

Strengthening of Heritage Timber Truss Bridges

Bridge over Abercrombie River

Abercrombie, NSW

R. Oates (RTA), R. J. Taylor (R J Taylor Consulting Pty Ltd), I. Berger (RTA)

SYNOPSIS

With increasing live loads on NSW roads, the load carrying capacity of most of the State's aging 53 remaining timber truss bridges is under threat. These bridges were built between 1877 and 1930 and most are classified as heritage structures.

The Bridge over Abercrombie River on MR54 was built in 1919 on the masonry foundations of a previous bridge swept away by floods in 1916. The superstructure consists of 2/21.6m Allan truss spans; 1/27.4m Allan truss span, 2/10.4m and 2/7.6m timber beam approach spans. MR54 links Bathurst with Goulburn and is being progressively upgraded to carry B-Double vehicles. Strengthening was, therefore, required for this locally significant heritage bridge to allow greater live loading.

The three Allan truss spans were strengthened by the installation of continuous steel plates inside the bottom chord timber flitches, new steel cross girders and transversely stressed Stress Laminated Timber (SLT) decks. The approach spans were strengthened by lowering the main timber girders; introducing steel cross beams and providing transversely stressed SLT decks. Austroads Level 2 traffic barriers attached to the steel cross beams and girders were also provided over the full length of the structure to increase safety.

The renovating methods used on this bridge have demonstrated acceptable ways of upgrading and strengthening timber truss bridges that are classified as heritage significant.

This paper provides an overview of the strengthening design and construction with emphasis on design and heritage issues that were encountered.

1 INTRODUCTION

The bridge consists of three Allan type timber truss spans, two of 21.6 metres (71 feet) flanking a main span of 27.4 metres (90 feet). The deck width is 4.6 metres (15 feet) between kerbs. There are two timber beam approach spans at each end giving the bridge an overall length of 106.4 metres (349 feet). An early photograph of the bridge is displayed in **Figure 1**.

Masonry piers support the timber truss spans. The material used is rough faced squared granite blocks laid in uneven courses. The stonework is of a good quality throughout, though the coping stones are roughly hewn and have visible drill marks from the quarry. Pier 2 is distinct from the others in that it appears to have been built in two stages. The base section extends up to a height of 0.8 metres at which point it forms a shoulder for the upper section that is 0.25 metres narrower for the remaining 1.1 metres. Piers 3 and 4 were increased in height by 1.8 metres through the use of concrete in 1919.

Timber trestles on granite bases support the approach spans. Rectification works in the early 1990s included the construction of a concrete Bathurst end abutment with wing walls. The orientation of the bridge is approximately northwest southeast.

MR54 links Bathurst with Goulburn and is being progressively upgraded to carry B-Double vehicles. Strengthening was, therefore, required for this locally significant heritage bridge to allow greater live loading.

2 BACKGROUND

2.1 History of Timber Truss Bridges in NSW

Timber truss bridges were preferred by the NSW Public Works Department from the mid 19th century because they were relatively cheap to construct, and used mostly local materials. The financially troubled governments of the day applied pressure to the Public Works Department to produce as much road and bridge work for as little cost as possible. This condition effectively prohibited the use of iron and steel, as these, prior to the construction the steel works at Lithgow (Hoskins) and then Newcastle (BHP) in the early 20th century, had to be imported from England or America.

Allan trusses were third in a five stage design evolution of NSW timber truss road bridges and were a major improvement over the Old PWD and McDonald trusses which preceded them. Allan trusses were 20% cheaper to build than McDonald trusses could carry 50% more load and were easier to maintain ^[1].

Allan trusses were the first truly engineer designed timber truss bridges, and incorporated American design ideas for the first time. This is a reflection of the changing mindset of the NSW people, who were slowly accepting that American ideas could be as good or better than European ones. The high quality and low cost of the Allan truss design entrenched the dominance of timber truss bridges for NSW roads between 1896 and 1930.

The Allan truss was modelled on the successful American Howe truss, with the top and bottom chords and compression diagonals in timber, and wrought iron rods for the vertical tension members.

Currently there are 53 timber truss bridges surviving in NSW from over 400 built. Of these 24 Allan truss bridges remain from the 105 built.

Timber truss bridges, and timber bridges generally, were so common that travellers knew NSW as the “timber bridge state”.

2.2 History of Abercrombie Bridge

The Scottish immigrant John McKenzie founded Abercrombie village in 1857. In the 1870s a ferry operated to take passengers across the river for 1/- a trip or 1/6 when the river was in flood.

The bridge was built at the ferry location to convey produce from Crookwell and outlying settlements into Bathurst. The need arose due to the establishment and subsequent growth of agricultural industries in the area that coincided with a massive influx of gold prospectors into the region following the reports of large discoveries.

The first bridge on this site was built in 1879 and was a lower level crossing bridge. This was a five span timber bridge, consisting of two timber beam spans and three timber Old PWD truss spans. It was marginally shorter than the present bridge at 90.8 metres (298 feet) long.

The carriageway was 4.65 metres (15 ft 3 inches) between kerbs on the timber beam spans and 3.96 metres (13 feet) between kerbs on the timber truss spans. The bridge was proclaimed a National work on 31st December 1906 in the Government Gazette No 286.

The superstructure of this bridge was swept away by floodwaters on 5th October 1916, though the stone piers remained undamaged. A low level bridge was built further downstream as a temporary measure, until such time as a new bridge could be built in the original location ^[2].



Figure 1: 1929 Photo of original bridge

In 1919 the piers were increased in height by 1.8 metres through the use of concrete and the present superstructure built. A photograph (**Figure 1**) taken in 1929 clearly illustrates the added portions of the piers, and original colour scheme. The light colour highlights the clean lines and symmetry of the Allan truss form, as well as establishing the bridge as a dominant feature in the local landscape.

2.3 Heritage Significance of Abercrombie Bridge

The heritage significance of the bridge was assessed during a study of the comparative significance of all timber truss bridges in NSW prepared for the RTA ^[3]. The bridge was assessed as being of local significance and was ranked 59th out of 82 bridges investigated in the study.

3 STRENGTHENING AND REHABILITATION DESIGN

The strengthening and rehabilitation design consisted of the following features:

1. Galvanized steel plates bolted to the inside of the two 300 mm high x 125 mm wide timber flitches that make up each truss bottom chord.
2. Galvanized steel RHS cross girders on the truss spans.
3. Introduction of steel and timber cross beams in the approach spans.
4. Increased sway brace angle to top chord.
5. Longitudinal stress laminated timber (SLT) deck the full length of the bridge.
6. Steel “Ordinance” barriers to Austroads Level 2 the full length of the bridge

3.1 Steel Bottom Chord Laminates

The load capacity of the Grade F22 timber bottom chords on a 90 ft Allan truss has been determined to be L50 (L42.5 represents a standard legal load 42.5 tonne semi trailer with a 1,2,3 axle configuration). A load rating of L50 is marginally greater than Austroads T44 loading and, therefore, theoretically strengthening was not required. However, it is known that failures regularly occur at the chord splices due to poor detail (reduced section to accommodate shear keys), poor workmanship, use of incorrect timber species, locating splices near nodes (therefore picking up bending effects) or a combination of some or all of these.

The product of the modulus of elasticity and cross sectional area (EA) of the steel strengthening plates (**Figure 2**) match the EA of the timber section and thus achieve strain compatibility. The introduction of the plates, therefore, effectively doubles the capacity of the bottom chord and if a timber flitch fails the steel alone will still be able to carry full T44 loading.



Figure 2: Steel plate reinforcement of bottom truss chords

The disadvantage of the system is the reliance on the timber to transmit loading from the shoes into the bottom chord. This means the condition of the timber under the shoes is critical and must be regularly inspected and maintained.

The advantage of the system is that the splices in the steel coincide with the splices in the timber and each segment can be shop manufactured and then lifted up into position under an existing truss without undoing any shoes.

3.2 Steel Cross Beams and Girders

Steel cross beams were introduced into the approach spans and steel cross girders in the truss spans. In the approach spans the cross beams were introduced to facilitate a longitudinal SLT deck and support traffic rail posts with a connection capacity equivalent to Austroads Level 2. In the truss spans the steel cross girders were introduced to overcome the well recognized weakness in the traditional timber cross girders as well as support traffic rail posts with the required connection capacity. In both cases the cross members were adjusted to provide a 1% cross fall as typified in **Figure 5**.

3.3 Cross Beams in Approach Spans

Alternate timber and steel RHS 200 mm high cross girders were introduced to allow a 140 deep longitudinal SLT deck over the approach spans with transverse stressing. This

necessitated the lowering of the pier timber capwales and the abutment concrete headstocks. Transverse stressing of SLT decks is preferred for maintenance access reasons in that restressing can be performed to counteract timber shrinkage without prolonged road closures.

Steel cross girders were provided at barrier post location only and extend outside the deck to allow typical post backstays to be provided over the full length of the structure. Back stays are required to allow the use of posts equivalent in section to the original ordinance posts while meeting the strength required. These steel cross beams use RHS sections as shown in **Figure 3** to simulate rectangular timber members in order to support heritage requirements.



Figure 3: Typical approach span refurbishment

3.4 Steel Cross Girders in Truss Spans

Steel cross girders were required in the truss spans due to the inherent under-capacity of the traditional timber cross girders to carry today's loadings as well as the difficulty in detailing a post connection to timber which satisfies the required traffic barrier capacity. The steel cross girders in the truss spans were made by welding two 380 PFC's together to form a 380 x 200 rectangular section as displayed in **Figure: 4**. The latter simulated rectangular timber members in order to support heritage requirements.



Figure: 4: Steel Cross Girder for Truss Spans

3.5 Increased Sway Brace Angle to Top Chord

With the introduction of the 190 deep SLT deck on the truss spans the elevation of the new steel cross girders were raised in order to maintain the existing road surface level. The original deck system consisted of timber stringers, decking and sheeting. The new SLT deck represented about a 200 mm reduction in depth or the same increase in elevation of the new cross girders. With this increase the existing lateral sway braces were rotated outwards to compensate as shown in **Figure 5** providing improved lateral stability.

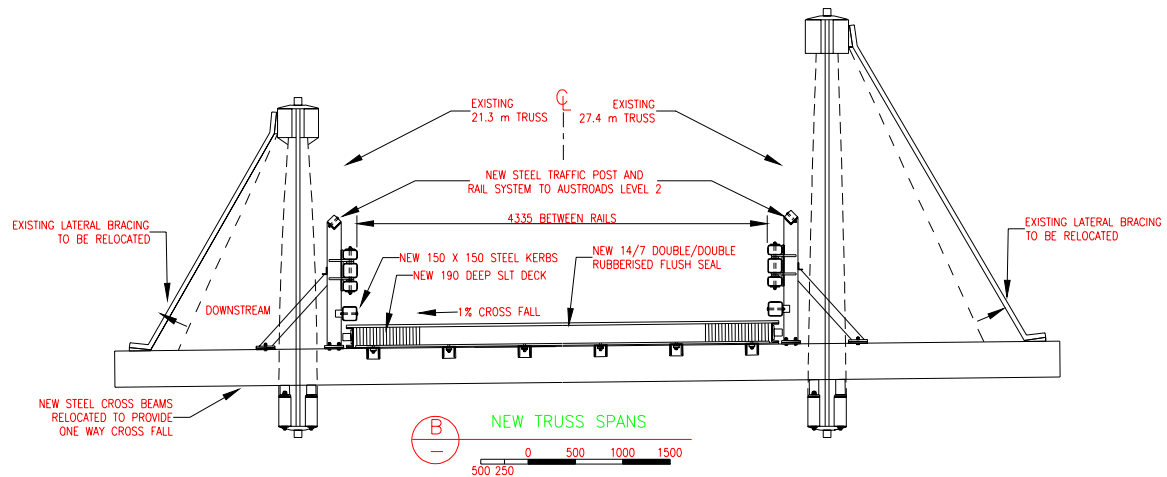


Figure 5: Typical Cross Section of Truss Spans

3.6 Stress Laminated Timber Decks

Transversely stressed SLT decks were installed over the full length of the structure.. The approach spans required 140 deep decks (see **Figure 3**) while the truss spans required 190 deep decks (see **Figure 5**). All decks were designed in relatively short lengths between 6 and 9 m to allow installation over numerous short duration road closures as will be discussed in the next section. Steel cover plates provide continuity between panels.

3.7 Steel “Ordinance” Barriers

The traffic barriers were designed to satisfy Austroads Level 2. In both the approach and truss spans the posts themselves utilize 150 x 100 steel RHS sections similar to the original (6' X 4'') timber posts as shown in Figure 6. In addition, a 100 x 100 SHS handrail is mounted atop the posts similar to the traditional (4' X 4'') timber handrail. The primary differences include the need for heavy steel traffic rails between posts and the post back brace to provide adequate strength to resist impact forces. It should be noted that a more recent design for the Hinton bridge near Newcastle NSW, has been able to reduce the traffic rails to only two RHS members instead of the three used at Abercrombie. This reduces the visual obtrusive impact of the rails.



Figure 6: Completed Refurbishment Prior to Paving

4 CONSTRUCTION

The strengthening and rehabilitation work on the bridge was conducted by RTA Western Region Road Services under a Single Invitation Contract (SIC). The work was undertaken in the following sequence::

1. The timber trusses were rehabilitated including bottom chord strengthening
2. The approach spans were then refurbished which included:
 - Lowering supports
 - Replacement of some girders
 - Installation of new cross beams, SLT decks and traffic rails
3. The final stage was the replacement of the truss span girders and installation of new SLT decking

The following provides a brief overview of some of the construction stages and methods.

4.1 Refurbishment and Strengthening of Trusses

The timber trusses were rehabilitated including the bottom chord strengthening under normal traffic with some restriction on width clearances. This was accomplished by installing temporary Bailey trusses similar to that displayed in **Figure 7**. These Bailey trusses are designed to support the cross girders and carry the traffic, as well as support scaffolding and truss components to allow dismantling and rebuilding of the trusses under traffic.



Figure 7: Typical Truss Support using Bailey Trusses at Clarence Town

4.2 Replacement of Approach Spans

Once the timber trusses had been refurbished the next stage was the rehabilitation of the approach spans. Each end of the bridge has two girder approach spans. Both spans at one end of the bridge were rehabilitated in a single 48 hour closure. This involved the lowering of the supports as previously discussed, followed by replacement of any deteriorated timber girders or other components which were to be retained.

The new timber and steel cross beams were then placed and secured as shown in **Figure 8**. This photograph also displays the first of the two SLT deck panels that make up the deck for the two girder spans. A view of the completed approach span was previously shown in **Figure 6**.



Figure 8: Abercrombie Approach Span Rehabilitation

4.3 Replacement of Girders and Decking in Truss Spans

The girder and deck replacement on the truss spans was conducted under 11 consecutive road closures which averaged about 12 hours each and were typically undertaken twice each week. The original (and advertised) closures were to be 24 hours (with the first set at 48 hours to allow a learning curve). However the work progressed well and the road was usually re-opened the same day.

Typically, during each closure, a 6 m long SLT deck panel and two cross girders would be replaced which was based on two truss panels. Near the centre of the middle truss there was one larger panel equal to three truss panels. The typical procedure included:

- Removal of the existing deck and cross girders in large sections (**Figure 9**)
- Installation of new steel cross girders (**Figure 10**)
- Installation of new SLT deck panel (**Figure 11**)

It should be noted that all of the component sizes including the old deck and new SLT panels were sized to facilitate the use of single 16 tonne Franna crane.



Figure 9: Removal of Old Decking on Truss Spans

Temporary support of the existing deck, not removed during a specific closure, was supported using one of the old timber cross girders adjacent to the panel point as can be seen in **Figure 10**.



Figure 10: Installing New Steel Cross Girder on Truss Spans

A special steel cross girder was required at the main piers between trusses which was detailed to sit directly on the piers as shown in **Figure 11**.



Figure 11: Special Cross Girder over Main Piers

5 CONCLUSIONS

In conclusion, the design and details were approved by the appropriate Heritage Agencies as acceptable. The overall strengthening upgraded the bridge to be able to accommodate for the increasing loads that are expected on the road in the future.

The project demonstrated that the methods and materials used to strengthen this local heritage significant bridge could now be successfully reused on similar structures with greater heritage significance.

The design and detailing successfully facilitated a construction methodology that minimised road closure. In fact the traffic disruption was less than originally anticipated.

The new SLT decks represent a major improvement in both strength and durability and require far less maintenance than the traditional timber decking. Their life expectancy is currently set at least 50 years. In effect, apart from the timber substructure in the approaches and some timber members on the piers, the only timber components remaining are those in the trusses. There are no longer any timber cross girders, stringers, decking and sheeting. These components represent most of the major maintenance requirements in existing timber truss bridges.

With the use of steel cross beams and girders, selected to simulate rectangular timber members, we now are able to attach a traffic barrier system designed to meet Austroads Level 2. This represents a significant increase in safety to the public and also improves protection of the bridge against collision damage.

REFERENCES

^[1] Department of Main Roads NSW, 1987 *Timber Truss Bridge Maintenance Handbook*

^[2] Roads and Traffic Authority of NSW, 1999 *Abercrombie Bridge over the Abercrombie River* RTA Section 170 Heritage Register, database entry for Abercrombie Bridge

^[3] McMillan Britton & Kell 1998 *Study of Relative Heritage Significance of all Timber Truss Road Bridges in NSW*, Report to the Roads and Traffic Authority of NSW.