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Working Together To Manage The Bridge Risk

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WORKING TOGETHER TO MANAGE THE BRIDGE RISK

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Abstract

The Douglas Shire Council, Texcel and its contractors are working together to manage the Shire's bridge risks. The substantial reductions in the risks are the outcome of a commitment from all levels of the Council to address the issues associated with bridges.

Douglas Shire Council and Texcel worked together to develop the bridge risk management strategy which involved the identification of the risks, their initial management via the application of load limits followed by more thorough investigations resulting in bridge replacements, bridge repairs, temporary repairs, permits to carry heavy loads for special vehicles and in some cases, no action was required in the short-term. The investigation techniques relied, in part, on the local knowledge developed whilst inspecting and maintaining the bridges. This was supplemented by theoretical evaluations and where considered helpful, physical testing of bridge performance under the passage of heavy vehicles.

Key Words: bridges, risk, asset management, testing, rating

Introduction

The key to managing the risks associated with timber bridges lies in the management of the asset. Over recent decades asset management of local authority bridges has been a low priority and consequently it has attracted low levels of expenditure. The consequence is that the national local government bridge inventory has deteriorated at a time when the loads applied to the bridge inventory continue to increase. The result is that the risks of failure have increased to the extent that bridge collapses (especially timber bridges) occur at unacceptable rates.

Industries within the Douglas Shire include tourism, sugar cane, grazing, construction and general industry. The Shires roads and bridges are vital elements that are necessary to support each of these industries.

The Douglas Shire Council recognised their exposure to unacceptable risks. Working together with its consultants and contractors, it set about managing these risks in a planned but practical manner. This paper discusses the risks, the objectives, the risk management strategy and its implementation.

Figure 1 Failure of a timber bridge under load (interstate location).

Initial Responses to the Risks

The Brodie versus Singleton Shire Council High Court Case in May 2001 overturned the

"Highway Rule" under which councils may escape liability through nonfeasance or failure to act. The case involved the partial collapse of a timber bridge under the weight of a truck delivering concrete to a construction site. Thus authorities with power to remedy the risk are obliged to take reasonable steps within a reasonable time frame to address the risk.

With increased awareness of the bridge risk, the Douglas Shire Council responded by installing load limits and speed limits on bridges judged to be at risk (Figure 2, Figure 4). The resulting restrictions on the movement of goods had a negative economic impact in the community. It also encouraged freight operators to disregard the load limits in order for business to continue and consequentially diminishing the standing of the Council and the engineering profession.

Figure 2 Bridges in need of risk management strategies.

Council Objectives

The Douglas Shire Council's shared values are continuous improvement, people concern, teamwork and quality services. The objectives of the bridge management strategy are as follows:

1) **Structural Safety:** Bridge failures under the loading of vehicles complying with the legal load limits applicable to each bridge are unacceptable;

2) **Load Carrying Capacity:** Bridges with load carrying capacities that are consistent with community demand and costs within 5 years;

3) **Economics:** The solutions to be judged on the life cycle costing, level of service and risk.

4) **Flood Immunity:** Maintain existing levels of service. Increase flood immunity where it is possible cost effectively.

5) **Bridge Geometry:** Carriageway widths and alignments on replacement bridges to be consistent with 20 year projections of traffic.

6) **Barrier Safety:** Bridge barriers commensurate with the desired level of risk to be accepted by the Council and the community within 5 years;

7) **Quality:** Ensure works are undertaken in a quality manner in the first instance.

8) **Managed Approach:** Procedures and training systems to ensure effective long-term bridge management.

Strategic Plan

A simple process was adopted to develop the strategic plan. This involved Texcel and the Council working together to:

1. Identify those bridges believed to provide the greatest risks.
2. Assign an engineering condition rating to each bridge (Table 1).
3. Rate the community need (Table 2).
4. Assign an upgrade priority (Table 3).

5. Develop and implement a strategic plan.

Table 1 Bridge rating

Rating	Description
1	As new
2	Good condition
3	Scheduled maintenance required
4	Action in next 12 months
5	Immediate action required

Table 2 Community rating

Rating	Description
1	Car access only
2	5 t – small commercial vehicles
3	10 t – farm equipment
4	15 t – can trains, school bus, some heavy vehicles
5	General access by buses and legal heavy vehicles

Table 3 Priority rating

Priority	Period
A	0 to 4 years
B	5 to 8 years
C	> 8 years

THE RISKS

Piers and abutments:

The timber piers and abutments ranged from being in good condition to poor / almost non-existent raising serious concerns about collapses. Some piles were replaced in the short-term.

Decks:

Deck condition was variable, exacerbated by a lack of scuppers to drain water. Two metal trough decks were severely rusted and some decks were 'flogging'. A number of the bridges had decks with large cantilevers and the girders clustered towards the centre raising concerns about failures to both the deck cantilevers and the external girders under eccentric wheel loads (Figure 3, Figure 4).

Girders & Corbels:

Girder condition varied from failed, requiring immediate action, to good. Large snipes cut into girders significantly reduced the load carrying capacity of some girders, further raising risks (Figure 3). Strengthening of defective girders and a snipe management program was required.

Truck near kerb (Round unshaved girders)

Description		#	Dia (mm)	BAG123 Rating		
Span #	2	1	400	1.61	0.53	1.61
Span (m)	9.6	2	400	2.11	0.64	2.11
Ext Spacing (m)	1.3	3	400	2.11	0.98	2.11
Int Spacing (m)	1.3	4	400	3.44	2.39	3.44

Figure 3 Theoretical rating of 4 girder span under eccentric loading.

Bracing:

Steel girder bridges without bracing to the compression flange were identified. Lateral movements of these bridges under load confirmed risks associated with buckling failures and the need for short-term action.

Traffic Barriers:

All the bridges relied on guideposts and kerbs to prevent vehicles driving off the bridge. This has been the situation for many years and even if a bridge barrier is warranted, it is often not possible to support the barriers on the existing structure. Thus risk management strategies were adopted on a case by case basis.

Figure 4 This load limited bridge has been replaced.

Single Lane Bridges:

All the bridges were single lane bridges. Most of these bridges were considered likely to remain as single lane bridges with the risk of accidents managed by good sightlines, speed controls and signing.

Load Limits:

The bridges had either been posted with a load limit or there was a planned load limit based on judgement. These bridges remained in use.

The Solutions

A cooperative approach to inspecting and rating these structures was adopted to refine the solution options which included temporary works, repair, strengthening, permit systems, replacements as well as no-action required.

Keeping the Cane Moving (Short-term Risk Management)

Short-term repairs (Figure 5) were required on some bridges to allow cane trains to continue to utilise the bridges. These works were undertaken utilising Council crews.

Figure 5 Temporary piers to strengthen deteriorated girders

Bridge Replacement Program (Long-term Risk Management

A total of five critical bridges have been replaced to date. One was a small girder bridge that was replaced with a baseless culvert due to the ecologically sensitive site (Figure 4). Four others have been replaced with prestressed concrete plank bridges with a cast-in-situ topping slab. These bridges are regularly submerged and thus a concrete wearing surface was adopted. One of the four bridges was a dual purpose bridge, supporting cane trains.

The replacement bridges were designed and documented prior to public tender. This allowed wide participation from contractors including small contractors based in the shire. On this occasion the local contractor (Kenmac Constructions) was successful, due to reduced establishment costs and fabrication of the piles locally.

Figure 6 Typical replacement bridge

The replacement bridges (Figure 6) resulted in improved alignments, removal of load restrictions, marginal improvements in flood immunity, the incorporation of safety barriers and dramatic reductions in maintenance expenditure and risk.

Extending the Life of Bridges

Stewarts Bridge is a long, single lane, timber bridge with concrete piers and abutments. Considerable expenditure has been invested in a new ply decking. The timber girders were in good condition, but small for the span.

The bridge had a restrictive load limit. Theoretical investigations confirmed the need for a load limit (Figure 3). A behavioural load test enabled the performance of this bridge to be further understood (Figure 7, Figure 8).

Figure 7 Test truck crossing bridge instrumented to measure deflection and strains.

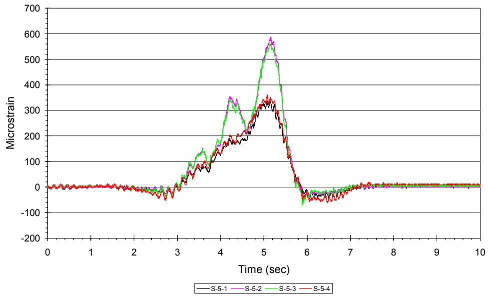

Figure 8 Typical strain response.

The testing demonstrated that the bridge was working strongly with additional load paths though the kerbs. The dynamic response was limited due to the restricted speeds possible on the bridge. This combined with the proven in-service track record of this bridge supported a strategy that involved keeping a load limit in place but implementing a permit system for legally loaded heavy vehicles that restricted speed and required central driving. Regular inspections and maintenance of the kerbs, deck and girders provides further support.

Other Issues

Managing the Bridge Risk by Managing the Road Profile

After recording the dynamic responses of many bridges, it is clear that a smooth road profile can be very beneficial in reducing the risks of damage to the bridge. Whilst the heavy vehicles' suspension, its speed and the bridges natural frequency are important, an uneven road profile is required before unacceptably high dynamic responses are generated. An uneven road profile over bridges can be just as damaging as grossly overloaded truck. Further guidance can be found in Heywood et. al. (2000).

Asset Management Software

The ongoing need to track the condition, maintenance, capital and depreciated value of bridges will continue to be a challenge. Bridge Asset Management software systems are aimed at assisting this task. BridgeAsyst™ has recently been approved by Local Buy as an approved system for local government in Queensland and will facilitate the record keeping required to support the ongoing bridge management task.

Conclusion

All levels of the Douglas Shire Council responded to the risks associated with its deteriorated bridges. Working together with its consultants and contractors the Council has identified its risks and set about managing them in a practical, planned and funded manner.

References

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Author Biography

Dr. Rob Heywood is Texcel's Business Manager for their Infrastructure and Transport business units. Rob and his team provide solutions based on understanding the issues and the behaviour of the underlying engineering systems. Rob is well regarded for his design, testing, asset management and research contributions in the areas of bridges, wharves, mining structures, heavy vehicles, road profile unevenness, dynamic interaction of vehicles and bridges, and the dynamic interaction of blasting and structures. Rob has Bachelor, Masters and PhD qualifications in Civil Engineering from the University of Qld. As well as his consulting career, Dr Heywood has lectured at the Queensland University of Technology for over a decade. Dr Heywood is a recipient of the WH Warren Medal (Institution of Engineers, Australia).

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Richard Karagania is a Senior Project Manager in Texcel's Infrastructure and Transport business units. He is also a chartered civil engineer with diverse overseas and Australian skills and experience in design of commercial development infrastructure, sewer reticulation and pump stations, water and mine infrastructure; project management and contract administration. Richard also has specialist experience in pavement and rehabilitation design of heavy-duty concrete and asphalt highway and airports pavements and has carried out pavement designs for major Australian highways and airports both locally and overseas. He has Bachelors and Masters qualifications from Queensland University of Technology.

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Bob Baade is the Director, Engineering Services for Douglas Shire Council where he has served for more than 25 years. In his career he has worked as a Roads Engineer, Shire Engineer, Deputy City Engineer and Building Surveyor in various locations including Victoria, Fiji and Northern Territory. He is a Chartered Professional Engineer, Fellow of the Institution of Engineers, Fellow of IPWEAQ and member of several municipal engineering and local government bodies. He also holds a Master of Business Administration (Technology Management) from Deakin University among several academic qualifications. Bob has also devoted time for community services and worked as Douglas Shire Controller, State Emergency Service, was President of North Queensland Local Government Engineering Association for 3 years and is a member of Mossman Lions Club including President for 3 years.

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