Australian Government

NSW NOW The new state of business

SOUTHBOUND BRIDGE OVER THE SHOALHAVEN RIVER IN NOWRA

Structural inspection and assessment

Summary report

SEPTEMBER 2014

RMS: 14.447
ISBN: 978-1-925093-98-8

Southbound bridge over the Shoalhaven River in Nowra

Structural inspection and assessment

Summary report

September 2014

Table of Contents

1 Executive Summary

The bridge

The southbound bridge over the Shoalhaven River in Nowra was opened to traffic in 1881. The bridge was designed to carry trains on one railway track. It is listed as state significant infrastructure on the Roads and Maritime Services Section 170 register.

Why this report

During 2013, Roads and Maritime Services carried out a structural inspection and load assessment of the southbound bridge over the Shoalhaven River at Nowra. The findings are documented in a technical report dated February 2014. The report also recommends actions to manage and/or rehabilitate the bridge so it can continue to carry general access vehicles (that is, vehicles with unrestricted access to the road system).

This report provides a reader-friendly overview of the technical report. To get the full technical report you can contact the Roads and Maritime Services project team:

Email: nowrabridgeproject@rms.nse.gov.au

Call: 1800 331 713 (toll free)

Post: Level 4, 90 Crown Street, Wollongong, NSW, 2500

Overview of findings

The bridge was investigated above and below water level in 2013.

The main finding is that the original bridge is damaged by corrosion and showing some signs of fatigue. There is also evidence of impact from vehicles, two cracks at piers 5 and 6 that pose an unknown risk to the stability of the bridge, and many small defects typical of old iron bridges.

Some of these issues could be remedied if the recommendations of this report are carried out.

Recommendations

The investigating team recommended that Roads and Maritime:

- Repair piers 5 and 6 to address the vertical cracks, and carry out more frequent underwater inspections of the piers
- Continue to control corrosion on the bridge
- Address a number of small defects
- Increase the inspection and maintenance program so unknown risks can be managed
- Design and install systems to minimise the risk of tall vehicles causing impact damage to the bridge.
- Design and install a new and more flexible attachment system to hold the deck in place.

Future use of the bridge

The investigating team concluded that the bridge is capable of carrying the vehicles that are currently allowed to use the bridge – including semi-trailers weighing 42.5 tonne and B-Doubles weighing 62.5 tonne – provided the recommended remedial work is carried out.

2 About this report

During 2013, Roads and Maritime Services carried out a structural inspection and load assessment of the southbound bridge over the Shoalhaven River at Nowra. The findings are documented in a technical report dated February 2014. The report also recommends actions to manage and/or rehabilitate the bridge so it can continue to carry general access vehicles (that is, vehicles with unrestricted access to the road system).

This report provides a reader-friendly overview of the technical report. To get the full technical report you can contact the project team.

Email: nowrabridgeproject@rms.nse.gov.au

Call: 1800 331 713 (toll free)

Post: Level 4, 90 Crown Street, Wollongong, NSW, 2500

3 Brief history of the bridge

The bridge was built in 1879–1880 and opened to traffic in August 1881. It was designed to carry trains on one railway track. There have been a number of changes to the bridge since it was built. For example:

- In the 1950s, the original timber deck was replaced with a corrugated steel deck in-filled with asphalt, and a footpath was added on the downstream side
- In 1981, the deck was strengthened and replaced with the existing concrete deck and traffic barriers, and the footpath was upgraded to its existing condition
- In 1997, the downstream truss of the first span at the northern end was damaged severely by a heavy vehicle. It was closed to heavy vehicles and one lane was closed to traffic for five months until the bridge was repaired and assessed as safe
- In 2010, a cathodic protection system was installed on the caissons of the piers

4 The bridge today

The bridge is 341m long and carries two southbound traffic lanes and a footpath.

The superstructure is composed of a truss, a structure of connected elements forming triangular units. The bridge is supported by eight piers, each made up of two cast-iron caissons. There are nine spans; eight are wrought iron trusses, and one is an iron-plate girder.

The concrete deck that carries traffic is supported on steel stringers that run parallel to the bridge and are supported by wrought iron cross girders that span across the bridge.

The bridge is listed in the Roads and Maritime Services Section 170 register.

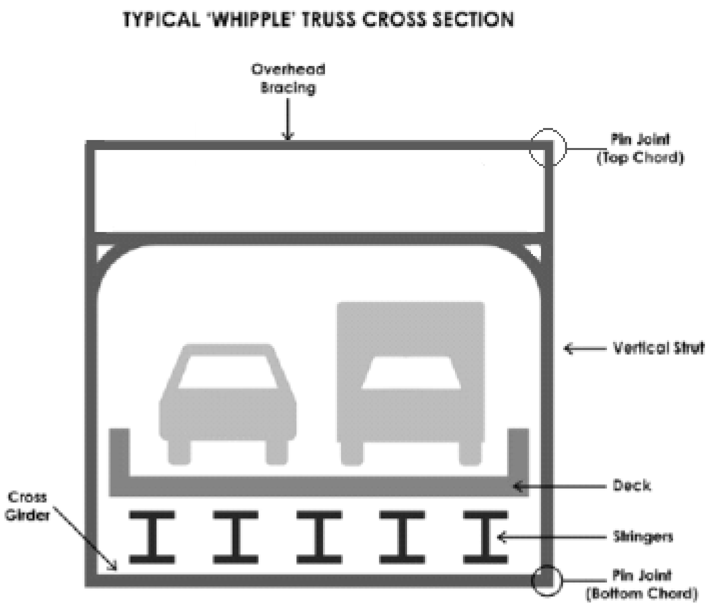
Explanation of terms

Truss bridge	A bridge in which the structure is composed of connected elements forming triangular units. The truss 'members' are the top and bottom chords, and the diagonal and vertical beams.
Chords	The top beams in a truss are called top chords; the bottom beams are called bottom chords.
Truss principal	The main diagonal beam that connects the top chord to the bottom chord at both ends of the truss.
Caisson	A caisson is a watertight retaining structure that is placed around the bridge piers.

Explanation of terms

Cathodic protection system	Sends a low voltage electric current through the caissons to counteract corrosion below water level.
Graphitisation	A type of corrosion that occurs on areas of the bridge exposed to water and tide changes. It causes graphite to form on the surface of the cast iron. Once cleaned, it causes the iron on the bridge to thin out gradually.
Pin joint	The pin connects the vertical, diagonal and the top chord together. The pin is a large bolt with a nut at either end.
Section loss	Holes in the cast iron caused by corrosion.
Girder	An iron I beam used to support the bridge from pier to pier.
Stringer	An iron I beam for supporting part of a deck between the cross girders.
Load	There are two types of load on a bridge, live load is the weight on a bridge caused by use (ie. traffic). Dead load is the weight of the bridge itself.
Web	This is the centre (vertical part) of a girder ("I" beam).
Flange	This is the top and bottom (horizontal parts) of a girder ("I" beam).
Bearing	Part of the bridge connecting the bridge deck to the piers. They allow the bridge to move safely.
Turnbuckles	These bolts connect two pieces of the iron bracing together.
Pitting	Section loss of the iron due to corrosion.
Seat	A large washer that secures the diagonal bracing to a vertical strut.
I Beam	A type of beam used for the girders, chords and stringers of the on the southbound bridge at Nowra.

Figure 1 Diagrams showing key elements of a truss bridge



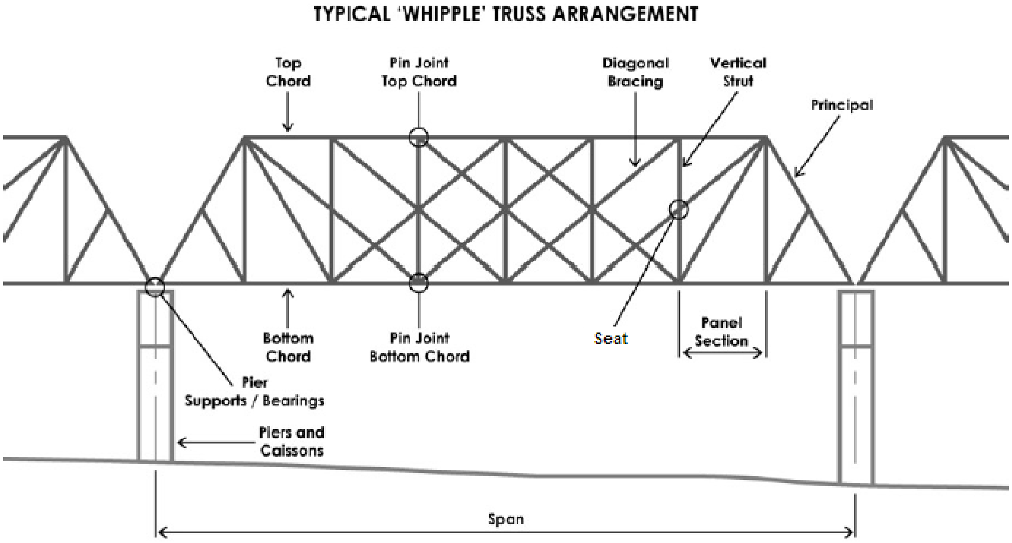
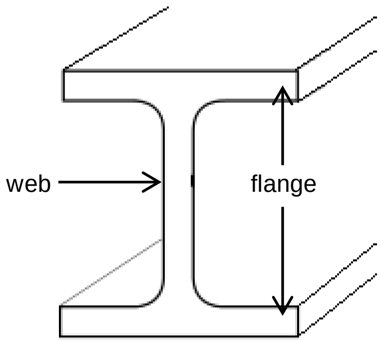


Figure 2 Diagram showing the different parts of an I beam.



5 Inspection methodology

The bridge was inspected by a bridge engineer and an inspector from Roads and Maritime's Bridge Assessment and Evaluation Section.

The inspection was carried out from a work platform mounted on a barge that allowed access to the underside of the bridge and the full height of the trusses without a need to close the bridge to traffic.

The underwater inspections, by specialist dive companies, assessed the extent of graphitisation of the cast iron caissons and audited the cathodic protection system for the piers.

6 Key findings

The assessment found a number of typical issues on the bridge that need to be addressed, in addition it found large cracks in two piers. These findings are discussed in the following pages.

The bridge was also assessed for its capacity to carry the vehicles that are currently allowed to use the bridge, including large vehicles such as semi-trailers weighing 42.5 tonne and B-Doubles weighing 62.5 tonne.

The assessment found the bridge is capable of carrying these loads. It is recommended that more regular inspection and maintenance is required:

- Increase the frequency of bridge inspections from once every two years to once every year.
- Increase the frequency of underwater inspections from once every four years to once every two years.

This will make sure that these vehicles can continue to travel safely on the bridge as it ages. This is not unusual for older bridges but means there are risks that must be managed.

6.1 Corrosion at pin joints along the top chords

The issue

The pin connects the vertical, diagonal and the top chords together. Where the pin goes through the top chord, the webs are strengthened with steel side plates.

At most pin joints along the top chords, there is internal corrosion within the chords, probably caused by an accumulation of salts. In a few places, the corrosion has created holes (known as ‘section loss’). There is also corrosion on the side plates. If the corrosion is left untreated, the joint will lose strength and will not be able to support the required loads.

Forty-five of the 118 pin joints at the top chords are in poor condition and need to be repaired or strengthened, although no joints have failed. Most other pins appear to be in fair to good condition.

Figure 3 Images from the old bridge showing corrosion at pin joints along the top chords

	
One typical pin-joint. Note the hole (section loss) in the web of the top chord.	Inside one typical pin-joint – section loss inside is not easily seen.

Recommended action

- Wash off the accumulated salts at all joints
- Strengthen all those joints that are in poor condition by installing side plates
- Paint all joints with a protective treatment to prevent further corrosion
- Repaint the top chords and truss principals.

6.2 Corrosion of the bridge bearings

The issue

The end diagonals or 'principals' of the trusses take the load down to the supports (that is, the bridge bearings). Many of these bearings are corroded and in poor condition. Some have section loss. There is also section loss at the truss principals. In addition, on some of the piers, the expansion bearings are not moving as they are designed to do. Typical bearings are shown in the photographs below.

Figure 4 Images from the old bridge showing corrosion of bridge bearings

	
Typical bridge bearings.	Typical corrosion with section loss.

Recommended action

- Clean off the corrosion
- After cleaning, inspect the area to determine if any areas of section loss require repair
- Paint the area with a protective treatment to prevent further corrosion
- Carry out maintenance on the expansion bearings so they move as designed.

6.3 Corrosion of end cross girders of truss spans

The issue

At the ends of each truss, there is a cross girder that is supported on the principal near its base. This cross girder supports the stringers that in turn support the deck.

The end cross girders are showing varying degrees of corrosion at the top and/or bottom flanges. This type of corrosion affects the bending capacity of the girder. As a conservative estimate, the bending capacity of all end cross girders on the bridge is downgraded by 30%.

The girders are generally in poor condition but still appear to be performing satisfactorily.

Figure 5 Images from the old bridge showing corrosion of end cross girders on truss spans

	
Typical end cross girder with crevice corrosion at bottom flange.	Close-up of the crevice corrosion at bottom flange.

Recommended action

Ideally, these cross girders should be replaced or strengthened. However, this is not easily done without disrupting traffic. Therefore, a realistic approach would be to:

- Consult expert advice

- Monitor these girders for signs of distress or deterioration, and repair or strengthen them if necessary.

6.4 Broken cast-iron seats on the trusses

The issue

Where a diagonal brace crosses the vertical truss there is a washer or ‘seat’ which holds the diagonal to the vertical and stops them vibrating. There are a number of issues with the seats:

- Some of the seats are broken and need to be replaced
- Some diagonals have turnbuckles (bolts) that have come loose and need to be tightened
- Some seats (washers) are corroded
- Some diagonals have moved and are no longer attached to the seats.

Figure 6 Images from the old bridge showing broken cast-iron seats on the trusses

	
Typical vertical truss showing seat with corrosion	Typical broken seat.

Recommended action

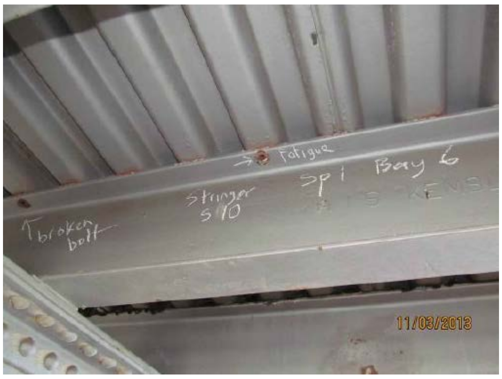
- Replace all broken seats
- Move diagonals back to their original location and reattach them to their seats
- Tighten turnbuckles that have become loose
- Paint the area with a protective treatment to prevent further corrosion.

6.5 Broken attachment bolts between stringers and deck

The issue

The steel decking is attached to the stringers by bolts. The main issue is that the attachment system does not sit evenly on the stringers. When traffic travels on the deck, the deck flexes, and this flexing causes high stresses at the attachment points. The attachments have fatigued and the weakest elements (the bolts) have failed. Some bolts are missing.

Figure 7 Images from the old bridge showing broken attachment bolts between stringers and the deck



Typical stringer missing deck attachment bolts.

Recommended action

- Design and install a new and more flexible attachment system to hold the deck to the stringers. This will reduce the stresses in the attachment bolts and make the attachment more durable.

6.6 Corrosion damage on original stringers

The issue

The stringers support the deck between the piers. Some of the original bridge stringers are damaged and most have pitting caused by corrosion. Also, some stringers have bent or cracked top flanges. It is very difficult to repair or replace these stringers. As there are 11 stringers between each pier, they do not need to be strengthened or replaced at this stage.

Figure 8 Images from the old bridge showing corrosion damage on original stringers

Typical stringer showing previous corrosion damage which had been repainted.

Typical stringer showing previous corrosion damage inside stringer.

Recommended action

- Continue to inspect the stringers
- If inspections indicate that the stringers are distressed, repairs will need to be carried out to strengthen the stringers.

6.7 Corrosion of cross braces on trusses

The issue

The upstream and downstream trusses are held apart by cross braces between the top chords above the traffic lanes. At the ends of the trusses there is a more substantial cross brace in the form of a lattice frame (Figure 8 below gives an example of a lattice frame on the old bridge). These cross braces are critical to the stability of the trusses and cannot be removed. However, they restrict the height of vehicles on the bridge (the vertical clearance is 4.3 to 4.6 m).

The cross braces have some corrosion with section loss, and there is evidence that over height vehicles have caused some impact damage (such as broken lace and bent angles).

Figure 9 Images from the old bridge showing corrosion of cross braces on trusses

	
Typical cross brace at front and back of the truss.	Local corrosion with section loss.

Recommended action

- Design and erect devices to protect the bridge from vehicular impact, especially the front and back cross braces and all truss verticals and diagonals
- Repair the damage on the cross braces
- Paint the area with a protective treatment to prevent further corrosion.
- Design and install systems to minimise the risk of tall vehicles causing impact damage to the bridge.

6.8 Damaged piers (piers 3, 5 and 6)

The issue

The bridge is supported by eight piers, each made up of two cast-iron caissons. The downstream caissons of piers 5 and 6 have a vertical crack above the water level. In February 2013, the crack at pier 6 was 750 mm long. A follow-up inspection in July 2013 found the crack had become 120 mm longer (that is, 870 mm).

Piers 3 and 6 are also missing horizontal braces that need to be replaced.

Figure 10 Images from the old bridge showing damaged piers

	
Pier 3 showing a missing bottom brace. The replacement of the missing brace is recommended as it helps to improve stability.	Piers showing graphitisation.

Recommended action

- On piers 5 and 6, take urgent action to stop the cracks getting longer in the caissons. This work should involve drilling 020 mm holes at the ends of the crack to arrest its growth, and binding the cracked area with a chain as an interim measure.
- To permanently strengthen the piers, design and install new collars for the cracked caissons
- On piers 3 and 6, re-install the horizontal braces
- Maintain the cathodic protection system on all piers
- Increase the frequency of underwater inspections from once every four years to once every two years.