shall be no less than 1950 mm.

The height of the kerb shall be no less than 600 mm. This may need to be reduced in special situations where hydraulic or other conditions demand, or increased where the track is on a grade or superelevated over the structure. Ballast shall not spill onto underbridge walkways.

C9-4.3 Transom top

Transom top bridges are generally not to be used for new or replacement bridges. If a transom top bridge is proposed for a particular situation, the prior approval of the Principal Track and Civil Engineer shall be obtained.

C9-4.4 Direct fixation

Direct fixation of the track to bridge decks may be considered where constraints such as limited vertical clearances exist below or above the track.

In situations where the deck is comprised of individual concrete girders with transverse stressing, the track shall be supported on monolithic girders to secure the track gauge.

Direct fixation bridges shall have concrete upstands to prevent a derailed train from falling over the side of the bridge. The upstands shall comply with the requirements of Chapter 8.

If concrete upstands cannot be provided, direct fixation bridges shall have guard rails in accordance with Chapter 8.

Track fastenings shall be approved resilient fastenings.

The maximum height of grout bed under the rail fixings shall be 60 mm. Where the hog of the girders results in a gap under the rail greater than 60 mm high, packers may be used but they shall provide for full lateral restraint to the holding down bolt.

High impact epoxy grouts/mortars or specially developed grouts shall be used under the rails on direct fixation bridge decks to accommodate the high dynamic effects and movement of the deck. There shall be no metallic elements in the epoxy. Standard cementitious grouts shall not be used.

The grout bed shall provide sufficient edge distance to the bolt to avoid cracking of the grout.

The transition from ballasted track to the direct fixation bridge deck shall be designed to ensure a smooth transition. Some structural configurations are detailed in Section C9-6 of this manual.

C9-5 Drainage and waterproofing

New underbridges, except transom top bridges, shall have positive drainage systems to prevent water discharging from the bridge to the watercourse or road below. Decks shall be structurally continuous in accordance with Section C9-4.1.

For the refurbishment/replacement of existing underbridges, decks shall where possible, have positive drainage systems. Where this is not possible, the waterproofing of the bridge deck shall be achieved by the use of membranes approved by the Principal Track and Civil Engineer, and protected in turn from mechanical damage from the track ballast by the installation of shock mats or similar materials.

Drainage of bridge decks shall generally comply with the requirements of CRN Engineering Manual CRN CM 421 “Track Drainage”. The drainage system shall be cleanable. The minimum pipe size shall be 225 mm diameter.

Drainage systems shall be designed to capture the water and drain it away from the track structure at the bridge end.

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

C9-6 Bridge ends

C9-6.1 General

Problems have always existed at the ends of underbridges with regular deterioration of the track “top” or vertical geometry. Other related problems include the loss of ballast profile and fouling of the ballast due to formation failures.

The loss of top may be a result of:

- settlement of the subgrade, owing to inadequate compaction or poor drainage behind the bridge abutment;
- settlement of the track ballast both initially and following maintenance, and particularly settlement relative to the bridge itself;
- additional vibration set up because of the sharp difference in track stiffness between the bridge and the ballasted track;
- ballast losses due to inadequate formation width at the interface with the abutment and exacerbated by the additional vibration;
- wide tie support at the bridge abutment between the last transom and the first sleeper leading to increased forces and impact;
- movement or rotation of the abutment allowing settlement of the fill behind;
- cracking and rotation of ballast walls and wingwalls.

The design of new underbridges and the major refurbishment of existing underbridges shall provide for the stability and compaction of the bridge ends.

This applies to ballast top, direct fix and transom top bridges.

A high level of ballast compaction around bridge ends will assist in their stability and reduce the extent of track settlement. This can be achieved by compaction of the bottom ballast using suitable off track plant prior to laying of the track, and compaction of the top ballast using whacker-packer type equipment or a dynamic stabiliser. Stability of the bridge abutments must be considered before permitting the use of the dynamic stabiliser or off-track rollers.

C9-6.2 Functional requirements

Bridge ends shall be designed to:

- provide a transition between solid and flexible track support systems;
- maintain the integrity of the ballast profile at the end of the bridge;
- maintain the integrity of the ballast condition;
- maintain the tie support across the interface.

C9-6.3 Approved configurations

There are a number of approved structural configurations for improving the performance of bridge ends. Selection of the most appropriate configuration for each location will be influenced by the following factors:

- traffic density, tonnage and speed;
- feasibility of implementation;
- whether the improvement is part of a construction, upgrading or maintenance activity.

Typical details and drawings of approved configurations are provided in CRN CS 310 Underbridges Appendix 3. These configurations include:

- engineered backfill
- reslilient pads and vibration isolation rail fasteners
- approach slabs
- ballast retention walls
- intermediate rail support on ballast walls.

C9-6.3.1 Engineered backfill

The formation immediately behind the abutments can be constructed in layers of selected compacted fill reinforced with geogrid. Provision shall be made for drainage below the compacted fill.

A typical layout of engineered backfill is shown in CRN CS 310 Underbridges Appendix 3.

C9-6.3.2 Resilient pads and resilient baseplates

On transom top and direct fixation structures, resilient pads or resilient baseplates may be installed on concrete sleepers on the bridge approaches and on the bridge.

Timber transoms may be installed instead of sleepers on the bridge approaches to increase the stability of the bridge ends.

The use of concrete sleepers just at bridge ends in timber sleepered areas is not recommended, unless resilient baseplates are fitted to the concrete sleepers and transoms.

C9-6.3.3 Approach slabs

A transitional stiffness can be provided between the bridge approaches and the bridge deck itself by the installation of concrete approach slabs.

Where bridges are located on a skew, the end of the approach slab shall be shaped to be perpendicular to the track, to avoid rocking of the sleepers.

Approach slabs may be used in conjunction with track slab and ballast top, transom top and direct fixation bridges. When installed on a ballast top bridge, they should be provided with kerbs lining up with the kerbs on the deck of the bridge.

C9-6.3.4 Ballast retention walls

Ballast retention walls may need to be installed at bridge ends to prevent loss of ballast from the track. Retaining the ballast profile will reduce the rate of deterioration in the track top and also assist track lateral stability.

Ballast retaining walls may be typically constructed from posts and guardrailing or precast concrete walls. Typical layouts are shown in CRN CS 310 Underbridges Appendix 3.

C9-6.3.5 Intermediate rail support on ballast walls

The maximum spacing between the centre of the last sleeper and the centre of the first transom on a bridge should be limited to 600mm.

In situations where centres in excess of 600mm cannot be avoided, a specially designed support must be installed at the ballast wall, enabling the tie spacing to be restored to normal and reducing the forces at the bridge end.

This configuration includes the use of a resilient rubber pad on top of the ballast wall, which provides support to the rail when deflecting under load. A typical layout is shown in CRN CS 310 Underbridges Appendix 3.

C9-7 Scour protection

C9-7.1 General requirements

Scour protection is incorporated in the design of new bridges where there has been a previous record of scouring or where a hydrological and hydraulic assessment indicates that there is a potential for scouring around the bridge.

Scour protection may also be required to be provided to existing structures where scouring and damage have occurred. In these instances, reference should be made to the Principal Track and Civil Engineer, to provide an appropriate design for the particular circumstances.

Scour protection shall be designed generally in accordance with the RMS Guidelines and Austroads Guidelines.

C9-7.2 Culverts

Scour protection will not normally be required when any one of the following criteria apply:

- The calculated velocity of flow through the culvert opening at design flow is < 1.5 m/s.
- The 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%.
- The calculated velocity of flow through the culvert opening at design flow is < 2.5 m/s and the streambed consists of gravel or stones with 50% by weight exceeding 150mm.

Geometric considerations may require slope protection where scour protection of the bed is unnecessary.

If scour protection is required downstream of the culvert, it shall extend for a distance not less than 1.5 times the opening height from the end of the culvert. It shall also incorporate a cut-off extending 500 mm below the bottom of the protection or to rock, whichever is the lesser, and shall be carried to the wing walls or up the sides of the channel to at least the serviceability limit states level.

Negotiations will be required with adjoining landowners if this requirement results in the scour protection extending outside the railway boundary.

Scour protection shall be specially designed for channels with a grading steeper than 1%.

C9-7.3 Underbridges

Scour protection shall be provided to footings and pile caps where there is a potential for undermining resulting from scouring of the watercourse under the bridge.

The railway formation around the abutments and wings of a bridge shall be provided with appropriate scour protection where there is a history of scouring and washaways, or where hydrological and hydraulic assessments indicate a potential future problem. Similar protection of the railway embankment adjoining the bridge may also be necessary.

C9-7.4 Alternative construction materials

Alternative forms of scour protection approved for use around culverts and bridges include:

- Grassing of embankment faces;
- Hand placed loose rock (rip rap);
- Sand bags filled with lean grout (e.g. 1 cement to 19 loam);
- Revetment mattresses (concrete filled);
- Gabion baskets or Reno mattresses (rock filled);
- Mortared spall;
- Precast concrete headwalls;
- Cast in situ concrete headwalls;
- Cast in situ concrete aprons and cutoff walls.

C9-8 Protection of bridges over roadways

Protection of bridges over roadways shall be in accordance with the requirements of CRN Engineering Standard CRN CS 310 “Underbridges”.

Chapter 10 Overbridges and footbridges

C10-1 Lifting of overbridges

Before lifting an overbridge, a comprehensive work method shall be developed to address the potential effect of the work on the stability of the bridge structure.

In some early bridge designs, the bridge abutments relied on the superstructure to provide lateral support against overturning.

Appropriate investigation of the stability of the structure during and after the lifting process needs to be undertaken as part of the risk assessment.

The work method must ensure that:

- The bridge is securely constrained against any possible movement during the lifting operation, in particular when any fastenings are removed or ineffective;
- Trestles are secured against lateral movement at the base;
- Jacking operations are undertaken evenly and in small increments (20 mm), with a thorough check of bridge stability undertaken after each stage.

If the bridge is to be lifted clear of its abutments, the bridge ends shall be secured by increasing the height of the abutment wall, or by using diagonal bracing, or by other suitable means.

The detailed work method needs to be approved by a suitably competent civil engineer before undertaking any work.

C10-2 Configuration requirements

C10-2.1 Bridge decks

New bridge decks shall be structurally continuous without gaps or open joints to prevent matter and debris penetrating the deck within the spans. Where precast beams with gaps are used, there shall be a continuous deck slab rather than joints at the top surface.

Bridge decks installed during refurbishment/replacement of existing bridges shall wherever possible be structurally continuous.

C10-2.2 Stepways

Stepway riser and tread dimensions for footbridges shall be 150 mm and 300 mm respectively.

Stepway risers shall be closed in to prevent visibility from beneath the structure.

C10-2.3 Barriers and protection Screens

C10-2.3.1 Definitions

Barriers are defined as the fence or walls along the sides of overbridges and footbridges, installed to protect road vehicles, cyclists and pedestrians from falling over the edge of the bridge.

Protection screens are defined as screens installed on overbridges and footbridges to restrict objects from falling or being thrown onto the track below.

C10-2.3.2 Barriers

Bridge barriers for new structures and major refurbishments shall be designed in accordance with AS 5100. The barriers provided above the rail corridor shall be at least medium performance level and should be subject to a risk assessment to determine whether a higher performance level is required.

The approach barriers to new, extended or refurbished overbridges and footbridges must also comply with AS 5100.

Pedestrian barriers and balustrading for new structures and major refurbishments shall be a minimum height of 1200mm.

Roll top mesh, chain wire mesh and wire strand parapets are not permitted on new bridges and are to be progressively replaced on existing structures.

C10-2.3.3 Protection screens

Prevention of objects falling or being thrown from overbridges and footbridges shall be achieved by the provision of one of the protection measures listed in AS 5100, including full enclosure (footbridges), provision of solid opaque walls with a minimum height of 2.4 metres, or the provision of protection screens.

For overbridges and footbridges, the requirement for protection screens shall be assessed on the basis of a risk assessment. The assessment should include a review of incident data. Reference should also be made to RMS Bridge Technical Direction – Bridge Safety Screens for guidance on the risk assessment.

Where required to be installed, protection screens shall be designed in accordance with AS 5100. The design should provide a balance between functionality, aesthetics, effectiveness and value for money, giving due consideration to the following factors:

- Safety for train users/operators: the ability of the screen to prevent objects from being thrown onto the track;
- General safety and train operation: the ability of the screen to prevent trespassers from climbing onto safety screens, thereby endangering their lives and impacting on train traffic;
- Pedestrian amenity: the ability of the screen material and design to provide adequate ventilation, suitable acoustics, light to the inside of the bridge, and views through the screen to the surrounding environment;
- Visual aesthetics: the likely visual impact of the screened bridge as viewed by people in the surrounding area;
- Sharp edges: the design shall minimise any exposed sharp edges on the pedestrian side;
- Modular construction: barrier screens should be designed to be modular, so that individual panels can be replaced;
- Costs: the likely construction and maintenance costs, including initial, ongoing, life span, vandal damage, and graffiti.

C10-2.4 Service ducts

Provision may be required for accommodating services managed by UGLRL CRN (e.g. high voltage, low voltage, signalling, communications) or services owned by other authorities and utilities (e.g. telephone, water supply, sewer lines, power and gas).

Ducts shall be provided for both current services and future services where appropriate.

Services shall be segregated where necessary, e.g. power and signalling.

The location and fixing of such service ducts shall be designed so that future access to the services for maintenance is facilitated and access to the main structure for inspection and maintenance is not impeded.

Service ducts shall be provided within the structure (e.g. under footways), in preference to exposed service lines.

C10-2.5 Drainage

A drainage system shall be provided on all overbridges and footbridges and shall be directed away from platforms and other CRN infrastructure and shall not discharge onto the rail corridor. The drainage system shall be cleanable. The minimum pipe size shall be 225 mm diameter.

C10-3 Deck sheeting

Asbestos/fibrous cement deck sheeting is no longer approved for use on footbridges. Where installed on existing structures, it shall be progressively replaced on a programmed basis.

C10-4 Bird nesting

Design features such as spikes may be required to prevent birds nesting on the bridge structure.

Chapter 11 Signal gantries

C11-1 Existing structures

Where existing signal gantries require refurbishment or replacement, the opportunity shall be taken to design the replacement/ refurbished structure in accordance with the current and proposed future line usage and business requirements.

In these instances, field requirements shall be referred to the Principal Track and Civil Engineer for detailed design.

C11-2 General design requirements

To minimise maintenance, signal gantries shall be configured using smooth, clean faced structures without a proliferation of small members, fittings and metal to metal interfaces.

In addition the following design criteria will apply:

- the minimum thickness of major steel structure components shall be 8 mm;
- steel structures and fittings shall be galvanised, unless approval is given by the Principal Track and Civil Engineer to use alternative coatings (e.g. coatings to meet heritage requirements);
- the minimum size of fillet welds shall be 6mm;
- designs must ensure that moisture and debris collection pockets are not created;
- the top surface of footings and holding down bolts shall be clear of the track ballast, cess and sub grade levels;
- the structures shall be designed for a serviceable life of 100 years.

Chapter 12 Tunnels

C12-1 Emergency procedures

Existing tunnels within the CRN network may not conform to current standards and policies with respect to emergency procedures in the event of a major irregularity (e.g. fire or derailment etc.).

The Principal Track and Civil Engineer will determine whether additional emergency facilities shall be installed in the existing tunnels.

C12-2 Refuges

General policies and procedures with respect to the provision of refuges in tunnels are covered in Chapter 7 of this Manual.

C12-3 Provision for services

Provision may be required when designing tunnels for accommodating services managed by UGLRL CRN (e.g. electrical and signalling cables) or services owned by other authorities and utilities.

Services shall be positioned in accordance with the following requirements:

- Transit space standard CRN CS 215;
- Clear of any walking areas where they might present a trip hazard;
- Not to interfere with or obstruct emergency walkways;
- Not to obstruct access to or reduce the capacity of refuge areas.

The location of any services is also to be selected so that future access for maintenance of the services is facilitated.

C12-4 Tunnel invert

The migration of fines into the tunnel from within the rock mass beneath the tunnel invert must be prevented by appropriate invert treatment.

C12-5 Seepage and drainage

The rate of inflow of groundwater into the tunnel shall 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 must also 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 minimise 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 shall drip onto the track.

C12-6 Tunnel fittings

Seepage of groundwater can cause corrosion to structural elements of the tunnel. Appropriate measures shall be implemented in the design to protect these components from corrosion.

All fittings and fastenings securing services to the tunnel structure shall be stainless steel.

Mechanical and chemical anchors should be designed and installed taking into account the long-term strength of the natural ground and tunnel linings allowing for deterioration over time.

Chapter 13 Retaining walls and platforms

C13-1 New retaining walls

From time to time, it may be necessary for maintenance staff to install a new retaining wall, to rectify a land slip or to provide additional clearances for maintenance purposes.

All retaining walls over 900 mm high require structural design.

For retaining walls within 3 metres of a track centreline, the top of the footings shall be located at least 1 metre below rail level. This will permit the proper functioning of cess drainage and future ballast cleaning and track reconditioning activities.

Designs shall include appropriate provision for drainage (e.g. top drains and weep holes).

Provision will need to be made for a safety handrail on top of a retaining wall where the wall height exceeds 2 metres.

C13-2 Refurbishment and replacement

Where existing retaining walls or station platforms require refurbishment or replacement, the opportunity shall be taken to design the replacement/ refurbished structure in accordance with the current and proposed future user requirements. An example is a platform wall that has a sub-standard height or which impedes the track drainage.

C13-3 Surface finishes

At locations where vandalism may be an issue, walls shall have an anti-graffitti coating applied.

Where shotcrete is used in refuges, the shotcrete surface shall be steel-floated.

C13-4 Earthworks

Earthworks associated with the backfill of retaining walls and station platforms shall be designed in accordance with AS 4678 “Earth-retaining structures” for compaction and drainage.

C13-5 Temporary platforms

The provision of temporary station platforms may be required during new construction works or as part of major maintenance work.

If a temporary platform is required to be in service for twelve months or more, it shall be designed for full loading requirements as detailed in standards.

If a temporary platform will be required for less than 12 months, relaxation of the loading requirements may be allowed.

C13-6 Platform configuration and drainage

Platform ends shall be finished vertically; ramped ends are not permitted as they facilitate the mounting of the platform by a derailed train.

The length and width of platforms shall be determined on the basis of operating and usage requirements.

The height of platforms shall be in accordance with CRN CS 215.

Platform surfaces (including temporary platforms) shall be constructed in durable and impermeable materials that will resist warping, slipping and tripping.

Unrestrained earth slopes beneath open platforms shall be designed to prevent spillage of material onto the track.

Vertical platform walls or piers adjacent to the track shall be placed no closer than 750 mm to the edge of the cantilevered coping, to allow for adequate ballast profile and drainage.

Track drainage shall be specifically designed at platforms, particularly in cases where natural run-off from the track structure is interrupted by the platform wall. Where practicable, the top of the footings should be located a minimum of 1 metre below rail level, to facilitate future ballast cleaning and track reconditioning and to ensure that the platform is not undermined during such activities.

The slope of the platform surface shall be designed so that run-off is directed away from the track. A positive drainage system shall be provided to collect and dispose of all stormwater.

C13-7 Platform Copings

The lateral and vertical placement of platform copings in relation to the track shall be in accordance with CRN CS 215.

When refurbishing an existing platform coping, a steel edge may be used.

The use of materials such as fibreglass is subject to the approval of the Principal Track and Civil Engineer.

C13-8 Services

For new structures, services shall be located within utility ducts within the platform.

For existing structures, services, such as cables and ducting, may be attached to the platform wall under the coping. Services shall preferably be located no lower than 500 mm from the underside of the coping and extend laterally no more than 300mm from the platform wall towards the track.

C13-9 Excavation and upgrading works

C13-9.1 General

Reference should be made to Section C5-7 of this Manual for procedures and restrictions relating to excavation works in the vicinity of platforms and retaining walls. Particular care must be taken to avoid disturbance to or destabilisation of existing structural footings and underground services.

C13-9.2 Platforms

When undertaking excavations or other civil works on filled station platforms, there is a risk that the platform wall may be destabilised owing to the weight of heavy plant exerting undue pressure on the back of the wall. All motorised plant (with the exception of light equipment) must therefore not be used within 1.5 metres from the rear face of any earth retaining platform wall.

While excavating in-filled platforms, damage may also be sustained to ground anchors that may have been installed to support the wall. The anchors typically come in the form of round steel bar or old rails, extending either horizontally or sloping downwards from the top of the wall and terminating in a concrete block. Whilst it is useful to consult old platform details, it is inconclusive to rely on these being ‘work as executed’ and care must therefore be taken when excavating.

It may be necessary to prop a platform so that it can be secured during upgrading works on the platform. Platforms with brick walls must be propped for work involving the use of heavy motorised plant. Other platform walls require assessment by a structural engineer.

The sample design for propping detailed in Figure 6 is suitable for platform resurfacing works involving the use of a 2 tonne non-vibratory roller. If a heavier roller or a vibratory roller is to be used, a propping system shall be designed and approved by a person with the appropriate engineering authority for design.

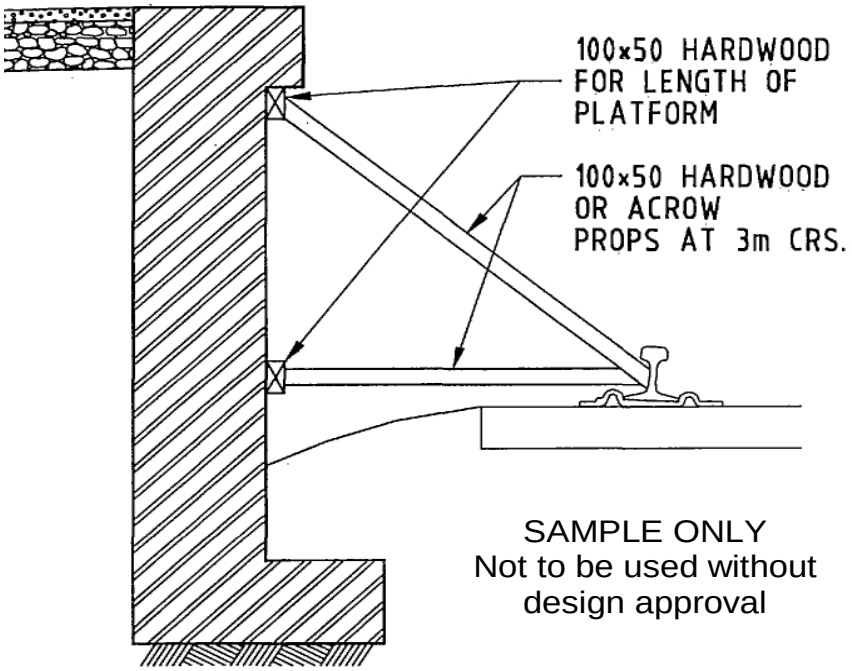

Figure 6 – Sample propping details

C13-9.2.1 Track requirements

If the propping system utilises the track structure, propping must be from the rail nearest the platform and the approval of the Principal Track and Civil Engineer is required.

If the propping design in Figure 6 is to be used, the following track requirements must be met:

- No rail traffic shall operate on track where propping is placed.
- The track situation must be reviewed by a qualified Track Examiner and the District Engineer.
- Propping shall not to be used in the Summer period (1 November to 31 March) if the work location has Priority One WTSA ranking. Propping would impose an unacceptable risk for the track section.
- If the track structure has concrete sleepers and the ballast profile and ballast condition is good, an Engineering Waiver is not required.
- If the track structure has timber sleepers in good condition, with 100% resilient fastenings and the ballast profile and ballast condition is good, an Engineering Waiver is not required.
- If timber sleepers are fastened with lock and dogspikes or dog screws the track has to be reviewed on a case by case basis and an Engineering Waiver will be required before work can commence.

C13-9.2.2 Controls

Control measures will be required for work on the platform when propping is used.

The control measures for work involving the sample propping design include:

- Asphalt compaction equipment MUST NOT exceed 2 tonnes fully loaded
- The compaction equipment MUST be non-vibratory
- NO work shall be undertaken on the track whilst the propping is in place. No machinery shall pass over the track unless work on the platform ceases. The machinery passing over the track

must be directly supervised and the track checked for any damage to the propping prior to work on the platform resuming

- The platform coping MUST be monitored by a surveyor for lateral deflection during construction
- The track MUST be inspected and certified by a competent Track Examiner after completion of the work. Any track movement or disturbance must be reported to maintenance staff
- Patrol staff MUST inspect the site closely for disturbance during regular patrol
- Screw jacks MUST NOT be over-tightened (snug tight only).

C13-9.2.3 Responsibility of works supervisor

It is the responsibility of the person supervising the platform work to ensure that the track requirements are complied with and that the control measures are implemented.

The supervisor shall liaise with the District Engineer and others as required.

If no work is permitted to be undertaken on the track, the supervisor must make arrangements to prevent it.

If track patrol staff are to check for track movement, they need to be instructed to do this by the District Engineer.

Chapter 14 Miscellaneous structures

C14-1 Overhead service crossings

Overhead service crossings are free-standing structures carrying utility services such as water or sewer mains.

Requirements are:

- design of the structure shall be such that the number of elements that are likely to be struck by a derailed train is minimised. Any columns at track level supporting the structure shall comply with the requirements for pier and column protection;
- access to CRN infrastructure must be maintained as specified for the particular site.

C14-2 Noise barrier walls

Noise barrier walls are structural elements erected for the purpose of attenuating the transmission of train noise to adjacent properties. They may be installed adjacent to the rail lines or along the rail corridor boundary.

The barriers shall be designed so as to provide access for maintenance and access to other rail infrastructure.

C14-3 Rockfall shelters

The stability of railway cuttings may deteriorate over time, resulting in the risk of earth slips and rockfalls over the track.

The collapse of cuttings or earth slips may be rectified under normal circumstances with remedial earthworks or techniques such as shotcreting etc. Where this type of action is not possible (e.g. because of access difficulties or height of cutting etc.), it may be necessary to consider the installation of a rock shelter structure to protect the track.

Rockfall shelters protect the track from falling rocks. The need to provide a rockfall shelter shall be determined by a geotechnical risk assessment.

Rockfall shelters and supporting elements such as columns shall be designed to resist impact loads from falling rocks. The design loads shall be determined on a site specific basis.

Where rockfall shelters are to be constructed, the vertical clearance between the ultimate approved rail level and underside of structure, and lateral clearance beside the tracks, shall be as specified in CRN CS 215.

Where applicable, provision shall be made for ‘safe areas’ for infrastructure staff to gain refuge from a passing train in accordance with Chapter 7 of this manual.

The design shall consider the future maintenance of the rockfall structure and the roof shall be designed for any temporary plant and equipment required for maintaining the roof.

C14-4 Lighting and communications towers

The design loads for lighting and communications towers shall be in accordance with the relevant Australian Standards for the type of structure.

The towers shall be designed and configured to meet the functional and performance requirements specified for each site by the tower owner.

C14-5 Structures over and adjacent to tunnels

Structures to be constructed over and/or adjacent to tunnels shall be suitably designed to take account of the interface with the tunnel.

Work methods shall be designed, staged and monitored to avoid damage to the railway tunnel. Work method statements shall be approved by UGLRL CRN personnel with appropriate engineering authority.

Prior to the commencement of works, a dilapidation survey of the tunnel and other rail infrastructure in the vicinity of the proposed works shall be undertaken. The existing condition of the rail infrastructure shall be agreed and recorded.

During construction works, the maximum peak particle velocity in the tunnel lining shall not exceed 20 mm per second.

Before commencing excavation within 5 metres of the tunnel, vibration monitors shall be installed inside the tunnel as close as possible to the point of excavation. Any cracks generated in the tunnel lining shall be monitored during excavation and repaired on completion of the work.

Appendix 1 Definitions

Term	Description
A	
Abutment	The support at each end of a bridge.
Abutment sheeting	Timber planks used to retain the filling behind an abutment.
Approach slab	Slab (usually reinforced concrete) laid above the formation behind bridge abutments and designed to provide a transition zone for track stiffness onto the bridge.
B	
Ballast log	Timber, steel or concrete member sitting on top of the abutment wall to hold back track ballast.
Ballast top	Underbridge with continuous deck supporting metal ballast.
Ballast wall	Member laid longitudinally at the outer edge of a ballast top span to prevent ballast spilling over the side.
Barrier	The fence or walls along the sides of overbridges and footbridges, installed to protect road vehicles, cyclists and pedestrians from falling over the edge of the bridge.
Bearing	Seating area of a load-carrying member; may be a separate fabricated member attached to the girder ends.
Body bolt	Vertical bolt in timber girders and corbels causing pairs of members to deflect together.
Bracing	Horizontal or diagonal member attached to main members to stiffen those members, or to minimise sidesway.
Bridge	A structure spanning a river, road, railway, or the like, and carrying vehicles or persons.
Butt transom	Intermediate transom linking the ends of girders from adjacent spans.
Broad flange beam	A steel girder designed in the 1920's with thicker and wider flanges and reduced height of web for use in locations where greater vertical clearance was required.
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.
C	
Caisson	A cylinder or rectangular ring-wall for keeping water or soft ground from flowing into an excavation. It may later form part of the foundation.
Capping	Impermeable layer of fill located immediately above the main formation and designed to shed water to the sides of the track.
Catchment	Area of land from which water flows into an underbridge.
Check	A separation that runs parallel to the timber grain and usually on the surface. It results from stresses that develop as the surface layers of wood loose moisture.
Compound girder	Timber girder made from two or more sections bolted firmly together on top of each other.
Compression flange	The face of a member that is in compression. For beams it is usually the upper face and in particular near mid-span. For a cantilever or a continuous member it is the lower face over the supports.
Coping	The longitudinal edge of a station platform.
Corbel	Short longitudinal member seated on a headstock providing a bearing for adjacent girders.

Corrosion	The gradual removal or weakening of metal from its surface by chemical attack. Generally, it requires the presence of water and oxygen, and is helped by carbon dioxide, sulphur dioxide and by other materials in small quantities in the air or water.
Crack	Open fissure on the surface of a member, but not necessarily right through the member.
Culvert	Arch, box-shaped or piped underbridge having integral walls, roof and floor.
D	
Damage	The sudden worsening of the condition of a structure, its elements and component materials due to the effect of a sudden event such as fire, flood, accident or vandalism.
Debris	Rubbish or other loose material lying near an underbridge and which impedes smooth water flow through the bridge opening.
Decay	Deterioration on or in a timber member causing loss of strength.
Deck	Part of bridge superstructure directly carrying the load.
Defect	Deterioration of a member of a structure from its original condition.
Deflection	Downwards displacement or sag of a girder when loaded by vehicles or persons.
Deflection wall	Structural wall installed to protect the supports of a structure adjacent to the track from collapse caused by a derailed train.
Deflectometer	Instrument for measuring deflection in girders - also referred to as “mousetrap”.
Deterioration	The gradual worsening of the condition of a structure, its elements and component materials due to the effects of traffic and other loadings, the action of the environment on the structure and/or the actions of the constituents of component materials over a period of time.
Driving mark	Mark cut into timber pile indicating in roman numerals the distance to the toe of the pile
E	
Engineered backfill	Compacted select earth fill behind abutments, reinforced with horizontal layers of geogrid or similar and used to stiffen the bridge approach”
F	
Flood level	Mark stencilled on No.1 Abutment of underbridges indicating height and date of maximum previous flood.
Footbridge	Bridge over the track carrying pedestrian traffic only. May be freestanding or combined with an overhead booking office.
Footway	Pedestrian access attached to, or included in, an overbridge.
Formation	Ground immediately beneath the capping and track.
G	
Gantry	An overhead structure consisting of side masts or columns joined at the top by a horizontal bridging member.
Girder	Main horizontal load-bearing member of a structure.
Guard rail	Rail placed in pairs and fixed to transoms or sleepers between the running rails, to guide the wheels of a derailed train.
H	
Handhold device	A system of handrails provided along a wall structure to provide support for personnel.

Headstock	Horizontal member(s) attached at or near the top of a trestle or pier, on which the superstructure bears.
I	
Intermediate transom	timber transverse member set between top and bottom girders in a ballast top span.
Invert	Earth or concrete floor of an underbridge.
J	
Jack arch	Form of bridge decking in which small concrete or masonry arches infill run between main longitudinal steel girders.
K, L	
M	
Maintenance	The actions necessary to preserve the serviceability, reliability and safety of a structure at or near its current level and to slow the rate of deterioration.
Minor opening	Underbridge less than 10 metres in length.
N	
O	
Obvert	Underside of bridge superstructure.
Overbridge	Bridge carrying road vehicles or livestock over a track.
P	
Packing	Piece of timber, steel, or other hard material, placed or driven between members to adjust their relative position.
Parapet	A type of barrier comprising a solid wall or post and rail fence along the sides of overbridges and footbridges, installed to protect road vehicles, cyclists and pedestrians from falling over the edge of the bridge.
Pier	Intermediate support of bridge spans between abutments, built of solid construction and usually in concrete or masonry.
Pile	A vertical or inclined member driven or cast in the ground to support a trestle, pier, sill, or abutment. Includes: - Batter pile: set at an angle to the vertical to resist sidesway; - Planted pile: set in excavated hole then backfilled and compacted; - Plumb pile: vertical pile; - Potted pile: set in concrete below ground level; - Pumping pile: a pile that is moving vertically in the ground under load; - Spliced pile: two or more pile sections joined end-to-end by plates; - Stump pile: pile section left in the ground after top removed.
Pile cap	Concrete member located at the top of a nest of piles to link their supporting action together.
Pipe	Hollow longitudinal void near the centre of a timber member where the heartwood is usually situated.
Pitting	An extremely localised form of corrosive attack that results in holes or hollows in metal. Pits can be isolated or so close together that they may look like a rough surface.
Protection screen	Screen installed on overbridges and footbridges to prevent accessibility to a safety screen and to restrict objects from falling or being thrown onto the track below.

Q	
R	
Refuge	A 'safe area' provided along a bridge, retaining wall or in a tunnel.
Rockfall shelter	A structure installed over and beside a rail track to prevent loose material from adjacent cuttings falling on to the rail line.
Rot	Internal decay of a timber member caused by fungal attack.
Repair	The actions necessary to increase the current level of serviceability, reliability and/or safety of a structure.
Runner	Longitudinal member bolted to girders and transoms to hold transoms to correct spacing.
S	
Safe area	A place where people and equipment will not be hit by a passing train.
Safety walkway	An area along an underbridge where personnel can walk without falling through to the ground.
Scaling	The gradual and continuous loss of surface mortar and or aggregate over irregular areas of concrete. It most frequently affects horizontal surfaces exposed to the weather or traffic, but could also be an indication of frost or salt attack.
Screwing up	Maintenance process of tightening up body and other bolts to improve the load capacity of a timber bridge.
Service crossing	Structure carrying commercial product or utilities over or under a track and across the railway corridor.
Shakes (in timber)	Complete or partial separation, usually across the timber grain and due to causes other than shrinkage. Possible causes of shakes are due to felling of the tree, impact loading, stream forces or wind force.
Shear zone	That area of a member near to a support, where a force acts through the member.
Sheeting	Timber planks or steel panels, restraining the fill behind a wall type structure.
Sill	Concrete or masonry footing supporting a trestle.
Soffit	The underside of a bridge superstructure.
Spalling	Drummy or loose concrete, masonry or stone surfaces, which may have been initiated by corrosion of reinforcement or by heavy impact.
Span	(a) deck of a bridge between adjacent substructure supports (b) the distance between girder supports.
Spandrel wall	A wall carried on the extrados (upper convex surface) of an arch, filling the space below the deck.
Split	Fissure in a timber member running parallel to the grain, from one face right through to the opposite face.
Station platform	Line-side structure built to provide public access to passenger trains.
Stiffener	Vertical steel plate used to stabilise and strengthen the web of girders.
Strain	The lengthening or shortening of a member under load.
Substructure	The supports for a bridge deck including trestles, piers, abutments and foundations.
Subway	Underbridge passing over a pedestrian pathway.

Superstructure	The deck or “top part” of a bridge spanning between supports.
T	
Tension face	The face of a member that is in tension. For beams it is usually the lower face and in particular near mid-span. For a cantilever or a continuous member it is the upper face over the supports.
Teredo	Marine borer which destroys timber in tidal areas.
Termite	Insect (incorrectly called white ants) which attacks timber by eating the cells, causing strength loss.
Through span	Span type where the main girders rise above track level.
Tie bar and tie rod	long bars used to hold adjoining concrete girders or culvert units together across the track
Tie plate	steel plate used to hold adjoining concrete culvert units together across the track
Tip end sheeting	Sheeting behind extended timber girder ends of abutments.
Transom	Structural member (usually timber) laid across girders for attachment of rails on transom top spans.
Transom packer	small packers, usually steel, located between the underside of a transom and top of a girder, used to adjust the height and superelevation of the track and to remove loading from the girder flanges
Transom top	Underbridge where the track is directly fixed to the superstructure and metal ballast is not provided.
Trestle	Intermediate support for bridge spans between abutments, usually constructed as a timber or steel frame.
Troughing	Pipe in timber member starting at the top face.
Truss	Girder made from two horizontal members (top and bottom chords), joined by vertical and diagonal members.
U	
Underbridge	A bridge supporting a track and passing over waterways, roadways, pathways and flood plains etc.
V	
Viaduct	An underbridge consisting of multiple spans with total length over 100 metres.
W	
Waling	Headstock constructed from 2 pieces of timber bearing on pile
Walkway	An area along an underbridge where personnel can walk without falling through to the ground
Waterway	Clear area under a bridge for water to run through.
Wing	Piles and sheeting or concrete or masonry wall restraining embankment on each side of an abutment.
X, Y, Z	