AUSTROADS BRIDGE CONFERENCE 2025
Brisbane | 25-27 June 2025

Peer reviewed paper

Condition Assessment and Maintenance Strategies for South-West NSW Bridges

Muhammad Khattak, Structural Engineer (Bridges), Transport for NSW

Kaushalya Perera, Bridge Maintenance Planner, Transport for NSW

Abstract

Transport for New South Wales (TfNSW) interfaces with multiple states via a network of major highways and subsidiary roads, predominantly linked by road bridges. These bridges serve as crucial conduits for facilitating interstate transportation, particularly for heavy vehicles. Maintaining these bridges in good condition is of critical importance for the state, assets managers and the road user.

In the Southwest region of NSW, which borders Victoria, this paper focuses on two key border bridges which span over the Murray River: Heywood Bridge (B07331) in Wodonga and Mulwala Bridge (B05819) in Mulwala.

Heywood Bridge, built around 1984, exhibits significant concrete deterioration, spalling, and exposed reinforcement on the bridge parapets and planks. Cracks are also prevalent on the plank soffits.

On the other hand, Mulwala Bridge, originally constructed in 1919 with subsequent extensions, faces challenges like deteriorating beam ends and headstocks in the simply supported spans. Concrete beams and pier headstocks around the seated areas display cracks and severe spalling.

Comprehensive structural inspections have identified common deterioration patterns near the beam supports and headstocks in both cases. While both assets remain safe and operational, an action plan has been proposed, encompassing strengthening and rehabilitation measures aimed at ensuring the continued safe functionality of these critical bridges. To oversee this initiative, a robust monitoring system has been implemented until the completion of rehabilitation efforts, focusing on maintaining the load-bearing capacity suitable for heavy vehicular traffic.

This paper aims to provide valuable insights to bridge asset managers tasked with overseeing similar conditions, aiding in effective bridge management and maintenance practices.

Keywords: Bridges, Inspection, Monitoring, Rehabilitation, Deterioration, Maintenance

1. Introduction

Transport for New South Wales (TfNSW) manages a bridge stock of over 6000 structures, including bridge-sized culverts, as recorded in the TfNSW Bridge Information System. Among these, 34 bridges are located at the borders with neighbouring states, commonly referred to as border bridges. Many of these bridges are at the Victoria border, with some connecting to Queensland and a few to the Australian Capital Territory.

TfNSW is responsible for ensuring the safe operational condition of these bridges for road users. It oversees all aspects of bridge management, including maintenance, structural inspections, and rehabilitation strategies. This involves conducting detailed Level 3 (L3) structural inspections[*2], assessing bridge conditions, and recommending rehabilitation, strengthening, and repair strategies. TfNSW implements these strategies with a focus on maintaining the continued safety and functionality of the structures, including the management of border bridges with Victoria.

This paper presents case studies on structural inspections and the implementation of maintenance strategies for selected border bridges in Southwest region of Albury and Mulwala.

2. Case Studies

2.1 Heywoods Bridge

The Bridge is located on Trout Farm Road over Murry River below Hume Dam near Albury connecting NSW and VIC states (as shown in Figure 1). Bridge is constructed in circa 1984. The bridge is consisted of 11 simply supported spans of prestressed planks (PPLNK). Each span comprises 14 planks, supported by piers and abutments (as shown in Figure 2). The piers consist of concrete headstocks and walls, which are supported on concrete footings (as shown in Figure 3). The bridge carries an average daily traffic volume of approximately 1,700 vehicles, including heavy vehicles.

Figure 1 Location of the Heywoods Bridge

Figure 2 Elevation of the Bridge

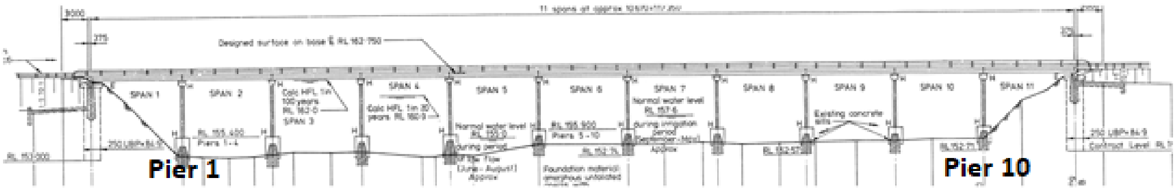
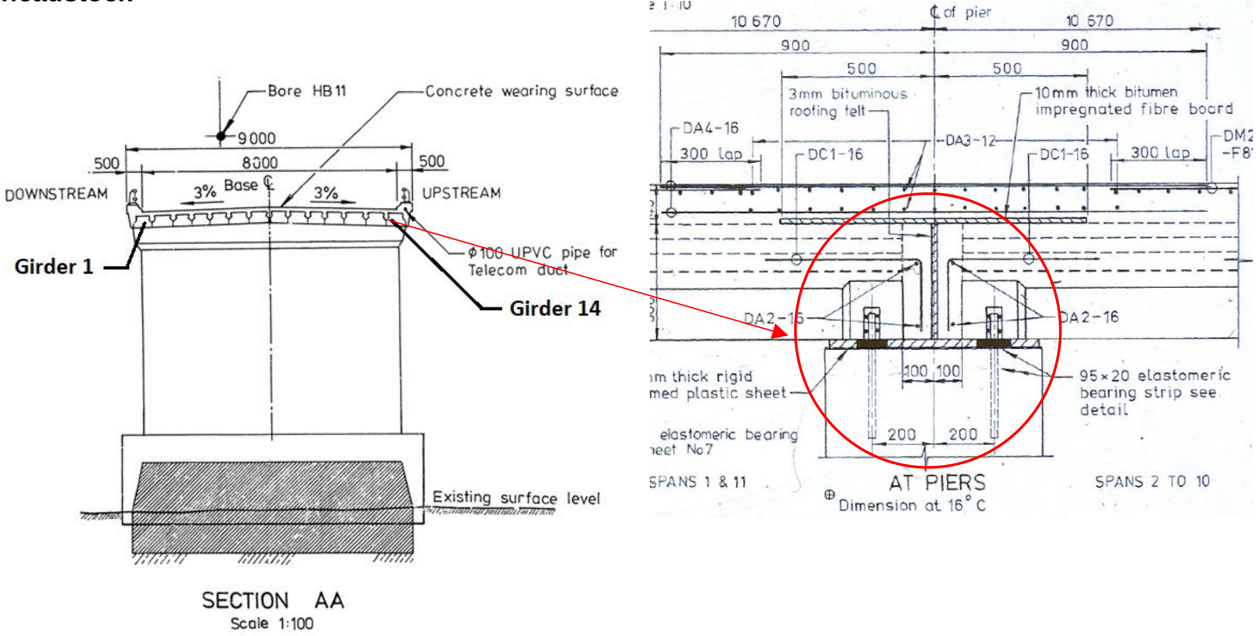


Figure 3 Elevation of the Pier and details planks(girders) seating arrangement at pier's headstock



The beam shown in Figure 3 are supported at the headstock at each end in respective spans. A dowel bar is extended from the headstock to these beams to restrain the movement of the planks/girders.

Level 3 structural Inspection

The 2019 Level 3 inspection of Heywoods Bridge identified significant concrete deterioration, including spalling and exposed reinforcement on the parapets over the headstock in almost all spans (as shown in Figure 4). Additionally, cracks and delamination were observed in the surrounding areas of most pier joints.

The bridge planks/girders exhibited both longitudinal and transverse cracks (as shown in Figure 5), which were measured and recorded during the inspection, with a maximum crack width of up to 0.6mm. It was noted that certain spans had more extensive cracking than others, particularly Span 3 at Pier 3, Spans 9 and 10 at Pier 9, and Span 11 at Pier 10, where girders (planks) displayed a higher concentration of longitudinal and transverse cracks compared to other spans.

Figure 4 Spalling in planks and pier's headstock at outer faces

Structural analysis indicates that the observed cracking is due to a combination of temperature-related loading and support restraint effects at all piers. It was also noted that the transverse cracks are located 350 to 500 mm from the face of the respective headstock in each span. This is the region with hardly any prestress due to transmission length and strand de-bonding.

Figure 5 Longitudinal and transverse cracks observed in the plank's soffit of Heywoods Bridge

The Level 3 inspection report recommended the following strengthening, repair, and maintenance strategies:

- The bridge parapets need to be repaired/rehabilitated.
- The deteriorated headstocks/pier walls need to be repaired/rehabilitated.
- The longitudinal cracks in planks soffit need to be monitored and rehabilitated.

Asset Maintenance Strategies

Based on the Level 3 report recommendations, maintenance action plan was developed as below.

- Initiated the repair/rehabilitation process of prestressed planks affected by longitudinal and transverse cracks.
- Initiated the repair and rehabilitation of deteriorated parapets.
- Planned the installation of a structural monitoring system to remain in place until repair and rehabilitation work is completed.

Structural monitoring System

TfNSW managed the design and implementation of the bridge monitoring system to ensure effective approach to bridge maintenance. A detailed monitoring plan was developed, including the installation of tell-tale gauges and electronic gauges, with the latter recommended for critical crack locations (As shown in Figures 6 and 7). Readings from these crack gauges were to be monitored monthly, with more frequent Level 2 inspections*1 advised to track readings and detect any abrupt changes. The electronic gauges were battery-operated and accessible remotely, though their range was limited to the close vicinity of the bridge.

Figure 6 Crack Gauges (Electronic and Tell-tale) Installation Plan/Layout for Span 10

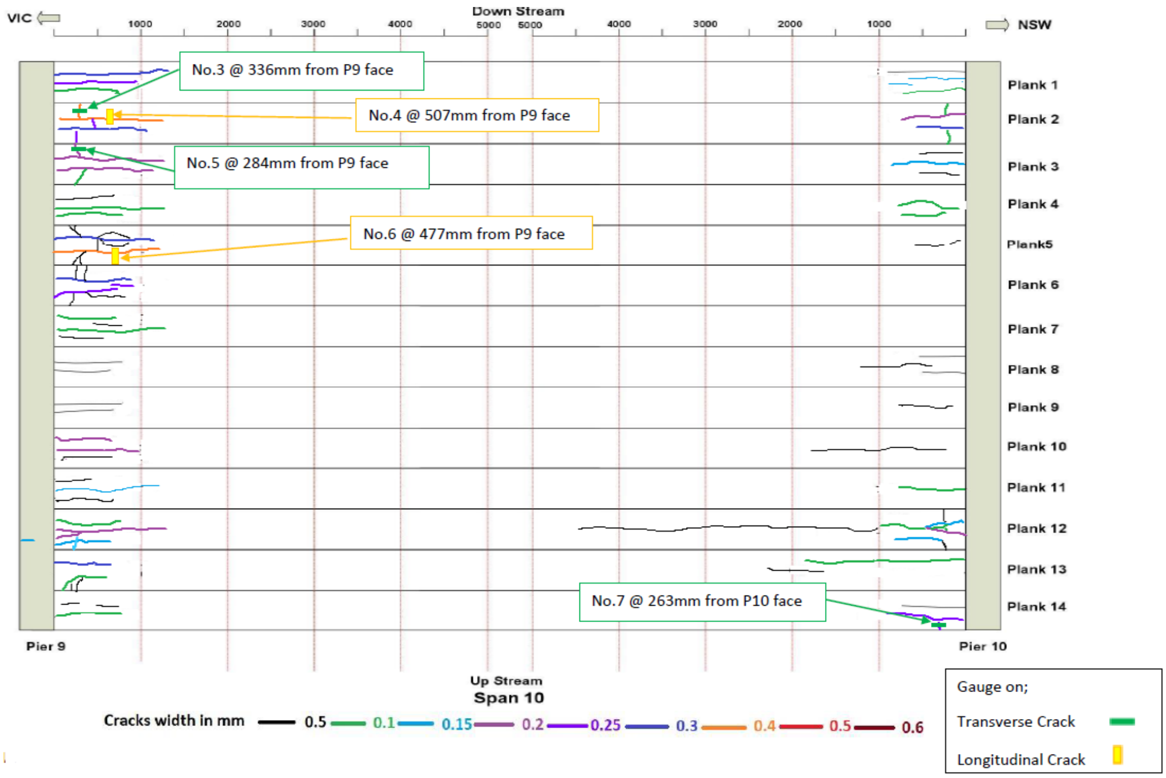
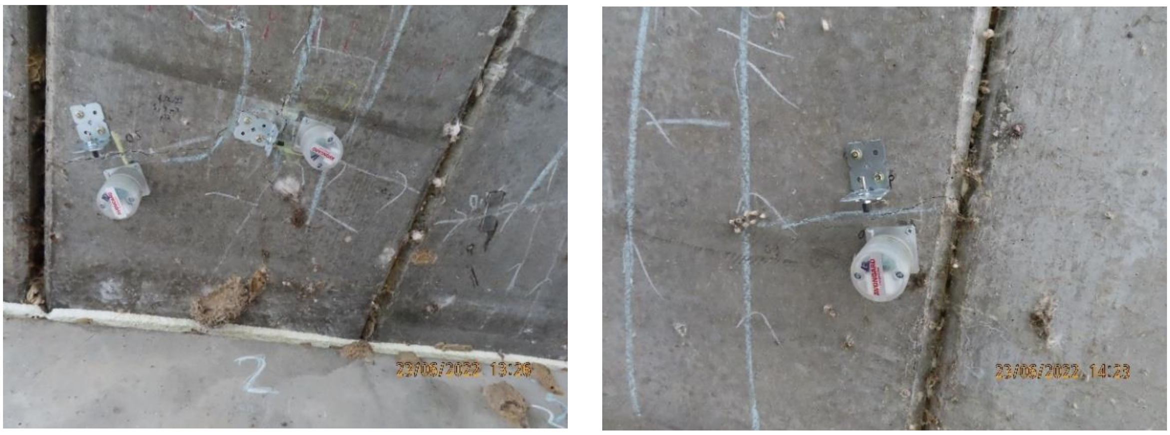


Figure 7 Electronic Crack Gauges installed at the critical cracks in Heywoods Bridge



Level 2 Inspection and follow up Level 3 Inspection

Level 2 inspections were conducted on monthly basis to collect data from crack gauges and monitor the bridge for any further deterioration. These inspections were carried out from ground level. However, it was observed that some electronic sensors were not responding remotely. Consequently, a follow-up Level 3 structural inspection was conducted in 2022 to assess the structural condition of the bridge and identify any further deterioration. This inspection also provided an opportunity to evaluate the functionality of the electronic crack gauges.

The Level 3 inspection found that most bridge cracks remained unchanged. However, in some locations, cracks had elongated. Based on these findings, the follow-up Level 3 inspection recommended the urgent implementation of bridge rehabilitation work.

Rehabilitation Work

TfNSW considered multiple rehabilitation options for this bridge and determined that Carbon Fiber Reinforced Polymer (CFRP) was determined to be the most suitable option for addressing the longitudinal cracks in the plank (as shown in Figure 8 and 9). Additionally, concrete repair work was carried out at the parapet, at the joint location over the relevant pier. All rehabilitation work was satisfactorily completed in early 2023, ensuring the continued safety and functionality of the structure.

Figure 8 Details of rehabilitation option CFRP laminates drawings

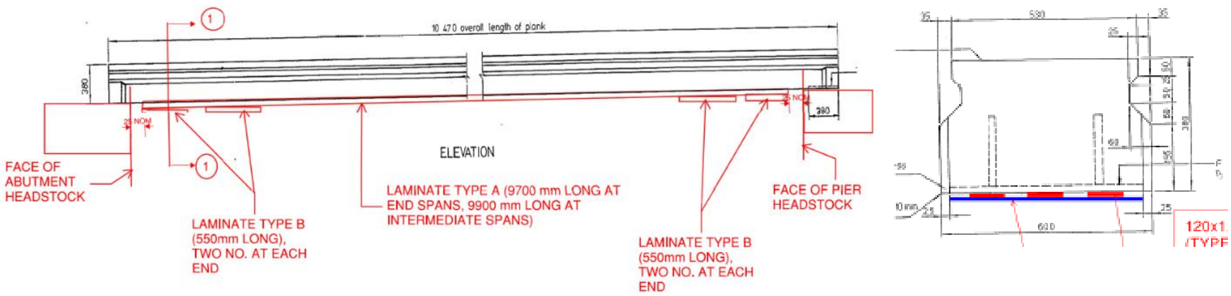


Figure 9 CFRP installed on plank soffit in Heywoods Bridge

2.2 Mulwala Bridge

The Bridge over the Murray River at Mulwala consists of three different span configurations. The Mulwala Bridge was originally constructed in 1919 and consisted of continuous reinforced concrete beam spans, now designated as Spans 33 to 39. In 1924, the bridge was extended with the construction of steel truss spans (Spans 6 to 8) and simply supported reinforced concrete beam spans (Spans 1 to 5 and Spans 9 to 32), bringing the bridge to its present span configuration (as shown in Figure 11). The bridge currently has the following span configuration:

- Concrete Beam (CBEAM) Spans 1 to 5 – completed in 1924 (as shown in Figure 12).
- Steel Truss (STRUS) Spans 6 to 8 – completed in 1924.
- Concrete Beam (CBEAM) Spans 9 to 32 – completed in 1924 (as shown in Figure 12).
- Concrete Beam (CBEAM) Spans 33 to 39 – completed in 1919.

The Mulwala Bridge is a key structure in this location (as shown in Figure 10), connecting two states and carrying an average daily traffic of 12,000 vehicles, including heavy vehicles.

Figure 10 Mulwala Bridge Location

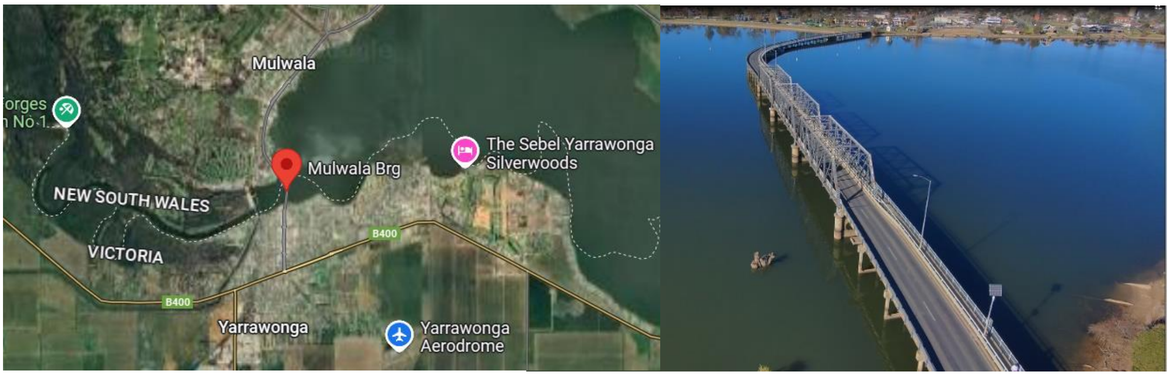


Figure 11 Bridge Spans layout

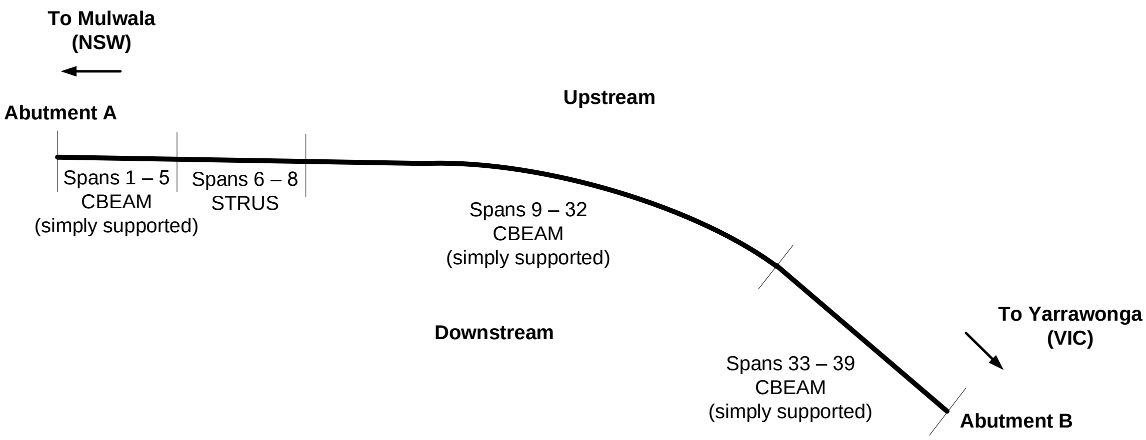
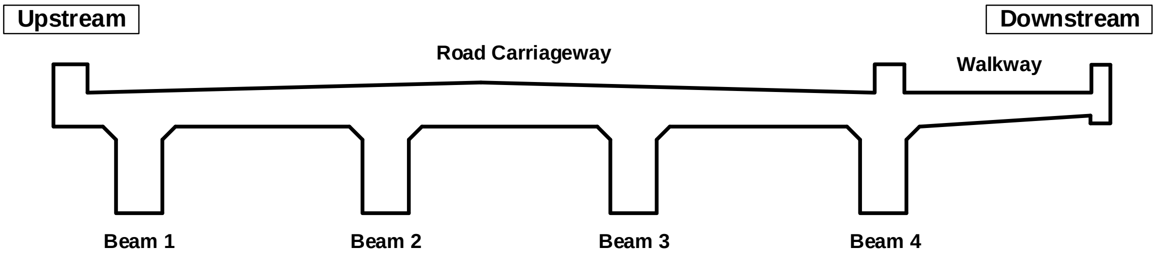


Figure 12 Concrete Beam Spans 1 to 5 and Spans 9 to 32 (simply supported) Layout

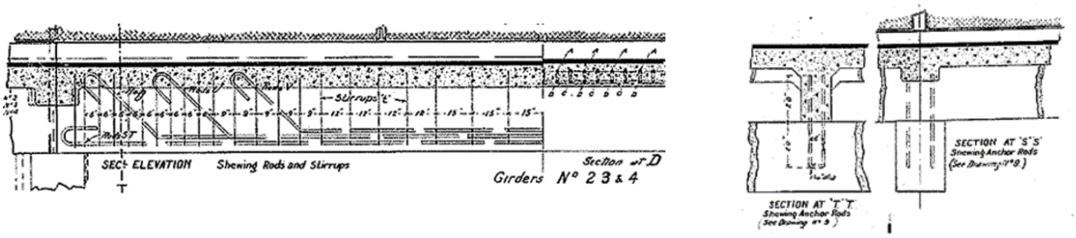


The beams shown in Figure 12 are supported at the headstock at each end of their respective spans. A dowel bar extends from the headstock to these beams to restrain the movement of the bridge.

Level 3 structural Inspection

The Level 3 structural inspection, carried out in 2018, found deterioration at the ends of the beams (Figure 12 shows the beam configuration) in the simply supported concrete beam spans (Spans 1 to 5 and 9 to 31). The deterioration manifested as cracking (up to ~1-2 mm) and spalling on the side faces of the beams over the seated areas (as shown in Figure 13). At the most severely affected locations, cracks extended from the beams into the headstock, accompanied by spalling of the headstock.

Figure 13 Concrete Beam at headstock seating and dowel bar arrangement



In these spans, concrete beams are seated directly on top of piers, with stiff dowels provided between each beam end and the headstock (as shown in Figure 13). Consequently, bridge deck deformations due to thermal effects are restrained, causing cracking, and spalling of the beam ends over the headstocks. In the fully restrained condition, the resultant thermal stresses at the beam ends were found to exceed the concrete's tensile strength. Beam ends are highly stressed regions, with an interaction between thermal restraint and bearing stresses. Inadequate and poorly detailed reinforcement at these locations has further contributed to the deterioration and severity of the cracking (as shown in Figure 14).

Figure 14 Photos showing crack at the beam ends at the headstock support locations.

Deterioration of the beam ends and headstocks in the simply supported spans was a significant structural issue identified during the inspection. The Level 3 inspection report also categorised each beam end, at the support location, into different condition states to assist in maintenance strategies.

The level 3 inspection report recommended the following strengthening/rehabilitation and maintenance strategy,

- Restore support areas and rehabilitate beam ends and headstocks in 'poor' or 'very poor' condition. Refer to previous memo for all affected locations identified from the inspection.
- Install interim concrete crack gauges and/or data logger on critical beam ends and headstocks in 'very poor' condition.
- Inspect inaccessible simply supported span beam ends (Spans 21 to 32) – use of a telescopic camera or alternative access arrangements may be necessary.
- Inspect beam ends for any ongoing deterioration during future Level 2 inspections and if further deterioration noticed, urgent Level 3 inspection need to be carried out.

Durability inspection

A durability investigation was also carried out in 2018, and it was found that chlorides do not appear to pose a major corrosion risk at that point in time. On the other hand, the depth of carbonation and visual observation of exposed steel suggest that corrosion has initiated in many areas, with significant section loss of the reinforcement. The durability report recommended restoring concrete elements with cracks, delamination, and spalls, using in-patch anodes as required, and reinstating rebar with significant section loss. Control moisture ingress by repairing the cracks.

Asset Maintenance Strategies

The Level 3 report recommendations were assessed, and maintenance strategies were implemented based on available resources. As an immediate measure, the installation of a structural monitoring system was prioritised to ensure safety until the planned strengthening and rehabilitation work could be completed.

Structural Monitoring system

TfNSW managed the design and implementation of the bridge monitoring system to ensure effective approach to bridge maintenance. A detailed monitoring plan was developed. The monitoring instruments, including tilt meters and linear displacement sensors, were recommended for installation at locations in poor to very poor condition. Below (as shown in Figure 17) is the layout of the installed monitoring system, including condition ratings for all beam ends. As shown in Figures 15 and 16, a linear displacement sensor (in blue) was installed at two beam ends to measure displacement movement, while a tilt meter (in green) was installed at the end of each beam to monitor tilt.

Figure 15 Proposed installation of sensors at respective piers and beam ends locations

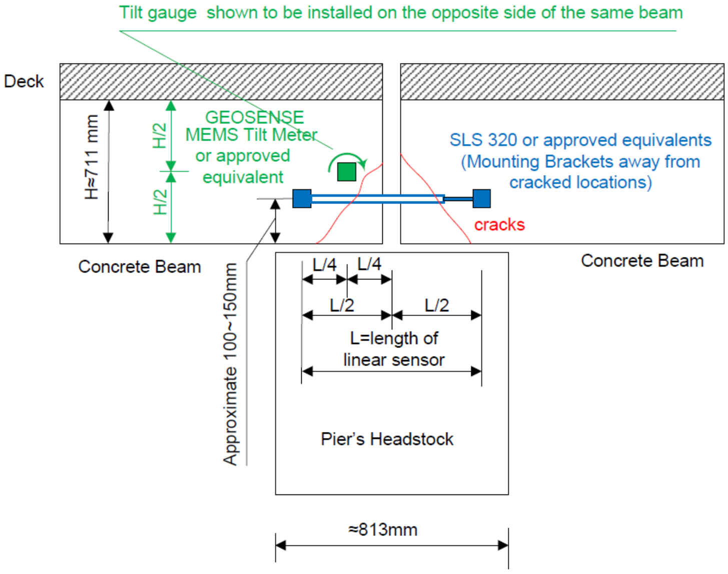
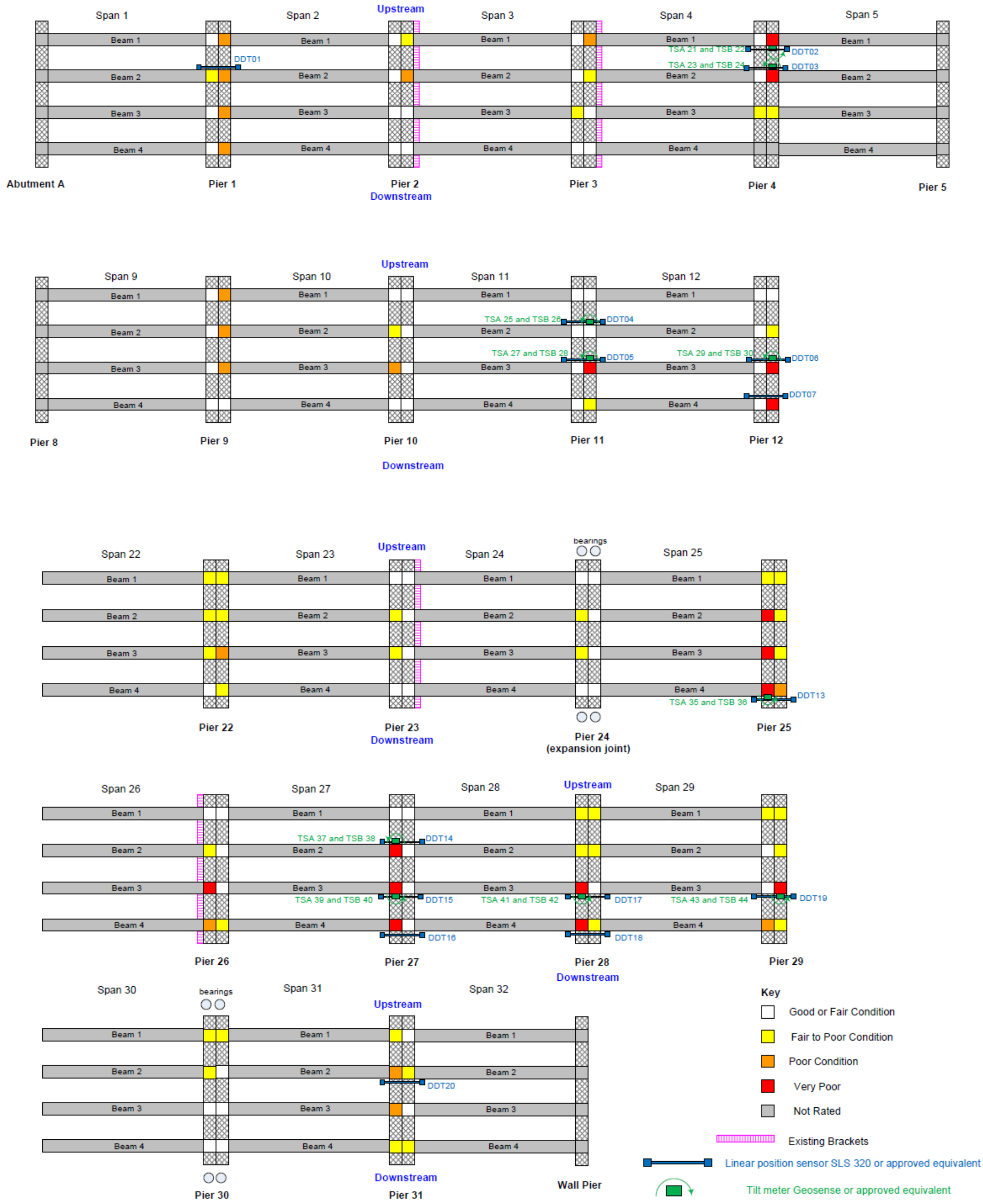


Figure 16 Monitoring system Post installation photo

Figure 17 Schematic showing condition states of the concrete beam ends and proposed monitoring instrumentation layout



After installing the monitoring sensors as per the layout provided in Figure 17, readings from these sensors were gathered at the end of each month to analyse for any critical events. The sensor data were compared on a monthly basis with previous data to carefully monitor any alarming activity.

During data monitoring, it was noticed that some linear displacement sensors were showing abnormal activity. This raised an alarm to determine whether actual movement had occurred or if it was a sensor malfunction. A special structural inspection was organized to validate the data and investigate the anomaly.

Level 2 and follow up Level 3 inspection

A Level 2 inspection, along with an urgent follow-up Level 3 inspection, was organised in 2022 to investigate the alarming sensor activity of some linear displacement sensors. Locations with abnormal readings were inspected first. No changes in the condition states of the beam ends at these locations were observed, and it was concluded that the abnormal sensor readings were likely due to the long length of the displacement sensors and other parameters. All beam ends were checked during this inspection. The findings were compared with previous inspections and revealed that most locations remained in a similar condition to those observed during the Level 3 inspection carried out in 2018 (as shown in Figure 18).

Figure 18 Comparison between photos of L3 inspection 2018 and 2022

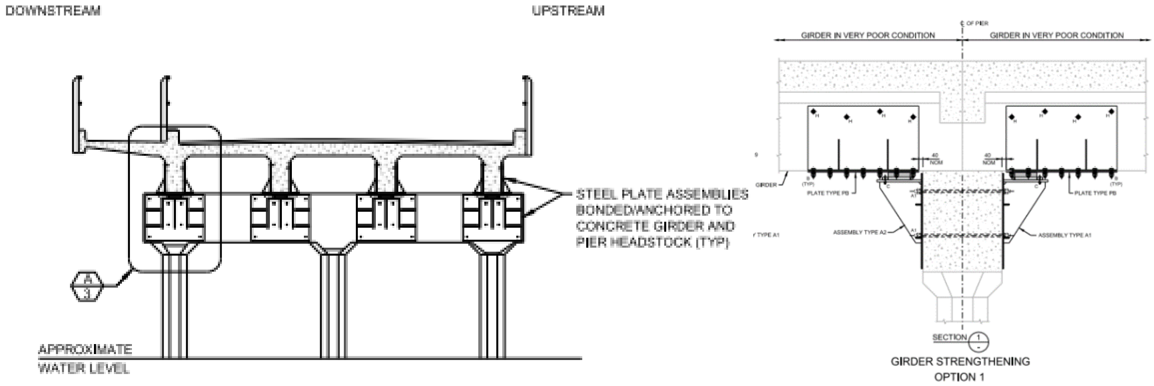
Rehabilitation work

Bridge rehabilitation design work was initiated in early 2023 to address cracks and spalling issues at the beam ends. The rehabilitation design work (as show in Figure 19) was carried out in the following stages:

Stage 1: Repair all cracks and spalling at the beam ends using the recommended materials. This was completed before proceeding to Stage 2.

Stage 2: Develop the rehabilitation design for all beam ends in poor to very poor condition.

Figure 19 Rehabilitation/strengthening option with steel plates



Stage 3: Order the fabrication of the proposed bearing support brackets and establish the construction site Figure 20 shows barge set up for installation of steel plates and brackets.

Figure 20 Barge setup for installation of the steel plates

Stage 4: Install all brackets on the headstock at the beam ends in poor to very poor condition. Figure 21 shows the post-installation photo.

Figure 21 Post installation photos showing steel plate bracket installed

Stage 5: Remove the monitoring system from the bridge.

All rehabilitation and strengthening work were completed in 2024. The monitoring system was removed upon completion of the rehabilitation work. The bridge is now maintained in a reasonable condition to ensure the safety of road users.

3. Conclusion

In conclusion, the condition assessment and maintenance strategies highlighted for the Heywoods and Mulwala Bridges serve as critical examples of effective management practices for aging infrastructure in South-West NSW. Both bridges demonstrate the challenges faced by aging structures, including significant concrete deterioration and cracking, which can impact their operational integrity. The comprehensive structural inspections revealed common deterioration patterns that necessitated immediate attention.

The proposed strengthening, rehabilitation and maintenance action plans for both bridges reflect a well-coordinated approach between regional asset maintenance teams and technical services, ensuring that timely repairs and rehabilitation efforts were initiated. The implementation of structural monitoring systems allowed for real-time assessment of bridge conditions, facilitating proactive maintenance and ensuring safety for road users.

With the successful completion of rehabilitation work on both bridges, including the application of Carbon Fiber Reinforced Polymer (CFRP) and structural strengthening, the safety and load-bearing capacity of these vital transportation links have been assured for the road users. These case studies provide valuable insights for bridge asset managers facing similar challenges, underscoring the importance of rigorous inspections, monitoring, and timely interventions in maintaining infrastructure integrity. Through these efforts, Transport for NSW demonstrates its commitment to the safety and efficiency of the state's transportation network, ultimately fostering improved road user experiences and sustained connectivity.

4. References

1. TfNSW Bridge Inspection Procedure Manual (2007 & 2018)
2. Transport for NSW (2019) Bridge Inventory and Inspection Policy (TS 01630_0.00).

Acknowledgments

The Author would like to acknowledge the below for their contribution in this paper directly or indirectly.

Singh Santhanam.

Bridges and Structure West Team

Bridges and Structure South Team

Bridge Maintenance Southwest Team,

Bridge Works Southwest team and Assets South Team.