Blaxland Bridge Bearing Replacement

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ABSTRACT

The bearing replacement design for the bridge crossing Nepean River at Blaxland’s Crossing, Wallacia, was initially presented at the 2017 Small Bridges Conference by Arcadis.

Aurecon prepared an alternative bearing support design which resulted in Wollondilly Council awarding the construction contract to Complex Civil contractors.

The new bearing supports feature innovative steel brackets braced to the sides of the pier with high strength stress bars. This design has been successfully adopted on other Aurecon bridge projects in the past.

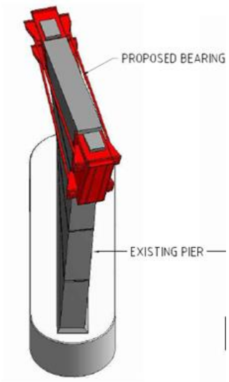
Whilst this project is ultimately about the replacement of elastomeric bearings, this paper discusses the progression of this innovative design from concept stage at tender, the use of LIDAR technology through to detailed design, fabrication and construction.

1 INTRODUCTION

The Blaxland’s Crossing bridge is located in Wallacia, where Silverdale Road crosses the Nepean River. This bearing replacement project is an example of innovation in design and digital technology, and was ultimately a lesson in practicality for a complex design.

The history behind this project began in 2011 when Aurecon undertook the design of a steel bearing support for a road bridge on Gungaghlin Drive. Complex Civil were the contractors involved in the construction of the steel brackets that Aurecon had designed. This bracket design had been used successfully by Aurecon on the Cross City Tunnel project in Sydney in 2005.

Complex Civil approached Aurecon in September 2017 to determine if a similar design could be adapted for the piers in lieu of the proposed concrete bearing supports, which had raised some challenges with construction.



Aurecon presented the design where two steel brackets were tensioned against the side of the pier with tie rods. The replacement bearings would be supported on the top face of the bracket (Figure 1).

This alternative tender design was accepted by Wollondilly Shire Council. The success of this solution can be attributed to the lower cost and improved constructability for these highly constrained pier locations within the Nepean River, where access was limited to the eastern bank or from the deck.

Aurecon’s scope of work comprised the design of the steel bearing supports at the piers, assisted by the use of LIDAR technology and 3D modelling.

Figure 1 - Proposed bracket design for tender submission

2 DESIGN

2.1 Site investigation

The five span, continuous deck, post tensioned bridge is supported on piers within the river, which are uniquely shaped. The top of the pier headstock supports the deck parallel to the diaphragm within the deck, with a twisted, tapered, rectangular form allowing the lower half of each pier to be parallel to the river flow (Figure 2).

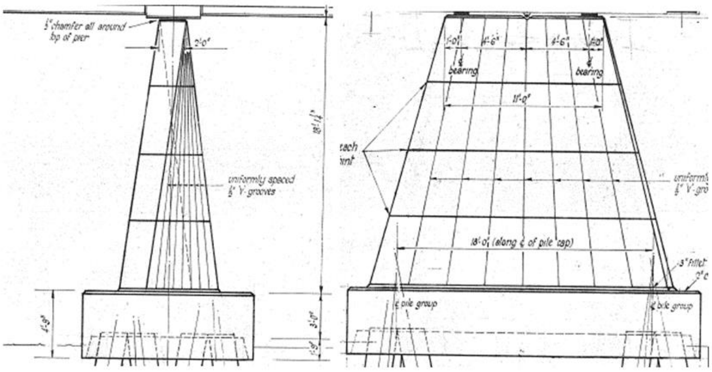


Figure 2 - Existing pier elevations

Due to the limited site access, a survey was undertaken of the piers from eastern bank only. The laser scanner was set up in two locations to form adequate contours, since the scans would only pick up what was within line of sight. The LIDAR scan was then used to create an accurate 3D model surface (refer image on left, Figure 3). This model of the pier would then be used to accurately set out the new bearing support brackets.

The design of the support brackets was initially based on the ‘As Built’ drawing dimensions and could not take into account any possible variations in the construction of each of the four piers. The benefits of the LIDAR survey and 3D modelling are apparent when the scans for the piers are overlaid against each other. The image below on the right highlights where two piers differ in their dimensional form. This check allowed the design to take into account any variations between the piers. The deviation between the constructed tolerances remained mostly within 5mm for each pier (shown as green in Figure 3).

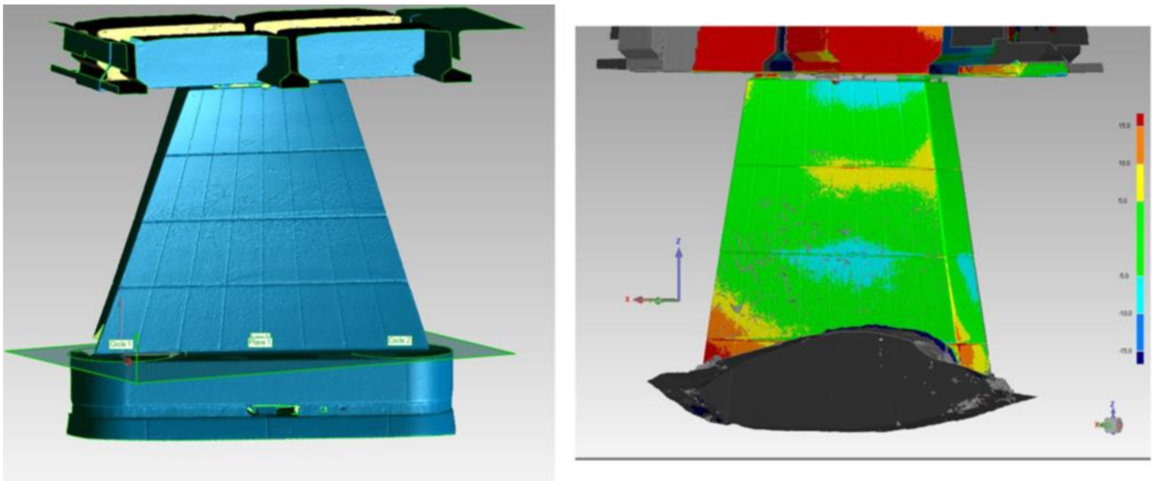


Figure 3 – LIDAR scan and QA deviation

2.2 Bracket detailed design

The design of the support bracket relies upon interface friction between the pier face and the steel bracket to support the design loads imparted through the bearings above. The design of the brackets assumed the same loads and laminated elastomeric bearings as nominated within the Arcadis design documents.

In order to generate the required friction, high tensile rods are tightened through the bracket on each side of the pier. It was determined early in the design development that only four tension rods would be required. The reclined angle of the existing pier end faces contributed to the vertical support actions mainly generated by friction.

This concept of providing a steel bracket held in place by post tensioned rods to the end of the pier has been previously used on a number of bridges. The significant difference on this project was due to the plan twist and taper of the pier. The end section of the pier that interfaces with the bracket is not vertical, resulting in the bearing load being offset relative to the centroid of the interface. This resulted in torsion on the bracket as well as vertical shear. Previous bracket designs did not have to deal with this torsional effect.

This combined effect could not be resisted simply by increasing post tensioning loads, since the compressive capacity of concrete governed. Four lateral plates at each corner of the bracket, where it connects to the pier, were designed to carry the torsion by direct compression onto the side of the pier. It was critical that the plate interfaces were fully grouted against the pier to provide this resistance (shown in yellow in Figure 4).

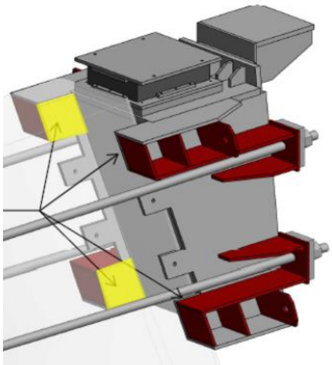


Figure 4 - Steel bracket design with torsional restraint

The complex interaction of compressive forces laterally and longitudinally to the bridge as well as the vertical shear force on the end of the pier resulted in critical stresses being formed at the corners of the pier. To reduce these effects. it was necessary to minimize eccentricity of the load from the new bearing, relative to the bracket centroid.

An additional steel restraint system was designed to carry any uplift or lateral forces the deck could encounter during flood events. The restraint allowed longitudinal freedom of movement during normal service conditions.

An appropriate paint system compliant with RMS NSW specifications and the adequacy of the steel plate thickness provided the required durability for the steelwork. The design solution, being formed of steel, also offered robustness under flood events.

2.3 Design challenges

Adopting a previous design onto a new bridge structure presents the opportunity to improve on design. What was not immediately apparent at concept design was the impact the unique pier form would have on the detailing.

Provision of additional stiffeners within the steel bracket to counteract applied loads and torsional effects created difficulties in the steel fabrication and welding. These plates also significantly added to the self weight of the bracket and affected the proposed construction methodology. Multiple small stiffeners were replaced by a more simplified layout with thicker internal plates. Weld details were modified to facilitate fabrication.

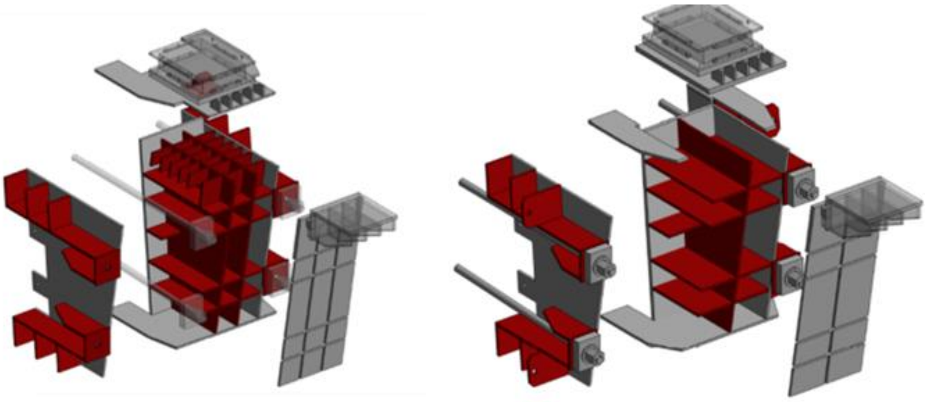


Figure 5 - Exploded view of bracket before and after changes

Due to the twisted nature of the pier, the brackets were designed to remain square between each other and not with the pier.

The pier is both skewed and twisted in plan; to minimize variation in grout thickness between bracket and pier, the bracket is set out such that at its mid-depth, it is parallel to the pier. At the top and bottom of the bracket, the bracket alignment is not parallel to the pier. The grout is placed between the bracket and roughened pier face to maintain the even surface contact.

Likewise there is an apparent skew in the tie rod connections from top to bottom. The use of spherical washers allowed the rods to remain in even contact with the brackets at the differing angles.

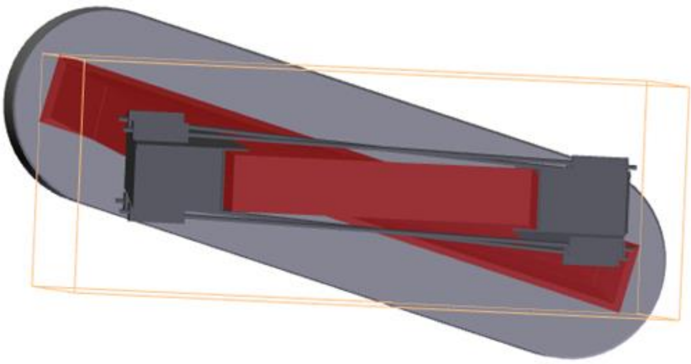


Figure 6 Twisted tie rod alignment in plan

The bearings were not located on the centre of the pier headstock but aligned with the centreline of the bracket to reduce torsional effects. The design therefore assumed the bridge bearings were offset longitudinally relative to the bridge deck pier diaphragm.

However, permanent longitudinal movement of the continuous deck due to shrinkage and creep created an additional offset between deck and substructure, notably at Piers 1 and 4. This eccentricity would cause additional torsion on the bracket, which was critical to the design.

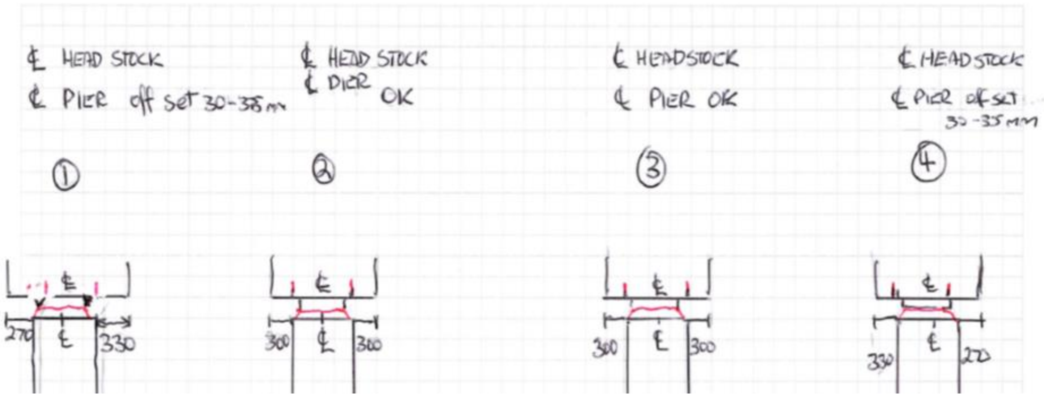


Figure 7 Offset of diaphragm and pier - Courtesy Complex Civil

Complex Civil proposed a solution by slightly rotating the bracket within the tolerances available on site and moving the upper keeper plates.

This allowed the bearing to be placed slightly offset from the deck diaphragm yet still remain centrally placed on the bracket. The effect on the deck would be minimal and no additional torsion was introduced.

3 JACKING AND BRACKET INSTALLATION

The difficulty in lifting and placing a 2.5t steel bracket, working off a temporary platform with low head clearance was solved using a block and tackle arrangement. This allowed the bracket to be “slid” up the face of the pier into position. This solution eliminated temporary fixings to the pier and provided constant support to the bracket.

Once the brackets were fixed and grouted in place, the next stage of bearing replacement commenced. Jacking was to occur at one pier at a time, with no concurrent live loads. Traffic management was limited to short durations during the jacking and lowering processes, with controlled traffic flow at the centre of the bridge during the bearing replacement.

A revised methodology for jacking the bridge was proposed; four interlinked jacks, two on each bracket, would be placed either side of the bearing location, rather than on the pier. Modifications to the bracket were made involving local plate strengthening at jack locations. This solution solved the difficultly in trying to jack from the existing pier where clearance between deck and substructure was limited to 90 mm. Any potential deck movements due to temperature were minimised as jacking was required for short periods only.

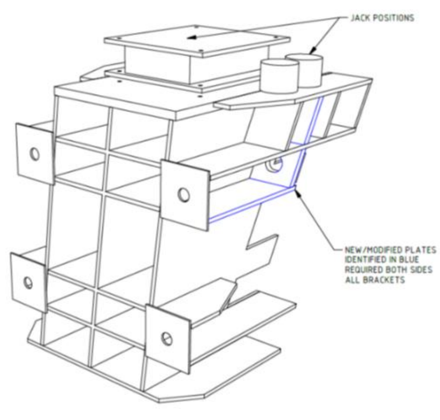


Figure 8 Jacking support modifications - Courtesy Complex Civil

4 CONCLUSION

From the initial assessment and design undertaken by Arcadis, this project has undergone numerous phases of development. The amenability of Wollondilly Council to consider alternative solutions has led to the implementation of an innovative design which has run its course through to construction. The use of LIDAR scanning is becoming more commonplace; this project exemplifies the practicality and suitability of scanning complex structures and how this digital technology contributes to the design solution and accuracy of detailing.

The overall success of this project can be measured by the application of proven innovative techniques, as well as the problem-solving skills of both designer and contractor to facilitate the design, fabrication and installation of this alternative bearing support structure on a complex structural form.

5 REFERENCES

- Arcadis tender design
- Wollondilly Shire Council – Blaxlands Crossing As Built drawings

6 ACKNOWLEDGEMENTS

I would like to acknowledge and thank the contributions of Matt Haskins, Lach Haskins and Aaron Kaplun from Complex Civil, for their collaboration with Aurecon and their ongoing contribution to the final design and construction; Ken Maxwell from Arcadis for providing the basis of the design and his later reviews; and Mike Nelson of Wollondilly Shire Council and Wasique Mohyuddin of Penrith City Council for this opportunity to showcase these innovative techniques.

7 AUTHOR BIOGRAPHY

Marcia Prelog is an Associate within the bridge and civil structures team in Aurecon. She has extensive experience in the design, assessment and restoration of a variety of bridge structures in Australia and overseas on rail and road projects. Her 18 years in the Bridges discipline encompasses design in steel, concrete, composites and timber.