UGL REGIONAL LINX

MAINTENANCE PLAN - FIRST GENERATION WROUGHT IRON LATTICE TRUSS UNDERBRIDGES

CRN-MAN-CVL-713026361-693

CRN CM 111

LINKING COMMUNITIES. CONNECTING CUSTOMERS.

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Document Control

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

Revision	Issue Date	Revision Description
1.3	26.11.2021	UGLRL Operational Standards Template applied
2.0	10.12.2021	First approved and issued UGLRL version
3.0	24.01.2022	Issued for publish to intranet and webpage

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

Chapter 1 Introduction

C1-1 Overview

The Maintenance Plan (MP) specifies the specific maintenance management systems and procedures for the following First Generation Lattice Truss Wrought Iron Underbridges.

- Wellington, Main West Line 412.847km - single track on 3x 48m spans (See Figure 1)
- Tamworth, Main North Line 454.125km - single track on 1 x 48m spans (See Figure 2)
- Woolbrook, Main North Line 510.202km - single track on 1 x 48m span (See Figure 3)

Figure 1 -Wellington

Figure 2 – Tamworth

Figure 3 – Woolbrook

The maintenance plan covers the wrought iron span superstructure and substructure components only. This includes the single lattice truss span of Tamworth and Woolbrook underbridges and 5 spans of Wellington underbridge. These underbridges were constructed in the period from 1876 to1883 and consist of 48.5m through truss superstructure units comprising riveted wrought iron

main lattice truss longitudinal girders. The deck members comprise riveted wrought iron I beam sections spanning between the lattice trusses with riveted web connections to the trackside faces of the bottom chords.

The 3 lattice truss spans of Wellington underbridge and the single lattice truss span of Tamworth underbridge are supported on twin cast iron caissons. The single lattice truss span of Woolbrook underbridge is supported on brick wall piers.

Wellington underbridge was upgraded in June 2014 with a full deck replacement of all 5 spans (2 plate web girder approach spans and the 3 main lattice truss spans in the middle). The works included replacing all the old wrought iron cross girders with 204 new steel cross girders, replacing the old longitudinal timber stringers with new steel stringers and replacing all transoms and one upside walkway. Related wrought iron rivet at connections were replaced by steel swage fasteners and standard grade bolts.

Due to the age and quality of metallurgy, the bridges require a safety assurance regime for continuing use and operation. This is achieved by the implementation of a specific Maintenance Plan for the bridges.

This document is provided for the use of personnel responsible for implementing maintenance policies, programming preventive and corrective maintenance work and responding to identified defects for these structures. This Maintenance Plan is based on the mandatory examination requirements documented in CRN Engineering Standard CRN CS 100 “Civil Technical Maintenance Plan”. Some frequencies detailed in this plan differ from those mentioned in CRN CS 100. The frequencies detailed in this plan take precedence over frequencies detailed in CRN CS 100.

This Maintenance Plan incorporates the following:

- Maintenance management systems
- Procedures for maintenance management
- A continuous improvement and risk management process

In particular this document identifies the following:

- Maintenance requirements unique to these structures
- Current defects and required maintenance / repair works
- Mandatory responses, including intervention levels, for observed defects
- Particular risk management issues associated with these structures

C1-2 Context

The manual is part of UGLRL CRN’s engineering standards and procedures publications.

More specifically, it is part of the Civil Engineering suite that comprises standards, installation and maintenance manuals and specifications.

Manuals contain requirements, processes and guidelines for the management of structures, geotechnical and right of way assets and for carrying out examination, construction, installation and maintenance activities.

C1-2.1 How to read this manual

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

When you read the information, you will not need to refer to CRN Engineering standards. Any requirements from standards have been included in the sections of the manual and shown like this:

All the wrought iron lattice truss underbridges must be inspected in detail in accordance with the following requirements extracted from CRN CS 100

Technical Maintenance Plan					
Service Description	Applicability	Service Schedule	Period	Latitude	Comments
Detailed Structures Examination	Wrought Iron lattice truss underbridges at Tamworth, Wellington, Woolbrook	CSS 201	1 year	36 days	See Appendix 3

Reference is, however, made to other manuals.

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

- Principal Track and Civil Engineer
- Civil Maintenance Engineer
- Area Manager
- Structures Superintendent
- Supervisor
- Bridge Examiner

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”

C1-3 References

C1-3.1 Australian and International Standards

AS 1171 - Non-destructive testing- Magnetic particle testing of ferromagnetic products, components and structures

Unless otherwise specified, all references relate to the latest standard versions, including amendments and relevant superseding standards.

C1-3.2 CRN Documents

CRN CS 100 – Civil Technical Maintenance Plan

CRN CM 001 – Civil Technical Competencies & Engineering Authority

CRN CM 211 – Track Geometry and Stability

CRN CM 302 – Structures Examination

CRN CM 304 – Underwater Examination

CRN RM 001 – Train Operating Conditions (TOC) Manual

C1-3.3 Drawings

See Appendix 4

C1-3.4 Reports

See Appendix 4

C1-4 Definitions abbreviations and acronyms

MP Maintenance Plan - covers defect management and responsibilities for aspects of the plan.

Infor UGLRL CRN's Defect Management System.

C1-5 Objectives of the maintenance plan

The objectives of the maintenance plan are:

- To maintain the bridges 'fit for purpose' for rail operations in accordance with the Train Operating Conditions Manual
- To identify the responsibility and accountability for the bridge management, inspection, and maintenance
- To ensure that the inspection and defect management are carried out in accordance with the approved program, in the correct format and by competent experienced personnel
- To ensure that all inspection data is recorded and actioned appropriately
- The inspection tasks and minimum frequencies defined in this document are mandatory.
- Any proposed alteration in operational speed, loading, task scope or frequency must be authorised by the Principal Track and Civil Engineer

Inspectors and maintainers must also review any abnormal / unusual situations and notify the Civil Maintenance Engineer / Structures Superintendent accordingly.

Civil Maintenance Engineer / Structures Superintendent accordingly must obtain written approval of any changes from the Principal Track and Civil Engineer.

C1-6 Maintenance concept

C1-7 General

The maintenance concept provides for preventive maintenance to minimise or avoid disruption to services, commensurate with UGLRL CRN's safety and reliability obligations. There are two types of maintenance to support the system:

- Preventive Maintenance
- Corrective Maintenance

C1-7.1 Preventive maintenance

Preventive maintenance is undertaken to keep an item in condition above a minimum specified operating condition through regular maintenance tasks and through systematic examination to detect and prevent potential failures. The former of these includes routine servicing and regular scheduled maintenance based on time or traffic. The latter comprises surveillance examination, condition monitoring and functional checks. The MP details periods at which preventive maintenance is required. (See Section C5-1.1)

C1-7.2 Corrective maintenance

Corrective maintenance is undertaken to restore items to a specified condition by repairing or replacing items. Corrective maintenance is carried out as a result of failures or unsatisfactory conditions detected during preventive maintenance examination and checks.

Chapter 2 Management requirements

C2-1 General

The Infrastructure Maintenance Manager is accountable for the structural integrity of all bridges on the CRN. This is achieved by providing a framework of engineering standards and practices, within which other parties must work to undertake design, construction and maintenance activities.

No party can deviate from the standards without first referring the matter to the Principal Track and Civil Engineer for approval.

By complying with the standards, the Infrastructure Maintenance Manager is able to manage their accountability for the condition and safety of the bridges.

C2-2 Specific accountabilities

C2-2.1 Principal Track and Civil Engineer

Responsible to the Manager Engineering Services for:

- Holding Engineering Authority for bridge related engineering decisions
- Review and authorisation of bridge standards and waivers
- Assessment based on condition reports / defects and reporting on the technical integrity of the Lattice Truss Bridges and associated technical support systems
- Timely dissemination of standards affecting this MP to all involved parties
- Follow up on non-compliances identified during integrity audits and any other reports
- Approval of modifications to any of the bridges
- Provision of special reports and instructions as required

C2-2.2 Civil Maintenance Engineer

Responsible to the Infrastructure Maintenance Manager for:

- Certification that work has been carried out in accordance with this MP, or approved variations
- Certification that the bridge's condition meets the required standard and is thus 'fit for purpose';
- Certification that if the bridge does not meet the required standard, that the deficiency and associated risks are being appropriately managed
- Providing recommendations for future MP and Capital programs as required.

C2-2.3 Area Manager

Responsible to the Infrastructure Maintenance Manager for:

- Management of allocated area resources and funding for this MP;
- Ensuring defects are addressed within the stated target response times;
- Arranging higher level assessment of defects when required

C2-2.4 Structures Superintendent

The Structures Superintendent, who is responsible for the overall maintenance of bridges and structures in his area, must

- Ensure that inspection of all structures nominated in the CRN CS 100 occurs as scheduled
- Ensure entry of inspection results and examination documents into the Asset Management System (Infor)

- Ensure Mid-Cycle examinations of bridges are undertaken
- Assess defects detected and reported by the Bridge Examiner in the weekly summary and detailed examination reports
- Refer defects where necessary to the Civil Maintenance Engineer for higher level assessment;
- Confirm defect categories and repair priorities where assigned by the Bridge Examiner
- Submit non-standard issues to the Civil Maintenance Engineer
- Initiate special examinations where there are doubts concerning the condition and safety of a structure

C2-2.5 Bridge Examiner

The Bridge Examiner is responsible to the Structures Superintendent.

The Bridge Examiner:

- Undertakes detailed examinations of the bridges within his area
- Reports immediately to Structures Superintendent any defect affecting the continuing safety of a bridge. Verbal reports must be confirmed in writing
- Undertakes special examinations of known or anticipated hazards, especially during periods of heavy rain, of flooding, or following damage by road or rail vehicles, using self-initiative where necessary, or as directed by the Structures Superintendent
- In emergency situations the Bridge Examiner is authorised to protect the running line and in such circumstances should advise the Structures Superintendent immediately
- Where competent, undertakes magnetic particle or dye penetration testing of cracks in the bridges

C2-2.6 External consultant / contractor

External consultants and/or contractors may be engaged by UGLRL to undertake underwater examinations, magnetic particle testing, material testing, load rating, etc.

Where engaged, the external consultant / contractor shall:

- Comply with UGLRL safety and commercial requirements
- Complete the scope of work and detail the findings in a report format
- Fully address comments from UGLRL and finalise the report
- Report to UGLRL immediately any defects (or structural deficiencies) affecting the continuing safety of the bridge. Verbal reports must be confirmed in writing

Chapter 3 Competency

All maintenance inspection, assessment, monitoring and review functions shall only be performed by suitably competent persons on a regular basis as set out below.

NOTE: These competencies may enable activities to be carried out in other manuals. For a comprehensive list of all activities that are covered by a given competency see CRN Engineering Manual CRN CM 001 “Civil Technical Competencies and Engineering Authority”.

To carry out this work	You need these competencies
Locate & identify defects in structures	TLIB2086 Apply awareness of structures fundamentals
Detailed examination of structures	TLIB3098 - Examine concrete/masonry structures TLIB3088 - Examine steel structures TLIB3087 - Examine timber structures **AND** The following CORE competencies Apply awareness of structures fundamentals Carry out routine maintenance of structures Repair concrete/masonry structures Repair steel structures Repair timber structures Maintain bridge bearings
Mid-cycle examination of structures	TLIB3098 - Examine concrete/masonry structures TLIB3088 - Examine steel structures
Structure damage assessment	TLIB3098 - Examine concrete/masonry structures TLIB3088 - Examine steel structures **AND** Assess structures
Special examination of structures	TLIB3098 - Examine concrete/masonry structures TLIB3088 - Examine steel structures
Specialist testing of steel structures	MEM24001 - Perform basic penetrant testing MEM24003 - Perform basic magnetic particle testing
Underwater examination of structures	Accredited diver + Structures knowledge (see CRN CM 304)
Assessment of structures	Assess structures
Load rating	Authorised Structural Engineer

Chapter 4 Present bridge condition

The main defects applicable to the First Generation Wrought Iron underbridges are:

1. Varied breakdown of protective coatings.
2. Crevice and pitting corrosion around connections and along bottom chords.
3. Corrosion of bolts and rivets.
4. Deterioration of timber transoms and stringers.
5. Moderate/severe corrosion in bearings.
6. Rolling defects (laminations / cracks).
7. Cracking in cross girder end connection angle cleats.
8. Loose bolts and rivets.
9. Cracking in cast iron caissons.

The defect management systems, including inspection requirements and defect intervention levels for defects 1 to 5 are detailed in CRN Engineering Manual CRN CM 302 “Structures Examination” and Section C5-1 of this manual.

For defects 6 to 9, the defect management system, including inspection requirements and intervention levels are as detailed in Section C5-3.

C4-1 Allowable loads and speed limits

The allowable loads and speed limits for the First Generation bridges are summarised in Table 1 below. The current traffic and operating conditions under which they are allowed to traverse the bridge are documented in CRN Engineering Manual CRN RM 001 “Train Operating Conditions (TOC)”. Permanent / temporary speed boards shall be installed in accordance with CRN Engineering Manual CRN CM 211 “Track geometry & Stability”.

Any proposed alteration in operational speed or loading, must be authorised by the Principal Track and Civil Engineer.

Underbridge	Maximum current operating Axle Load	Max UDL*	Permanent Speed Restrictions (km/h)
Wellington	25 t	7.8 t/m	50 for Passenger & 10 for Freight trains
Tamworth	21.5 t	5.82 t/m	30 for Passenger & 10 for Freight trains
Woolbrook	21.5 t	5.82 t/m	30 for Passenger & 10 for Freight trains

Table 1 – Operating Conditions – WI bridges

* Freight / steel wagons are marshalled with lighter / empty wagons to satisfy the UDL requirements.

Chapter 5 Defects, inspection requirements and intervention levels

C5-1 General inspection requirements

C5-1.1 Bridge examination

Bridge Examination indicates the condition of the bridges and what repairs are required. It also forms the basis for the review of the Maintenance Plan, preparation of repair programs, or of renewal programs.

The results from the 2013-14 full examinations of the wrought iron underbridges in Wellington, Tamworth and Woolbrook reveal the following:

- No crack was found at the lattice truss splices in magnetic particle tests
- Minor surface corrosion, graphitisation and scattered pitting was found in cast iron caissons in underwater examinations

In addition, considering all the wrought iron cross girders were replaced during the deck replacement of Wellington underbridge in June 2014, the following amendments to the maintenance plan have been adopted:

- For Wellington underbridge, magnetic particle testing only applies to the lattice truss splices on the reachable faces of the top and bottom chords
- Examination frequency and extent to cover all lattices truss splices shall be reviewed by the Principal Track and Civil Engineer if cracks are identified on any the lattice truss splices at Wellington, Tamworth or Woolbrook underbridges
- For Wellington and Tamworth, the service frequency of special underwater testing (CSS 236) has been extended. Woolbrook is not required to have this exam

All the wrought iron lattice truss underbridges must be inspected in detail in accordance with the following requirements extracted from CRN CS 100

Technical Maintenance Plan

Service Description	Applicability	Service Schedule	Period	Latitude	Comments
Detailed Structures Examination	Wrought iron lattice truss underbridges at Tamworth, Wellington, Woolbrook	CSS 201	1 year	36 days	See Appendix 3
Underwater examination	Wrought iron lattice truss underbridges at Tamworth and Wellington	CSS 230	6 years	216 days	

All the wrought iron lattice truss underbridges must be inspected in detail in accordance with the following requirements extracted from CRN CS 100

Appendix 3 - Wrought Iron and Steel Bridges Nominated for Special Examination

Service Description	Applicability	Service Schedule	Period	Latitude	Comments
Detailed Structures examination	Wrought iron lattice truss underbridges at Tamworth, Wellington, Woolbrook	CSS 201	1 year	36 days	Detailed Structures examination with particular examination to the cross girder end connections, lattice truss splices, welding and the effectiveness of any packing under the ends of any timber stringers
Special Examination and Testing	Wrought iron lattice truss underbridges at Tamworth and Woolbrook	CSS 207	2 years	72 days	In conjunction with Detailed Structures examination: From a platform below the bridge, undertake a very close visual examination of the bottom flanges of cross girders Undertake magnetic particle testing of the cross girder end connections and lattice truss splices in accordance with AS 1171
	Wrought iron lattice truss underbridges at Wellington	CSS 207	2 years	72 days	In conjunction with Detailed Structures examination: Undertake magnetic particle testing of lattice truss splices at the accessible areas of the top and bottom chords in accordance with AS 1171.
Special Underwater Testing	Wrought iron lattice truss underbridges at Tamworth and Wellington	CSS 236	12 years	360 days	In conjunction with standard underwater examination, undertake graphitisation testing of the cast iron caissons
Special Structures Defect Examination	Wrought iron lattice truss underbridges at Tamworth, Wellington, Woolbrook	CSS 237			
	See CRN CM 111: Rolling defects, cracks in cross girder end connection angle cleats and cracks in caissons		1 year	36 days	In conjunction with Detailed Structures examination
	See CRN CM 111: High severity cracks in cross girder end connection angle cleats		6 months	18 days	
Visual Bridge examination	Wrought iron lattice truss underbridges at Tamworth, Wellington, Woolbrook	CSS 202	1 year	36 days	At least once in the period between Detailed Structures examinations.
Structural bridge assessment		CSS 234	1 year	36 days	To follow Detailed Structures examination.

- The Special Structures Defect Examination (CSS 237) is only required when the specific defect as detailed in Section C5-3 of this manual is identified
- No magnetic particle inspection is required for Detailed Structures Examination (CSS 201) unless requested and the extent defined by the Principal Track and Civil Engineer
- Specific inspection/monitoring of designated defects by the Bridge Examiner or other testing may be required if stated in this MP
- Visual Bridge Examination by Structures Superintendent

Detailed examination of the structures is to be made by competent staff as set out in this MP.

All inspection requirements including type and frequency are included in this Maintenance Plan, including if and when MPI is required.

During the Detailed Structures examination, a close visual inspection is to be made of all the structural components of the bridge in accordance with CRN CM 302.

Where access makes this impractical an indirect inspection using tools such as mirrors may be employed, where approved by the Principal Track and Civil Engineer.

Access: A permanent maintenance gantry has been installed at Tamworth and Woolbrook underbridges to provide suitable access for thorough inspection and maintenance from underneath the bridge.

At Wellington bridge, since all cross girders have been renewed, close examination of the new steel cross girders and end connections from underneath the deck is not required. Examiners can carry out a Detailed Structures examination from the deck level with working at height protection and other assistance such as hi-rail EWP and extendable arm mirror. All the connections are accessible from deck top. The accessible areas for MPI include top and internal vertical faces of the top chord via EWP, external vertical face of the bottom chord on the upside and both vertical faces of the bottom chord on the downside via harness and static line.

General inspection requirements shall be carried out in accordance with CRN CM 302:

Any proposed alteration in task, scope or frequency (lengthening time between tasks) must be authorised by the Principal Track and Civil Engineer.

C5-1.2 General defects and intervention levels

General defects as identified shall be classified in accordance with CRN CM 302:

C5-2 Criticality path diagrams

Total loss of track support will occur if main girders collapse, stringers collapse, a series of transoms fail or there are a significant number of stringer to cross girder connection failures.

Main girder collapse could result from the failure of substructure, bottom chord (tension failure) or top chord (compression flange buckling).

The Criticality Path diagrams, attached in Appendix 1, show various failure sequences and associated risk levels for the First Generation Lattice Truss bridges.

Figure 5 shows the possible failure mechanisms of the main girder elements such as chords, lattice webs and bracing systems, and the substructure elements such as caissons or piers that could potentially lead to loss of track support.

Figure 6 shows the possible failure mechanisms of the deck elements such as transoms, cross girders or stringers that could potentially lead to loss of track support.

These diagrams were prepared to determine a set of appropriate inspection regimes based on criticality of each element in the bridge.

C5-3 Defect management system

For the following identified defects the defect management system including inspection requirements, intervention levels and responses are as detailed below.

C5-3.1 Identified defects

The following defects have been identified as requiring particular inspection regimes:

- Rolling defects (laminations / cracks)
- Cracks in cross girder end connection angle cleats
- Cracks in caissons
- Loose rivets and bolts

For all other defects, inspection and intervention shall be in accordance with CRN CM 302.

C5-3.1.1 Rolling defects (laminations / cracks)

The following inspection requirements relate to rolling defects such as surface / hairline / single type laminations / cracks identified in the bridge elements such as cross girder angle cleats, cut edges of splice plates/angles, arch connection angles, etc.

In general, these types of defects have no adverse effects on the structural integrity of the bridge unless they show signs of propagation.

All large laminations/cracks shall have their extremity properly marked and photographed. Liaise with the Principal Track and Civil Engineer wherever there is any doubt on the condition monitoring. Where rolling defects (except cracks at cross girder end connection angle cleats which are detailed in Section C5-3.1.2) have been identified in the bridge the inspection requirements and frequencies detailed in Table 2 shall be carried out:

Defect	Service Schedule	Inspection Frequency	Requirements	Inspection required by
Rolling defects	CSS 237	Yearly	Visual (MPI if required). Record type & location of defect. Measure and record length if a single lamination/crack > 50mm.	Bridge Examiner (in conjunction with CSS 201)

Table 2 – Inspection requirements for rolling defects

For the rolling defects the defect intervention levels shall be as detailed in Table 3 below:

Defect	Intervention Level	Response
Rolling defects	Overall length >200mm. In 50mm or longer Laminations/cracks, propagation is > 10mm per year	Seek Principal Track and Civil Engineer's advice.

Table 3 – Intervention levels for rolling defects

C5-3.1.2 Cracks in cross girder end connection angle cleats

The following inspection requirements relate to cracking defects identified in the cross girder end connection angle cleats. The location and crack type identification for these cracks is shown in Figure 4. All cracks exceeding 50mm in length shall have the extremity of the crack properly marked and photographed.

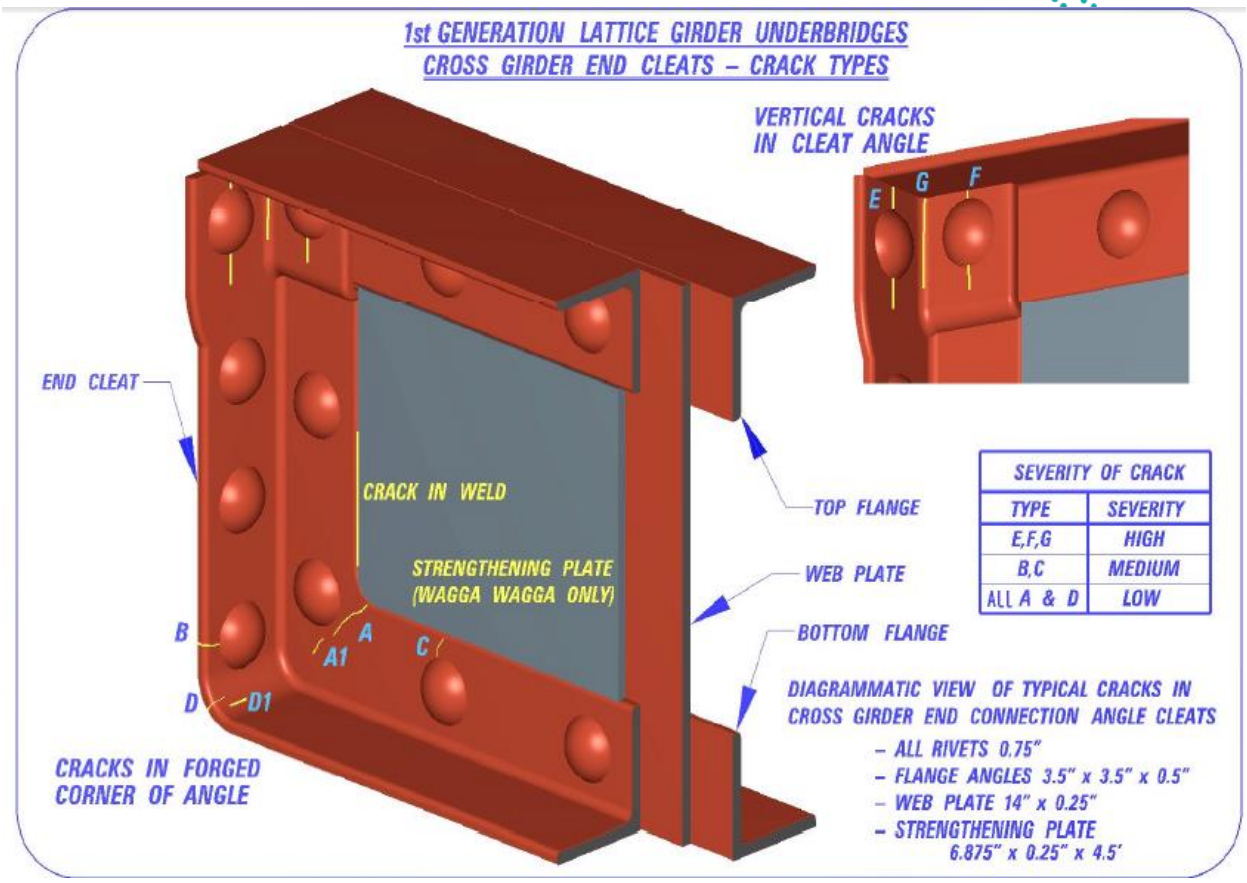


Figure 4 - Cross Girder End Connection Crack Identification Diagram

Where cracking has been identified in the end connection angle cleats the inspection requirements and frequencies detailed in Table 4 shall be carried out:

Defect	Service Schedule	Inspection Frequency	Requirements	Inspection required by
All Type A,B,C,D,E,F,G cracks less than 50mm in length	CSS 237	Yearly	Visual. Record type of crack. Measure, mark extent and record length	Bridge Examiner (in conjunction with CSS 201)
All known Type A,B,C,D,E,F,G cracks greater than 50mm in length	CSS 237	Six monthly.	Visual. Record type of crack. Measure, mark extent and record length	Bridge Examiner
	CSS 237	Yearly	MPI. Record type of crack. Measure, mark extent and record length	Bridge Examiner (in conjunction with CSS 201)

Table 4 – Inspection requirements for cracking in end connection angle cleats

For the cracks in the cross girder end connections the defect intervention levels shall be as detailed in Table 5 below:

Crack	Intervention Level	Response
A	Total crack length (A+D) on both sides greater than 300mm	Install new connection cleats or replace whole cross girder within 6 months
D		
B	Total crack length of B or C on both sides greater than 150mm	
C		
E	Maximum crack length of E, F or G on either side greater than 150mm	
F		
G		
All	Adjacent cross girders have cumulative crack length close to the intervention levels above	Refer to the Structures Superintendent (or Structures Engineer) Note 1

Table 5 – Intervention levels for cracking in end connection angle cleats

Note 1 Interaction between adjacent weakened cross girders may lead to failure.

C5-3.1.3 Loose rivets

There are two types of rivets in the bridge system:

- Structural Rivets: Rivets that need to be tightly fitted, e.g. rivets connecting lacing bars to top / bottom chord webs
- Stitching Rivets: Rivets that do not need to be tightly fitted to hold the elements together, e.g. rivets connecting diagonal lacing bars or lacing bar components such as spacer pipes

For the loose rivets the defect intervention levels shall be as detailed in Table 6 below:

Rivet Type	Intervention Level	Response
Structural	Shows leaching of rust stain or looseness apparent to a hammer tap	Replace within 12 months with same diameter, fully tensioned 8.8 grade galvanized structural bolts or "Huck" bolt or seek Principal Track and Civil Engineer's advice
Stitching	Showing signs of slackness due to excessive wear & tear, > 2mm play.	Replace within 12 months with same diameter HSS galvanised bolts, fully tensioned.

Table 6 – Intervention levels for loose rivets

Inspection Regime:

The Bridge Examiner shall visually inspect all the rivets / bolts once each year as part of the detailed inspection and properly identify locations of all defective fasteners.

C5-3.1.4 Cracks in caissons

The inspection requirements detailed in Table 7 relate to cracking defects identified in the cast iron caissons. Where cracking has been identified in the cast iron caissons the following inspection requirements shall be carried out at the frequencies detailed in Table 7.

Defect	Service Schedule	Inspection frequency	Requirements	Inspection required by
Cracks in caissons	CSS 237	Yearly	Visual. Record type & location of crack. Measure and record length if over 100mm	Bridge Examiner (in conjunction with CSS 201)

Table 7 – Inspection requirements for cracks in caissons

For the cracks in the cast iron caissons the defect intervention levels shall be as detailed in Table 8 below:

Crack Type	Intervention Level	Response
Vertical	Total crack length greater than 300mm	Install a metal strap within 6 months, refer drawing CV0227238 in Appendix 2.
Horizontal	Total crack length greater than 300mm	Seek Principal Track and Civil Engineer's advice

Table 8 – Intervention levels for cracks in caissons

C5-3.1.5 Underwater inspection of caissons

The caissons are comprised of 40mm thick cast iron shells in-filled with moderate to weak concrete.

The following underwater examinations have been undertaken at two of the wrought iron bridges:

- The caissons of the Wellington underbridge were thoroughly examined and photographed by professional divers in 2002. Also, the corrosion scales were tested for graphitisation. A second examination was undertaken in June 2013 at the 4 caissons and 8 cored samples were extracted from the cast iron shells for graphitisation testing
- General examination with scraping and cleaning at the shell surface was carried out at the 2 caissons of Tamworth underbridge in June 2014

Despite the caissons having been in service for over 130 years they are in very good condition below the water level. The following defects were found on the submerged shell surfaces:

- Surface corrosion
- Scattered pitting - mostly up to 3mm but some up to 15mm deep
- Surface graphitic corrosion – even distribution typically up to 2mm, spherical dispersion up to 17mm

The pier caissons have more than adequate capacity for the operation of current traffic and as such they incur a very low engineering risk in the long term.

C5-4 Recording of defects

All defects identified shall be recorded in the UGLRL CRN Defect Management System (Infor).

Chapter 6 Specific maintenance

Routine and major periodic maintenance items required for each bridge are generally as detailed in the current bridge inspection reports. In addition, the following specific on-going maintenance items are also required to be carried out.

C6-1 Wellington

C6-1.1 Specific on-going maintenance

Item	Specific on-going maintenance after each inspection if required (determined by Structures Superintendent)
Lattice truss bottom chord	Clean out debris and patch paint as required
Slotted drainage holes in Lattice truss bottom chord.	Grind / smooth profile of all oxy cut holes in bottom chord.
Steel Stringers / Transoms	Properly pack all stringers and transoms as required to maintain even distribution of traffic loading to cross girders. (If stringers require packing seek Principal Track and Civil Engineer's advice)
Top and bottom chord flange plates	Where separation between plate layers occurs, clear any corrosion, seal the gap and paint over the joint where required.
Lateral Bracing and clamps	Check and tighten turnbuckles and clamps.
Bearings	Lubricate bearings as required
Additional Major Periodic Maintenance	
Painting	Patch paint bridge superstructure and substructure to arrest identified corrosion around connections and pitted elements.

C6-1.2 URS Report

URS report 42859-021/REP0RT WELLINGTON rev 2 dated 22 May 2003 is outdated after the deck replacement of Wellington bridge in June 2014:

C6-1.3 Aurecon Report

All the short and long terms actions as recommended in Aurecon's examination report "Engineering Examination of Wrought Iron Underbridge UBW00412A in Wellington - Final Report" Rev 5 dated 09/10/2013 were completed as part of the deck replacement of Wellington bridge in June 2014.

C6-2 Tamworth

C6-2.1 Specific on-going maintenance

Item	Specific on-going maintenance after each inspection if required (determined by Structures Superintendent)
Any damage caused by machines / plant working beneath the bridge	Grind/smooth profile of damaged area(s). If the damage is severe, seek Principal Track and Civil Engineer's advice
Lattice Arch Portals	Thoroughly clean up corrosion and patch paint at connection of lattice arches to top chords. Provide 40mm dia. drainage hole in enclosed area of top chord if required.
Bent wind brace rod - at turn buckle	Closely monitor during yearly inspection. Replace with new brace if rod starts to crack.
Pier 2 - Viaduct span support girder: 4 loose rivets on upside	Closely monitor during yearly inspection. Replace with Blind Huck Bolts (or equivalent) if fingers could detect looseness in rivets.
Lattice truss bottom chords	Clean debris, patch paint, provide drainage holes and install mesh to prevent birds nesting

Item	Specific on-going maintenance after each inspection if required (determined by Structures Superintendent)
Upper capping of city downside column cracked	Monitor to check for occurrence of capping dislodgement
Connection bolts between stringers and cross girders missing / loose	Replace or tighten bolts
Timber stringers offset 250mm from the rail	Closely monitor any distortion/crack/split at the bottom face of the transoms during yearly inspection
Additional Major Periodic Maintenance	
Nil	

C6-2.2 URS Report

All the short and long term items contained in URS report 42859-021/REP0RT TAMWORTH rev 2 dated 22 May 2003 were completed except as below:

- Replace lattice arches - not required as RIC assessed the arches capacity and found them to have adequate load carrying capacity for the current operating conditions. - refer document, "Major Wrought Iron Bridges - Arches" in Appendix 2

C6-3 Woolbrook

C6-3.1 Specific on-going maintenance

Item	Specific on-going maintenance after each inspection if required (determined by Structures Superintendent)
Lattice truss bottom chords	Clean debris, patch paint, provide drainage holes and install mesh to prevent birds nesting.
Lattice Arch Portals	Thoroughly clean up corrosion and patch paint at connection of lattice arches to top chords. Provide 40mm dia. drainage hole in enclosed area of top chord if required.
Pier 2 - Impact damage to No. 2 post, downside at top inside angle, size 50mm x 300mm	Cut off damaged leg of angle and grind / smooth profile the cut / torn edges and patch paint.
130mm thick transoms	If any damaged, replace within 2 weeks.
Connection bolts between stringers and cross girders missing / loose	Replace or tighten bolts
Timber stringers offset 250mm from the rail	Closely monitor any distortion/crack/split at the bottom face of the transoms during yearly inspection
Wind bracing flat bar below cross girder No. 34 on the downside distorted 40mm	Closely monitor during yearly inspection.
Additional Major Periodic Maintenance	
Painting	Patch paint/repaint bridge superstructure.

C6-3.2 URS Report

All the short and long term items contained in URS report 42859-021/REP0RT WOOLBROOK rev 2 dated 22 May 2003 were completed except as below:

- - Replace lattice arches - not required as RIC assessed the arches capacity and found them to have adequate load carrying capacity for the current operating conditions - refer document, "Major Wrought Iron Bridges - Arches" in Appendix 2.
- - Repair spacer pipes (between lattice bars) - they do not need to be replaced unless a significant defect is present.

Appendix 1 Critical path diagrams

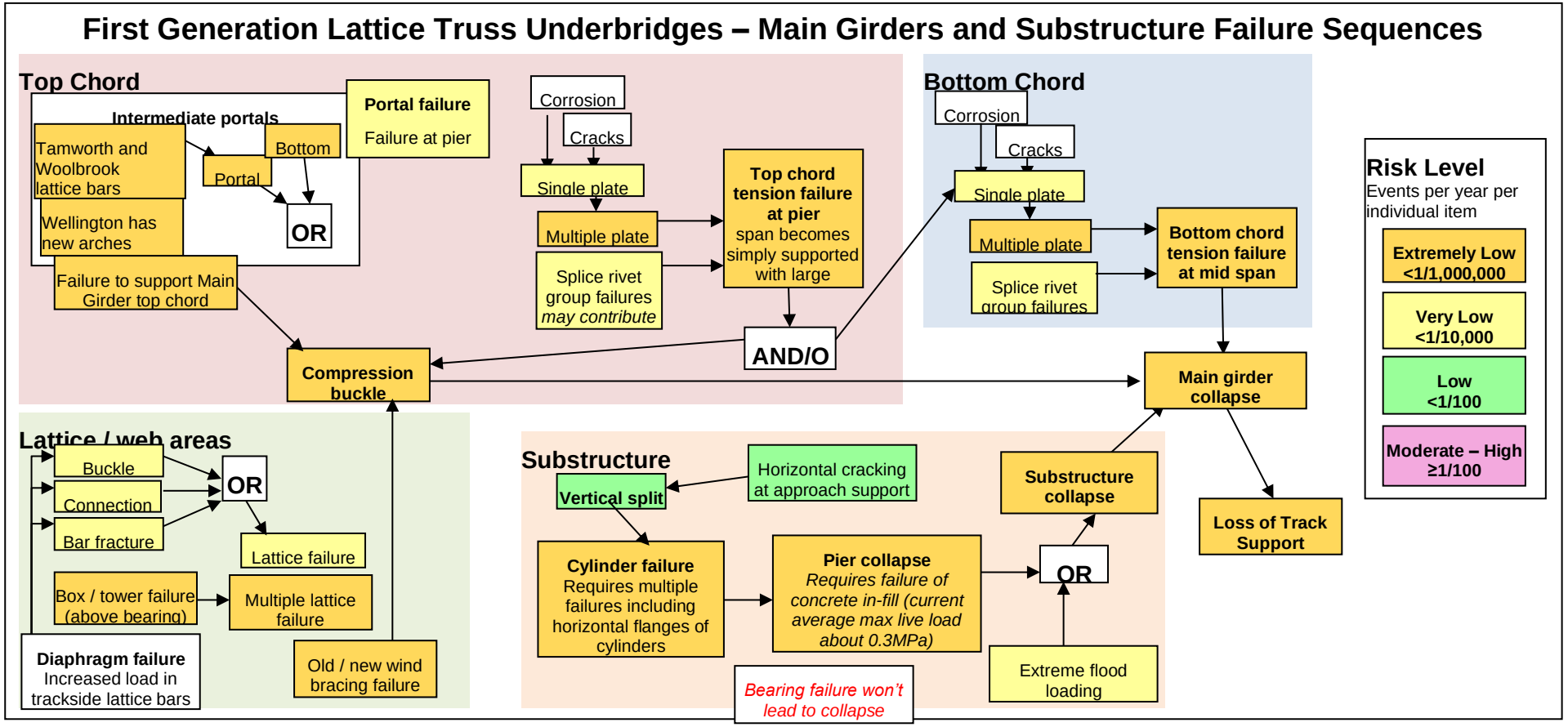


Figure 5 - First Generation Lattice Truss Underbridges – Main Girders and Substructure Failure Sequences - Criticality Path Diagram

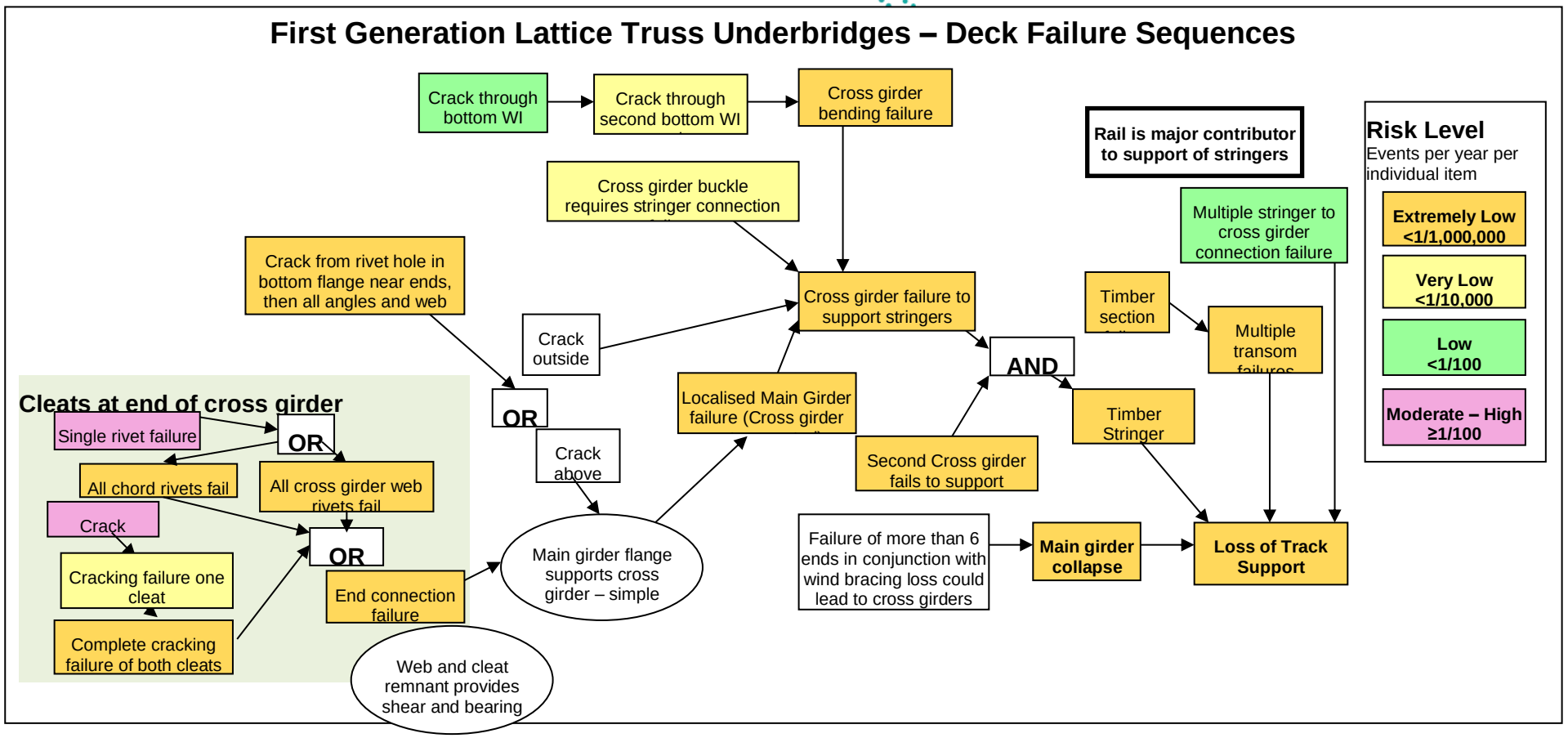
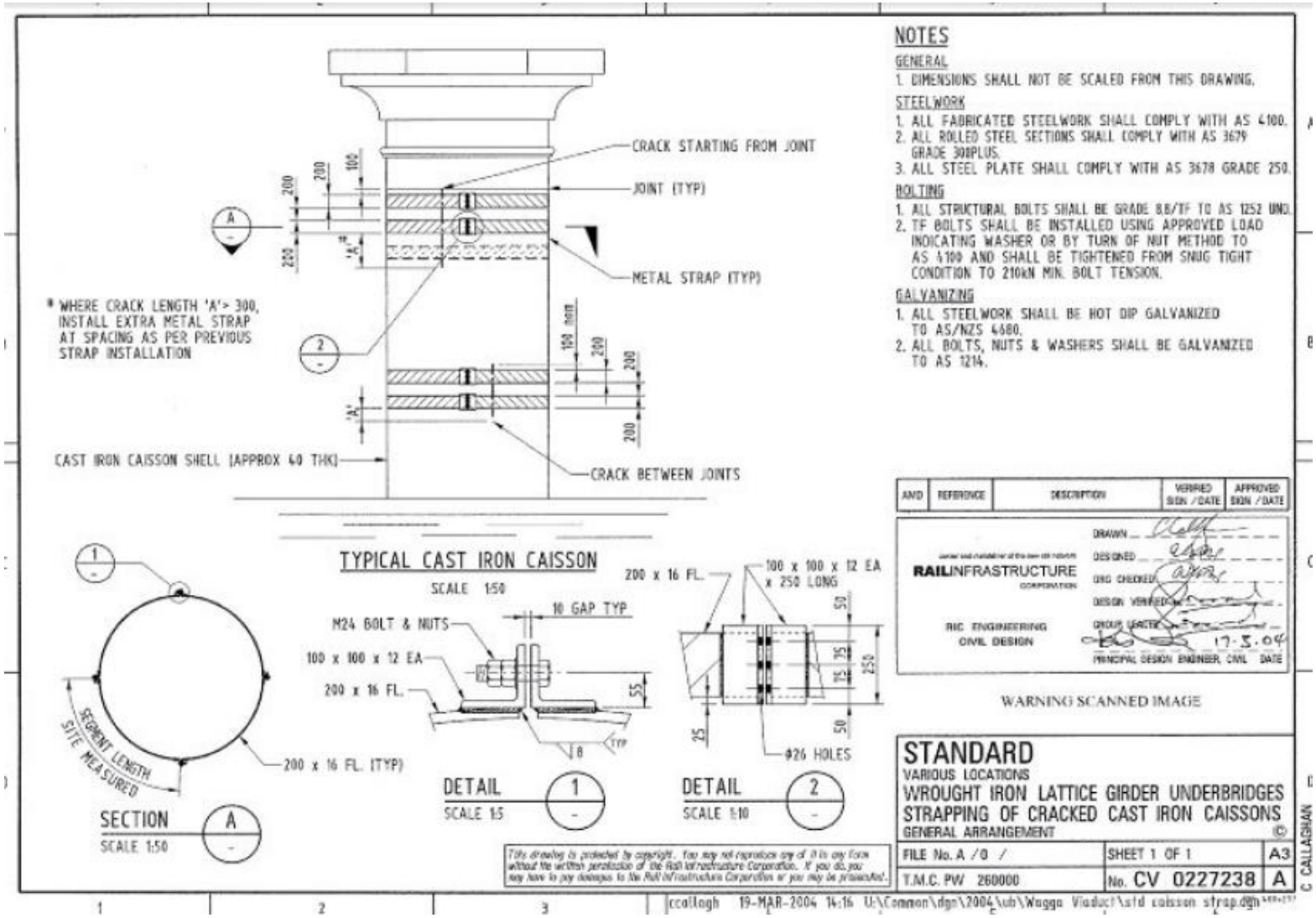


Figure 6 - First Generation Lattice Truss Underbridges – Deck Failure Sequences - Criticality Path Diagram

Appendix 2 Major wrought iron bridges - Upgrade works

Type/ Generation		Year	Location	Spans	Arch History/ Geometry	Load / speed limit	Arch Capacity
Lattice Truss	First Generation (53 cross girders per span of 48m)	1881	Wellington Main West 412.847	3x48m Continuous Single Track	1940's: Stools added to arches. 2001: Arches replaced. 2014: Deck replaced (all cross girders, longitudinal stringers and transoms).	7.8t/m - 10km/hr	Arches were replaced in 2001 because of perceived buckling of several lacing bars in one arch. Condition monitoring continues as part of Detailed Examination
		1878	Tamworth Main North 454.125	1x48m Single Track	2004: Repairs to Arches (several end rivets replaced by M24/8.8TF bolts).	5.82t/m - 10km/hr	Detailed analyses undertaken in June 2001. Analysis indicated that the first failure (rivets shearing) occurred at an Uniformly Distributed Load (UDL) of 3.4t/m. By replacing these rivets with 24mm high strength bolts (on 4 members per arch), capacity increases to 5.1t/m. These rivets were replaced in Jan 2004. Condition monitoring continues as part of Detailed Examination.
		1883	Woolbrook Main North 510.202	1x48m Single Track	2004: Repairs to Arches (several end rivets replaced by M24 8.8TF bolts).		

Appendix 3 Strapping of cracked caisson



Appendix 4 Engineering reports and drawings

Engineering Reports

1. "Condition Review of NSW Country Wrought Iron Underbridges" 42859- 021/REPORT BATHURST / WELLINGTON / TAMWORTH / WOOLBROOK rev 2 dated 22 May 2003.
2. "Wellington Bridge Inspection (CAISSONS)" dated January 2002, prepared by Gary Diving Services Pty Ltd (Report No. UB254).
3. Technical Report TR.056 "Strategic Study - Wrought Iron Bridges" dated July 1999, prepared by RSA Safety & Standards (CS56).
4. "Foundation Investigation for Macquarie River Bridge" dated June 1998, prepared by RSA Geotechnical Services.
5. "Report on Inspection of Some Wrought Iron Railway Underbridges in NSW" dated August 2003, prepared by Grundy Consultancy Pty Ltd.
6. "Wellington - Macquarie River Underbridge Structural Assessment - report No. UB254" dated June 2002, prepared by RIC Engineering Design - Civil.
7. "Wellington - Macquarie River Underbridge 412.847km MWL - report No. UB217" dated July 1999, prepared by RSA Consulting - Civil Design.
8. "The Assessment of the Load Capacity of the Railway Bridge over the Macquarie River at Wellington Main West 412.847km (Report No. 804615-R-1)" dated June 2001, prepared by Cardno MBK (Report No. UB226).
9. “Detailed Design Report of Wrought Iron Underbridge UBW00412A in Wellington”, Rev 5, dated 03/06/2014, prepared by Aurecon Australia Pty Ltd.
10. “Examination of Wrought Iron Samples Removed from Wellington Rail Bridge UBW00412A”, Rev 2, dated 1st July 2014, prepared by Bureau Veritas Australia Pty Ltd.
11. “Engineering Examination of Wrought Iron Underbridge UBW00412A in Wellington - Final Report”, Revision 5, dated 8th October 2013, reference No. 235716, prepared by Aurecon Australia Pty Ltd.
12. “Wellington Underbridge Underwater Inspection” dated 20th June 2013, prepared by The Diving Co NSW Pty Ltd.
13. “Graphitic Corrosion Assessment of Wellington Bridge Samples”, dated 27th June 2013, Report No. 13-2721499-2, prepared by Bureau Veritas Australia Pty Ltd.

Drawings

WELLINGTON - MACQUARIE RIVER UNDERBRIDGE

1.	Details of Pilasters & Bearings	Drg No.	3-96
2.	Conversion to Road/Rail Use	Drg No.	720-529
3.	Replacement of Cross Girders	Drg No.	CV 0046869
4.	Replacement of Arches	Drg No.	CV 0066258
5.	Bottom Chord Splice Strengthening	Drg No.	CV 0124504
6.	Drawing of Bridge	Drg No.	CV 0169342
7.	Drawing of Bridge	Drg No.	CV 0169343
8.	Bed Plates and Expansion Rollers	Drg No.	CV 0169344
9.	Drawing of Bridge	Drg No.	CV 0169345

10.	Block Diagram Shewing Erecting Marks	Drg No.	CV 0169346
11.	Wellington Wrought Iron Bridge UBW00412A - Strengthening Detailed Design	Drg No.	CC0027-01 to CC0027-50 Total 18 drawings
12.	Wellington Wrought Iron Bridge UBW00412A – Track Detailed Design	Drg No.	CC0028-00 to CC0028-31 Total 31 drawings

TAMWORTH - PEEL RIVER UNDERBRIDGE

1.	Proposed Strengthening of 159' Truss	Drg No.	E-517
2.	Proposed New Timber Deck & Bracing to Cross Girders	Drg No.	M-370
3.	Maintenance Gantry - General Arrangement	Drg No.	CV 0220226

WOOLBROOK-MACDONALD R. UNDERBRIDGE

1.	Maintenance Gantry - General Arrangement	Drg No	CV 0220230