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Echuca Bridge Footway and Lattice Arches

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SUMMARY The historic Echuca bridge stands as a fine example of the knowledge, skill and techniques of the engineers and workmen of the last century. Recent works carried out on the bridge to conserve its usefulness into the twenty-first century show how the appearance of an historic engineering structure can be preserved with care and dedication.

1. INTRODUCTION

The iron bridge over the Murray River connecting Moama in NSW to Echuca in Victoria was completed in 1878. Built to carry both rail and road traffic, the bridge replaced two existing punts and a pontoon bridge built by Henry Hopwood (1).

Jointly funded at the time by the NSW and Victorian Governments, the construction of the bridge enabled the railway to be extended northward from Echuca to the rich Riverina area of NSW.

The bridge which is 444 metres long between abutments was designed by William H. Greene, an engineer in the Victorian Railways. The bridge is included in the Register of the National Estate, is classified by The National Trust of Australia and is considered by O'Connor (2) to be amongst the four most historically significant metal bridges still existing in Australia.

Following construction of a new rail bridge 15 metres upstream a Conservation Plan was prepared for the rehabilitation of the historic bridge to carry road traffic only. This paper outlines the rehabilitation options under the Conservation Plan and details the design and construction aspects of the work undertaken.

2. BRIDGE HISTORY

The bridge was first used by rail traffic in August 1878. However, the bridge was not opened to road traffic until March, 1879 when, following a public meeting, a crowd stormed the bridge to accomplish the task (1).

Several modifications have been made to the original structure over the years. These include:

- the replacement of the original timber deck in 1896 by the existing composite deck of used railway lines and coke breeze concrete;
- the strengthening of the bridge in 1925 to take heavier railway loads whilst at the same time providing for two traffic lanes by removing the footway (originally located between the main girders) and cantilevering a new footway off the upstream side of the bridge. This work entailed the first large scale use of electric arc welding in Australia (3);
- the removal of the lattice curved bracing arches in 1979 and their replacement with rectangular steel portals giving greater vertical clearance to traffic; and
- the strengthening of some members in 1986.

The elevation of the existing bridge is shown in Figure 1.

3. DEVELOPMENT OF THE CONSERVATION PLAN

Planning for improved road and rail crossings of the Murray River commenced in the early 1960's. Following consideration of a large number of alternative crossings, and structural assessment studies of the existing bridge to carry modern rail traffic, it was determined that new road and rail bridges should be built downstream of the existing crossing.

Joint environmental studies followed with extensive public participation to cover engineering, environmental, social, heritage and economic factors. These studies, supplemented by further structural assessment of the existing bridge to carry road traffic only, formed the basis of two subsequent Environmental Impact Statements. The determinations of these Statements were that:

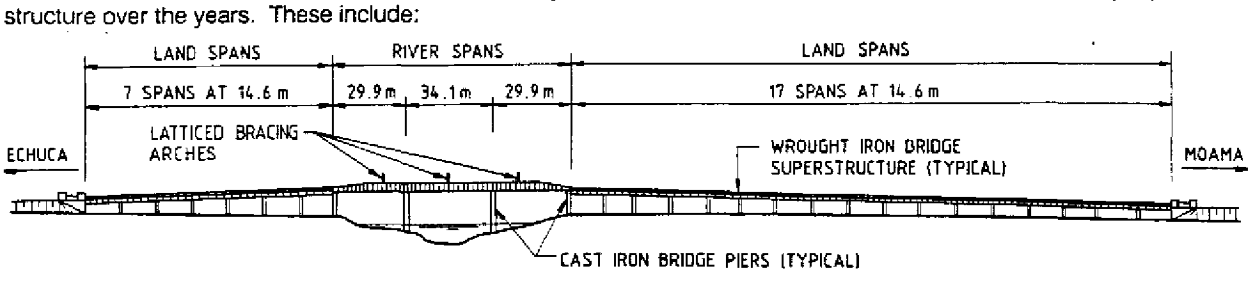

Figure 1 Elevation of bridge

- a new rail bridge would be built 25 metres upstream from the existing bridge by the State Transport Authority of Victoria (V/Line); and
- the existing bridge would be rehabilitated to carry road traffic only in accordance with a Conservation Plan with the work being jointly funded by The Roads and Traffic Authority of NSW (RTA) and The Roads Corporation of Victoria (VICROADS).

While the Environmental Impact Statement for the road crossing examined options for an additional road bridge to be built as traffic volumes increase, no decision on a future alignment was made.

The RTA, as the Authority responsible for the management of the project, prepared a Conservation Plan in accordance with guidelines provided by the Heritage Council of NSW. To assist in the preparation of the Conservation Plan the RTA engaged consulting engineers McBean and Crisp Pty. Limited.

The aims of the Conservation Plan were broadly stated by McCoy (1) as follows:

- to make the necessary modifications to the structure such that it will provide satisfactory future service as a highway structure under current loading and serviceability requirements; and
- to retain the existing structural form as far as possible including restoration of the appearance where appropriate consistent with the current strength and serviceability requirements.

A detailed description of the process involved in the development of the Conservation Plan is given by Atkinson et al (4).

4. WORK UNDER THE CONSERVATION PLAN

The Conservation Plan was approved by The Heritage Council of NSW under Section 60 of the Heritage Act 1977. A condition of approval was that each stage of the rehabilitation work should be developed in conjunction with "the advice of an engineer experienced in conservation" (1). The RTA established a further commission with consulting engineers McBean and Crisp Pty. Limited to satisfy this requirement.

Rehabilitation work completed to date under the Conservation Plan includes:

- the removal of the rail lines and the restoration of the running surface with asphaltic concrete:
- the strapping of the cast iron piers at the junction of the land and river spans to contain existing cracks;
- the construction of a new combined footway/cycleway on the downstream side of the bridge, the skeleton of the existing upstream footway being retained to show the 1925 addition;
- the replacement of the existing rectangular steel portal braces by new lattice bracing arches; and
- the provision of improved footway and street lighting.

For the detail design of the footway/cycleway addition and the lattice bracing arches the RTA engaged consulting engineers Tierney and Partners Pty. Limited. The design brief was in accordance with the aims of the Conservation Plan.

Rehabilitation work still to be addressed under the Conservation Plan includes:

- the provision of new deck expansion joints to be designed and detailed by consulting engineers Tierney and Partners Pty. Limited;
- the monitoring of the bridge articulation to assess the performance of the existing bearings.
- the monitoring of individual structural members for any signs of distress;
- the repainting of the bridge in a colour similar to the original; and
- the restoration of the brick parapets at the abutments.

5. NEW FOOTWAY TO THE LAND SPANS

The girders in the 24 land spans of the bridge (17 on the New South Wales side and seven on the Victorian) have been found to be close to their safe capacity under modern traffic loading, and it was decided that the new footway on the land spans should be supported from members which could transfer the footway loads as directly as possible into the piers of the land spans. This meant that the footway needed to be designed to span the 14.6 metre length of each land span and to be supported off the land span girders as closely as practicable to the piers. This system of supporting the footway would impose insignificant additional moments on the land span girders, and would not lead to overstress in those girders.

Earlier proposals for support of the footway had suggested an asymmetrical truss arrangement installed between the land span girders with a cantilevered extension beyond the downstream girder to carry the new footway beams. Tierney and Partners reviewed this proposed solution, and concluded that an aesthetically more desirable solution should be investigated. It was felt that the asymmetrical truss skeletons at each pier would mar the effect of the long symmetrical vaulted bridge framework that was visible to the observer from underneath the land spans.

Options were investigated to support the footway off the land span girders while preserving the symmetry of the bridge's underside. Tierney and Partners initially proposed a system of twin universal channels spanning across the tops of the land span girders at the piers and cantilevering out from the downstream side to support the footway. This required the removal of longitudinal stringer beams (which once supported the railway track) from between the two transoms closest to each pier to allow the cantilevering cross beam to be inserted just below the soffit of the deck. Had the roadway not already been resurfaced with asphaltic concrete (following the removal of the railway line) this solution would have been feasible. The RTA's Divisional Engineer rejected the option because it would have required further work to the surface of the deck, and would have been too disruptive.

As an alternative solution, it was proposed to crank the new cantilevered cross-beams so that they would pass below the longitudinal stringers. Quite complicated field splices would be required at the cranks to permit erection, but it had the merit in the context of the Conservation Plan of preserving the symmetry of the steelwork framing underneath the deck of the land spans. The cranked beam is shown in Figure 2.

The design has replicated this pattern on the outer edge of the new land span footway by the inclusion of short rounded stub beams welded to the outer longitudinal footway support beam. Figure 3 illustrates this feature. These stubs also provide a convenient means of attaching the posts for the new railing.

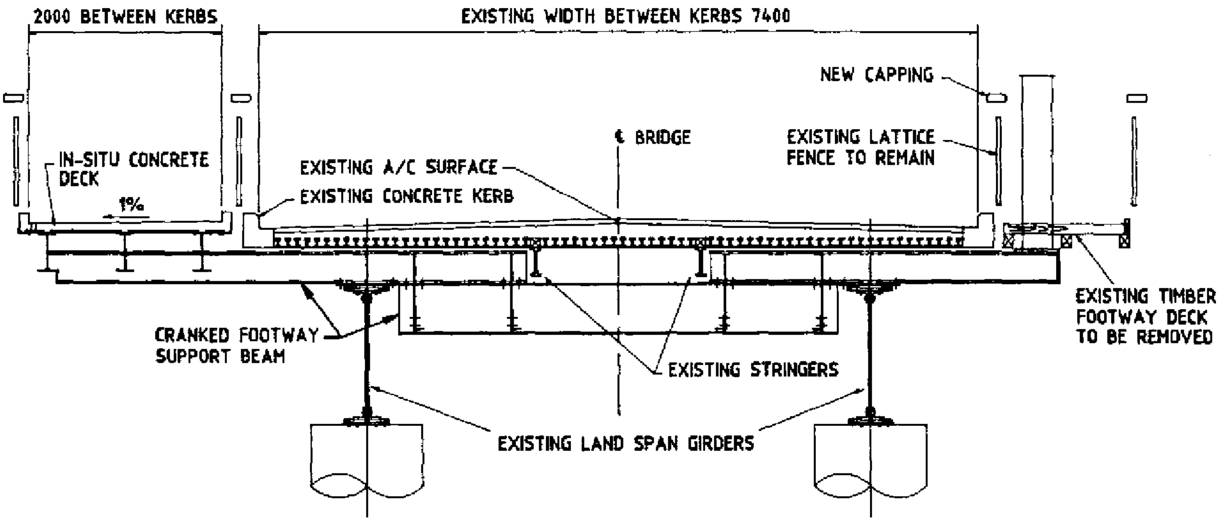

Figure 2 Footway details in land spans

The cantilevered cross-beams have been sized to limit their deflection, and it was important that the mass of the footway deck be minimised. Concrete was the RTA's preferred material for the footway surface, considering its dual use as a cycleway. Each span of the footway between the cantilevered beams at the bridge piers was designed to be supported by three longitudinal beams. These beams carried compressed fibre cement sheets which acted as permanent formwork for the relatively shallow cast-insitu deck slab.

The design paid careful attention to the appearance of the outer edge of the new footway, which is a prominent feature of the bridge when viewed from the river, the banks, or the historic Echuca Wharf precinct. A striking feature of the land spans of the old bridge is the regular pattern produced by the rounded ends of the transoms and their attached railing posts.

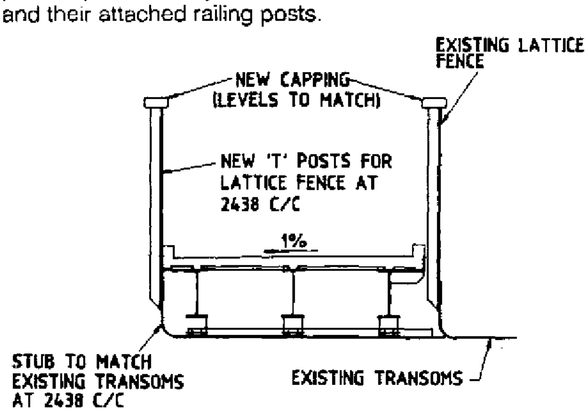

Figure 3 Footway details at existing transoms

6. NEW FOOTWAY TO RIVER SPANS

The old footway on the outer side of the upstream river span girder was attached in 1925. A horizontal cantilevering beam and an inclined prop were welded to the stiffeners of the river span girder and the timber footway was erected on this steel support system.

It was decided that a system of similar appearance should be used to support the new footway and barrier railing on the outside of the downstream river span girder and the resulting arrangement is shown in Figure 4. However, the greater width of the new footway and the preferred concrete deck imposed a greater load on the river span girder than the old footway. The critical effect appeared to be the twisting action imposed on the girder by the cantilevering footway. A structural solution was achieved by restricting the torsional effect on the girder by tying the footway support point on the girder stiffener back to an anchor on the transom with an assembly of tie rods as shown in Figure 4. This device had the advantage of causing minimal alteration to the river span girder; small holes in the web through which the tie rods passed were all that was needed.

With the restrictions imposed by the footway support systems on the river and land spans and the need to preserve a constant footway level between the river and land spans, the deck of the river span footway could not be supported on a system of longitudinal beams similar to the land span footway. The footway deck had to span the 2.4 metre distance between the supports cantilevering off the girder stiffeners, so precast reinforced concrete deck units were used having the required length and 2.2 metres width, complete with kerbs and drainage crossfall.

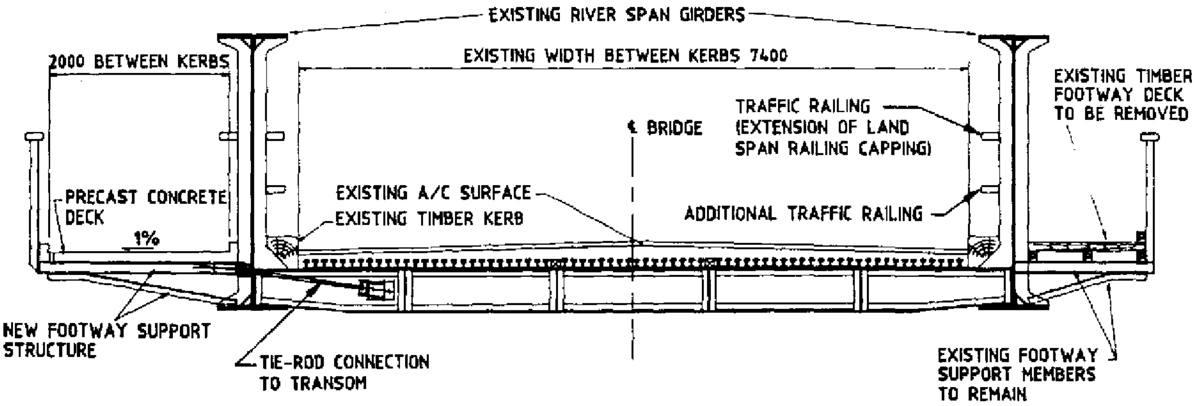

Figure 4 Footway details in river spans

7. NEW FOOTWAY AT ABUTMENTS

The old footway was attached to the masonry abutments by embedding its support framework in holes made in the brickwork and filled with mortar. This was considered to be an untidy treatment and unsympathetic to the character of the old masonry abutments. The attachments defaced the brickwork.

After considerable deliberation, Tierney and Partners decided to keep the new footway completely separated from the old abutments and to support it on its own small abutment and a pair of cross-braced circular steel columns shown in Figure 5. This solution avoided further damage to the abutments, and allows pedestrians to view the old abutments from the footway.

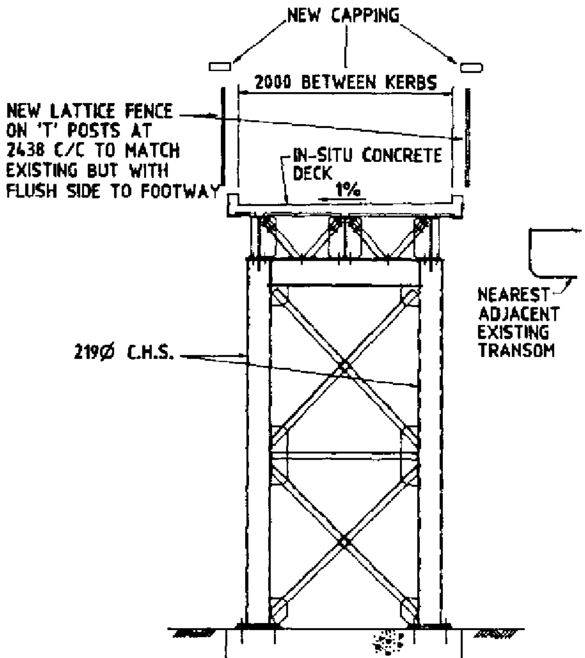

Figure 5 New footway piers near abutments

The steelwork detailing for this section of the footway which is not attached directly to the bridge attempted to preserve the appearance of the rest of the footway, right down to the inclusion of the rounded stub ends on the outer sides of the longitudinal support beams and the connection to them of the railing posts - see Figure 6.

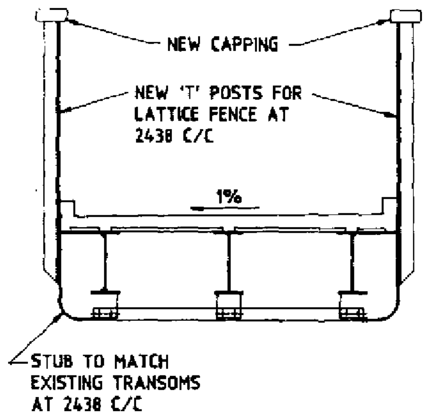

Figure 6 Footway details at abutments

8. PEDESTRIAN BARRIER RAILINGS

The posts for the new traffic barrier railing on the outer side of the footway have been attached to the vertical end of the rounded stub beams to replicate the attachment method of the old railing. The old latticed infill panels were reproduced in the new design, as anything other than latticed barriers would not have satisfied the Conservation Plan. The crossovers of the new latticed panels were welded whereas the old lattices were riveted. The extent of the weld protected the crossover points from collecting moisture which could eventually lead to corrosion.

The old lattice railings have had all their decorative top capping rails removed in the past. It was not economically practicable to reproduce the ornate capping section of the past, so it was decided to use a simple rectangular hollow section for the top rail attached to the posts of the old and new barriers by cleat plates and bolts. The rectangular hollow sections are safe as handrails, and are comfortable for people to lean against when viewing the river from the footway. If any sections of the top rail are damaged in the future by traffic impact, they can easily be replaced.

9. TRAFFIC RAILINGS

The existing lattice barriers will serve as traffic barriers on the land spans of the bridge. The construction of a new kerb suitable for the support of a modern traffic barrier railing would be very expensive, and a modern barrier would detract greatly from the appearance of the bridge carriageway. The bridge has a 60 km/h speed limit, and will be well lighted, and it was not considered necessary to provide for high speed impacts occurring on the bridge.

The rectangular hollow section top rail of the lattice barrier on each side of the carriageway on the land spans has been extended into the river spans as a traffic railing. It is attached to the vertical stiffener plates of the river span girders. A second traffic railing, also a rectangular hollow section, has been attached to the stiffeners at a lower level to produce an effective 2-rail traffic barrier on the river spans and to protect the river span girders from direct impact. Figure 4 shows these railings.

10. NEW LATTICE BRACING ARCHES

Following the removal in 1979 of the old lattic bracing arches from between the river span girders and their replacement by rectangular portal frames which provided increased clearance, one of the old arches was re-erected in Murray Esplanade, Echuca. This arch and the original drawings, provided sufficient evidence to enable the new arches to be designed as close replicas of the original structures. The locations of the arches in the river spans are shown on Figure 1.

The new arches provide ample clearance for modern highway traffic, and are designed to withstand lateral forces in the top flanges of the river span girders in accordance with current codes. The profile of the arches is shown in Figure 7. The original arches were riveted, but the new arches are fully welded.

The arches have been painted in the red-brown colour proposed eventually for the whole bridge. Once the public confirms its acceptance of the colour, the entire bridge will be painted in accordance with the Conservation Plan.

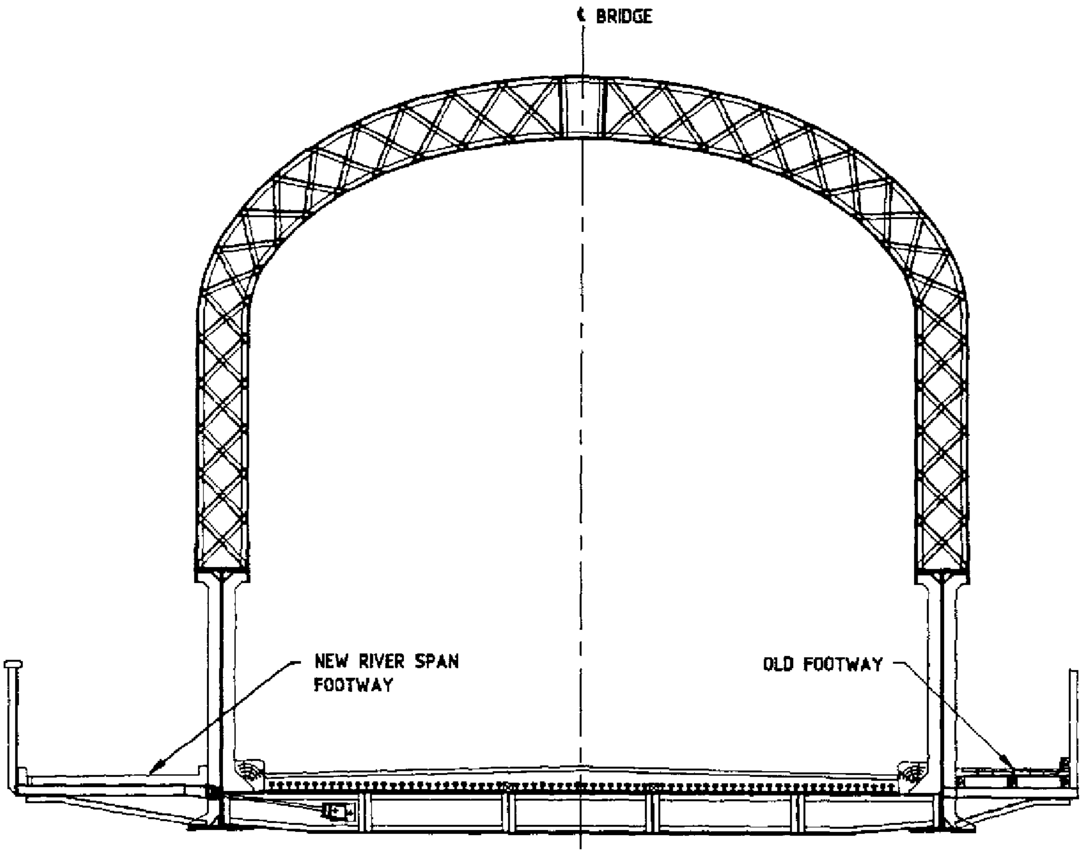

Figure 7 New lattice bracing arch

11. CONSTRUCTION OF FOOTWAY AND ARCHES

A tender from Austral Piling and Constructions Pty. Limited in an amount of $992,600 was accepted on October 30, 1990 for the construction of the new cycleway/footway on the Echuca Bridge.

The contract period was 35 weeks giving a due date for completion at acceptance of July 1, 1991.

During the course of the work a major variation was issued for the inclusion of the reinstatement of the lattice bracing arches on the river spans of the bridge. The variation price was $83,700 and an extension of time of five weeks was allowed extending the due date for completion to August 5, 1991.

Fabrication of the steelwork was carried out by sub-contractor McMahon Alfasi Group Pty. Limited of Moorabbin, and the precast footway panels for the river span were manufactured locally in Echuca by Humes Pty. Limited.

Progress on the work was excellent with the footway available for use in early June 1991 and the arch erection completed on July 3, 1991. Practical Completion was given on this date, nearly five weeks prior to the due date.

Given the nature of the work, construction difficulties were minimal and onsite amendments to suit actual conditions were generally easily effected. With the design drawings being based on the original plans it is interesting to note the Contractor's comments that the dimensional accuracy of the existing bridge was generally better than the new fabrication.

Delay periods during the course of the work were minimal. The Contractor was restricted by the documents in the time that traffic lanes could be closed and in any event most work was carried out from outside the bridge. One-lane closures were needed for placement of the deck slabs in the river spans but these were restricted to early morning.

For erection of the arches, the Contractor was allowed full closure of the bridge from 12.00 midnight to 6.30 am on three consecutive nights, one for each arch. However, the erection of all three arches was completed in one night over July 2-3, 1991.

During the process a temporary strut was placed across the girder top flange, the existing portal frame removed and the new arch slung into place using conventional cranes. No special techniques were used beyond amending the connection plates to provide slotted holes to allow for minor misalignment on erection.

The only arch to present any difficulty was on the Echuca side where the existing portal frame had been struck in a vehicle accident which caused damage to the top flange of the girder. In this case blank connection plates were provided and the bolting holes were formed on site to match the existing hole locations.

In summary, the erection process was efficient and completed with the minimum closure. Overall, the project was effectively managed by the Contractor and disputes were minimal and generally resolved onsite. Given the nature of the work the outcomes could not have been achieved otherwise.

12. CONCLUSION

The design and construction of the new footway and lattice arches on the historic Echuca Bridge illustrate how Australia's engineering heritage can be preserved and even enhanced by modern techniques. The work closely followed a Conservation Plan, and achieved the stated aims. The project demonstrates how sympathetic and successful restoration works can be carried out through the co-operation of authorities from two states, consulting engineers, construction contractors, and heritage bodies.

13. REFERENCES

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