

RURAL BRIDGES – GETTING THE MOST FOR YOUR BUDGET DOLLAR

Graham Murray; murrayg@conwag.com
Senior Bridge Engineer, Connell Wagner, Queensland, Australia

Abstract

Rural Queensland has many timber bridges on the road network. Built at the turn of the 20th century, these bridges are reaching the limit of their design life. With all these bridges of the same age, many councils and local authorities throughout Queensland are now facing crisis point, with many bridges suffering significant deterioration and approaching dangerous conditions. Faced with budgets which will not allow all these bridges to be replaced all at once, local authorities must consider the priorities of safety, budgets and consequence of road closures due to bridge failures.

The key objective of this paper is to discuss the various options available to assist decision making related to the rural bridge dilemma.

Key Words: Rural Bridges, Timber Bridges, Bridge Replacements, Budgets

Introduction

Currently there are in excess of 3000 timber bridges throughout Queensland, under the jurisdiction of the Department of Main Roads, councils, shire councils or local authorities. These bridges were generally constructed in the latter part of the 19th century or the early part of the 20th century.

These bridges have performed very well throughout the years, and in some cases are still performing well. They are now coming to the end of their safe useful life as a result of normal wear and tear, rotting timbers, insufficient maintenance due to lack of available funds, damage due to vehicle impacts or flood, increased mass limits and new truck suspension systems. All these factors combined, have resulted in a need to replace most of these bridges within the next few years.

With Council funding already spread very thin, the provision of minimum maintenance, let alone complete bridge replacement, is becoming a major issue to shire engineers.

This paper will look at options for restoration, replacement and funding opportunities for the many timber bridge problems throughout Queensland.

Auditing and Prioritising

The first dilemma facing all shire engineers is what to do to which bridge first. A complete audit of all bridges in the shire needs to be undertaken prior to apportioning funds and resources to the problem.

The 1999 DMR timber bridge audit carried out as part of the Mass Limits Review created the impetus for shires to look to their bridge records. The very short time available for the work resulted in a lot of bridges being missed. It did however, give the shires a fairly good indication of the future scale of the problem.

After a detailed audit is carried out, an assessment of the bridges needs to be undertaken and a rating system provided to establish a systematic approach to repair or replacement of the deteriorated bridges, and a funding regime set up to carry out this work.

That's the theory.

The real world dictates to us that this is just not feasible. The cost of a small 2 x 10m span timber bridge can be the entire maintenance budget for 12 months or mean

that 15 km of road reseal is missed from the years budget.

The prioritising carried out is usually based on such factors as

- Life threatening danger to motorists
- Main access into the regional business centre
- Access into a major housing or industry estate or property, where economics or community reaction dictates
- Politically motivated reasons
- Lack of alternative routes.

As well as the deterioration of the bridges themselves, many also lie on substandard roads, particularly on stream crossings which would preferably need to be raised to increase the flood immunity of the road. This then requires additional funding for the associated roadworks.

Prioritising can then be undertaken, based on the above criteria. Assembling a matrix which assists in this prioritising is a difficult

task, as subjective emotions can easily outweigh objective reasoning.

Load Limit Reduction

The initial solution to the typical timber bridge problem is to reduce the load limit on the bridge. This will usually only be a very temporary solution, as most timber bridges are on access roads to farms, quarries, mine sites etc.

Restoration Options

Restoration or repair options available to the shire engineer depend on the available funds in each budget. Most repair work is funded from the maintenance budget, which is usually spread very thin over the shire's road network.

The following Table 1 describes repair methods of timber bridges which are currently in use and also some innovative methods under development.

Table 1 Timber Bridge Repair Options

Problem	Possible Repair Methods	Cost Comparison	Ease of Repair
Localised damaged running boards	Replace with new timbers to fill hole.	Medium	Moderate
	Temporary replacement with plywood.	Low	Easy
Global damaged running boards	Replacement of running boards with new timbers.	High	Moderate
	Cast an in situ concrete slab over the existing deck.	Medium	Moderate
	Replacement with heavy duty structural grade plywood.	High	Moderate
	Corrugated steel sheets with in situ concrete infill over the existing deck.	Medium	Moderate
Rotted corbels	Replace with new timber corbels (finding cheap, legal timbers of the correct size is becoming difficult).	Medium	Moderate

Problem	Possible Repair Methods	Cost Comparison	Ease of Repair
	Replace corbels with a fibre composite corbel. This is currently under development, but with timber becoming more expensive, this will quickly become a common material and greater usage will reduce the production costs. Advantage is that these fibre composite corbels will be considerably lighter than timber and therefore easier to install.	High (in short term)	Moderate
Deteriorated girders	Reduce the load limit on the bridge.	Low	Easy
	Replace individual girders with new timber girders (finding cheap, legal timbers of the correct size is becoming difficult).	High	Difficult
	Replace girders with fibre composite girders. This is currently under development, but with timber becoming more expensive, this will quickly become a common material and greater usage will reduce the production costs. Advantage is that these carbon fibre girders will be considerably lighter than timber and therefore easier to install.	High (in short term)	Difficult
Rotted or split pier piles	Reduce load limit on the bridge.	Low	Easy
	Provide new concrete piles external to the side of the bridge, with steel beams each side of the existing pier to support the bridge.	Medium	Moderate
	Provide steel plates each side of pile splitting.	Medium	Easy
Increase in load limit	Provide new concrete piles external to the side of the bridge, with steel or concrete beams supporting the bridge to reduce the spans.	Medium	Moderate
Rotted guardrails (assuming they exist)	Replace with W or thrie beam guardrails.	Medium	Moderate
Rotted or missing abutment retaining wall boards	Replace with precast concrete wall panels.	Medium	Moderate
	Remove altogether and convert walled abutment to a spillthrough abutment.	Low	Moderate

1. Deck replacement only
2. Complete bridge replacement

Bridge Replacement Options

Bridge replacement options can be broken into 2 sections:

Deck Replacement Only

There are a number of bridges where the substructure is generally in good condition while the superstructure, the main deck, is in

a seriously deteriorated condition. Options exist to replace the existing timber deck with a new deck, maintaining the existing timber piles and headstocks. These generally consist of a proprietary system, with some new ones about to hit the market.

The piles, abutments and retaining walls need to be assessed for structural adequacy. If they are adequate, deck replacement options can often be an economic alternative to replacing the complete bridge.

Deck replacement alternatives are listed below, in no particular order.

- RTA Doolan Deck
- CSR Humes Humedeck
- Rocla M-Lock
- Fibre Composite Bridge Deck

Descriptions of each system are outlined below, as these options are also used for complete bridge replacements.

Note that the bridge will only be replaced to the same width as existing, which is usually less than current desirable for 2 lane bridges.

Apart from the Fibre Composite Bridge Deck, the costs of each of the systems above are broadly similar, depending on the location and situation of each bridge.

Complete Bridge Replacement

Complete bridge replacement necessitates the demolition of the old bridge, construction of new foundations and superstructure, possible new embankment protection and associated roadworks.

Culverts

The typical 6 to 9 metre span timber bridges can usually be economically replaced by simple culverts, either reinforced concrete box culverts, concrete pipe culverts or steel

pipe culverts. Steel pipe culverts, depending on location, can generally be economic, however, construction and fill compaction around the pipe requires competent construction and supervision.

Foundation and Substructure

Foundations will vary depending on the local geotechnical conditions, level of rock and stream flows. Generally, foundations will consist of a driven octagonal precast PSC piles, driven square reinforced concrete piles, driven steel piles (H or tube), or pad footings. Substructures will generally consist of in situ or precast concrete headstocks. These will be similar for both central piers and abutments. Where rock levels are high and pad footings are used, reinforced concrete columns will be used in lieu of piles.

Spillthrough abutments with longer spans, will generally be more economic than smaller spans with walled abutments, particularly if piles are required for foundations.

Superstructure

A variety of superstructure options are available for the bridge decks. These will consist of proprietary systems and accepted precast units for longer spans. The various systems are described below.

Doolan Deck

The RTA developed bridge deck, which consists of a 150 thick concrete deck slab cast on to 2 x 400 diameter hardwood logs. Each panel is in the order of 2 – 3.0 m wide, with 2 logs per panel, refer Figure 1. Although common in NSW, they are rarely used in Queensland, however, Esk Shire Council recently used them on a number of their bridge replacements. Spans available are generally in the range of 8 to 12 m.



Figure 1 Doolan Deck Bridge Deck

Humedeck

The Humedeck, by CSR Humes, is a modular precast concrete T beam and slab system. Deck widths are available up to 2.7m and spans from 8 to 12 m. Refer Figure 2 for the Humedeck layout.



Figure 2 Humedeck Bridge Deck

Rocla M-Lock Deck

The Rocla M- Lock bridge system consists of precast concrete inverted U planks, approximately 1200 wide. These planks are bolted together to form the width of the bridge. Spans are generally available from 7 to 12 m. Refer Figure 3 for the M-Lock layout.



Figure 3 M-Lock Bridge Deck

DMR Deck Units

The standard DMR deck units are available for spans from 10 to 30 m. The deck units are 600mm wide, precast prestressed voided deck units. The deck units are placed adjacent to each other and either transversely stressed or have an in situ concrete deck slab placed over. Transverse stressing is the quicker and cheaper construction method, however, some situations require the deck slab that has some durability advantages. Refer Figures 4a and 4b for the deck unit layout.

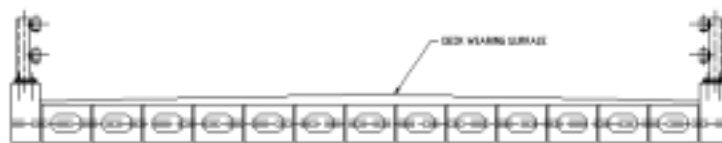
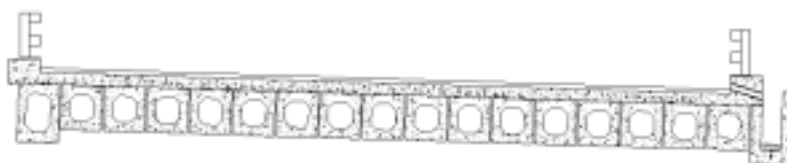


Figure 4a Deck Unit Bridge Deck with Transverse Stressing



Figures 4b Deck Unit Bridge Deck with Concrete Deck Slab

Super Tee Girders

Super Tee girder bridges are generally not economic for most timber bridge replacements, however they are mentioned for completeness where particular situations may warrant.

The Super Tee girders are available for longer span bridges, generally from 25 to 35 m. Due to the weight of the long span girders, craning will be a significant element in deciding the span used. Girders of this length are usually only used for crossing major road or river crossings where central piers cannot be located easily for smaller spans. Refer Figure 5 for the Super Tee layout.

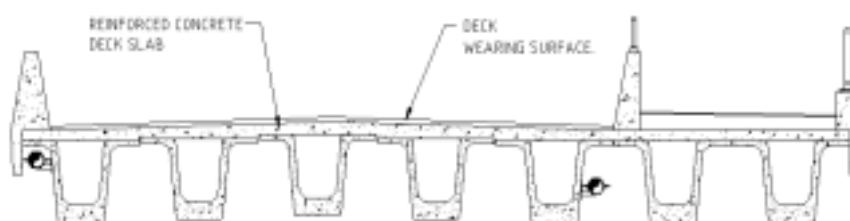


Figure 5 Super Tee Girder Bridge Deck

Standard DMR I Girders

DMR I girder bridges are again applicable for the longer span bridges, however, they have typically been replaced by the Super Tee girder bridges. There are some bridge contractors who retain I girder moulds and can offer savings with alternative designs. Refer Figure 6 for the I girder layout.



Figure 6 | Girder Bridge Deck

Fibre Composite Bridge Deck

There are in excess of 80 fibre composite bridges in service through out the world. Within Australia, the first prototype fibre composite bridge deck is currently being service tested in a quarry access road near Toowoomba. The first fibre composite bridge to be used on a public road in Australia is currently being designed by Connell Wagner, with construction due to commence shortly.

The fibre composite bridge deck will be prefabricated in the workshop and subsequently transported as a single or double unit to the site. As the deck is significantly lighter than most other bridge decks, a complete superstructure can be transported and erected in place, significantly reducing construction times. At present the cost of these units are significantly greater than the typical concrete units, however, greater usage is expected to reduce the manufacture costs. Refer Figure 7 for a typical fibre composite bridge deck.



Figure 6 Fibre Composite Bridge Deck

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Cost Comparisons

A quantitative cost comparison is not provided, as generally the costs are comparative for different situations.

For smaller 7 to 10 metre span bridges, the Doolan deck, Humedek and M-Lock systems will all be economic with the cheapest solution being dependent almost purely on location and industry tendering. DMR deck unit bridges are generally economic for the 12 to 25m spans. Spans

over 25m will require the Super Tee girder bridges.

Fibre composite bridge decks will eventually become economic as the usage increases and consideration of road closure times attains higher importance.

Industry tendering will generally always provide the most economic price. For initial budgeting purposes, a range of \$1500 to \$2100 per square metre of deck area will

give an initial budget estimate for the design, geotechnical investigation and construction of typical timber bridge replacements. This range will depend on location and access difficulties.

Consultants vs In-house Design

Most shires do not have an experienced bridge designer on their staff, therefore nearly all bridge designs will be outsourced to consultants. Most shires will carry out their own roadworks design for any changes to the approach roads. Hydraulic analysis is also generally carried out by external consultants.

Geotechnical investigation will need to be undertaken by specialist geotechnical investigation companies or consultants that have their own in house geotechnical capability.

A consultant that has capability in all aspects of the project including roadworks, bridge design, hydraulics analysis, geotechnical investigation and survey, i.e. a “one stop shop”, will provide an economic design service.

Smaller consultants can provide individual design or investigation services at a lower price, however, a greater degree of coordination is required.

All consultants rated to DMR BD1, HD1, HE1 will have the ability to design most shire timber bridge replacements. DMR rating to BD3, HE3, HD3 will be required for more complex structures.

The process of obtaining a consultant for the project is generally one of four methods:

1. Open advertising. This will generally elicit a large number of submissions by a lot of consultants chasing this work.
2. Using a single consultant who has a long established relationship with the shire.
3. Using a shortlist of consultants to provide submissions for each project.

These consultants will have had established relationships with the shire, but requesting submissions keeps the consultancy fees at market value.

4. Shortlisting consultants from the LGAQ prequalified consultants register. This avoids open advertising and provides a list of accredited consultants.

Day Labour Vs Industry Tendering

As a lot of the smaller shires do not have a large enough or experienced enough day labour force to construct new bridges themselves, industry tendering will generally be the only available method of bridge structure delivery. Industry tendering should generally give an economic construction method, as long as there are no major projects running that will entice the contractors away from the smaller projects, thus giving inflated prices for the work.

Shires with a day labour force capable of constructing the bridges will find it is economic to carry out the bridge construction, as long as it is approached as a commercial type project, adhering to a realistic construction programme. If a commercial programme of works is not followed, and the day labour force is used to keep them busy, rather than as a necessity, then construction costs will quickly exceed budgets.

Tendering for the fabrication and delivery of deck units and piles will still need to be undertaken for a day labour delivery.

Funding Opportunities

Funding for these bridge replacements will always be a major difficulty, as capital costs of \$200,000 or more are very difficult to fund by the larger shire budgets, let alone the smaller ones.

Creating a systematic replacement fund of 1 or maybe 2 bridges every 2 or 3 years,

appears to be a common feature among a number of councils.

Utilising flood assistance money from the Natural Relief Disaster Arrangements (NDRA) for capital works like bridge replacements, will provide some budgetary assistance. This fund will provide up to 75% of capital fund, however, it is a reactive source only. A flood needs to have occurred and damaged the bridge.

The Federal Government Roads To Recovery Programme has been instrumental in providing bridge replacement funds.

The Qld Government Local Authority Grants Commission provides a specific roads component to local authority funding.

The Qld Government Transport Infrastructure Development Scheme (TIDS) also targets local authority projects.

The Rural Living Infrastructure Program (RLIP) may be an option were the bridge is a "facility which enhances the tourism potential.....and also provides a general community use....."

Author Biography



Graham Murray is a senior bridge engineer with Connell Wagner and has over 20 years experience in the design and construction of bridges and tunnels in Australia and United Kingdom. Along with many timber bridge replacement structures for local government authorities, he has been involved in the design of major bridge structures on the Pacific Motorway, Bruce Highway Upgrade and South East Transit Project.

Graham 's contact details are:

Phone: 07 3246 4348
Fax: 07 3246 1002

Postal Address: Connell Wagner, Locked Bag 1800, Spring Hill, QLD, 4004

E-mail: murrayg@conwag.com

Conclusions

Ailing timber bridges throughout Queensland are creating a safety and financial dilemma for most, if not all, Queensland shire councils. Options for the refurbishment, replacement and funding of these bridges has been discussed in the paper.

Refurbishment options have been outlined to give alternatives to complete rebuilding.

Bridge structure options have been described, which indicate the types of decks which are applicable to different situations.

A comparison between design options and construction options has been carried out to enable consideration during the assessment process.

It is hoped that the paper has provided information to shire engineers to assist them in considering additional options when assessing timber bridge replacements.