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FINAL REPORT

Project Title: S31: In-line Timber Bridge Replacement Options (2017/18)

ARRB Project No: PRG17023

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Client: Queensland Department of Transport and Main Roads

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AN INITIATIVE BY:

SUMMARY

Queensland Department of Transport and Main Roads (TMR) is currently managing over 300 ageing timber bridges, of which the residual service lives are potentially being consumed by the increasing freight demand. Some of these bridges may require replacing in near future to meet the road demand and ensure safe operation.

Replacement of timber bridges typically occurs in-line. Traditional replacement bridge construction requires long bridge closure and a side track to facilitate construction. The cost of construction of the side track has been a concern due to the high cost often approaching the cost of replacement of the structure itself. Rapid construction methods have been identified as a viable option to avoid side track construction while minimising road closure time. Therefore, this report reviews the current market options for rapid construction of replacement bridges, which will allow replacement of timber bridges in a relatively short time.

Several pre-engineered bridge products which are currently available on Australian market have been identified and reviewed for their compliance with TMR bridge design criteria and specifications. In addition, this report proposes a three-step selection process with graphical initial screening, a matrix-based preliminary selection and detailed review for final selection.

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1 INTRODUCTION

1.1 Background

Queensland Department of Transport and Main Roads (TMR) is responsible for the management of over 300 timber bridges. Most of these ageing structures are designed to design standards that are insufficient in comparison to today's standards and level of service needs. Many of these structures constructed between the 1920's and 1960's have been in service for over 60 years and are currently approaching the high maintenance phase of their life. It is expected that the freight demands are likely to consume the residual service life of these assets at an increasing rate.

Currently, replacement of timber bridge structures typically occurs in the same alignment (in-line) as the existing bridge. This requires the construction of a temporary side track to facilitate construction, with the cost of the side track often approaching the cost of replacement of the structure itself.

This project aims to review proven rapid construction techniques available domestically. Key project criteria include the ability to employ a cost-effective and durable solution in a relatively short construction time with minimal disruption to traffic whilst maintaining the current alignment and road geometry.

1.2 Project Objectives

The objectives of this project are as follows:

1. Characterise the bridge, road and route configurations where TMR would typically target timber bridge in-line replacement, specifically determining available road closure windows and pre-works constraints. This characterisation may also be suitable for bridges that would not be typically done in-line, but that is not the focus of the characterisation.
2. Review and collate feasibility level cost based on recent projects to determine a baseline cost for typical projects.
3. Review and collate proven rapid bridge construction solutions, specifically collating their alignment with (1).
4. Evaluate bridge systems and identify any departures and non-compliance to *Design Criteria for Bridges and Other Structures* (TMR 2018) and relevant technical specifications.
5. Develop a framework 'Timber Bridge Replacement Options Selection Matrix'.
6. Populate (5) with the data developed in (2) to (4) and provide a supporting report.
7. Prepare a supporting database with more details on available options.

1.3 Scope

The scope of the project is to:

1. determine typical functional requirements for in-line timber bridge replacement projects
2. determine baseline cost for each system as nominated by the supplier (list in the option selection matrix)
3. determine available market solutions that align with (1)
4. provide a matrix to rapidly inform decision-makers of feasible options for in-line replacement based on typical project and product characterisation.

Exclusions to scope are:

- solutions that are bespoke (i.e. not substantially pre-engineered)
- culvert solutions
- non-timber bridge in-line replacement projects
- market solutions that do not comply with in-line replacement functional requirements
- solutions that are not currently available in the Australian market and not designed to Australian standards (e.g. AS 5100:2017 Series).

1.4 Limitations

- This study does not undertake a detailed engineering review of the bridge systems for TMR acceptance for construction.
- This report tabulates parameters of available proprietary bridge systems at the time of writing. The objective of the bridge system selection methodology outlined in this report is only to shortlist the bridge systems that are meeting project specific requirements. It does not imply that TMR has approved the use of these bridge systems.
- TMR acceptance of a new bridge system shall follow the TMR Engineering Innovation process. Inquiries regarding this Innovation process shall be sent to:

  Department of Transport and Main Roads,

  Director (Structures Design, Review and Standards),

  GPO Box 1412,

  Brisbane City. Qld 4000

2 TMR IN-LINE TIMBER BRIDGE REPLACEMENT CONSIDERATIONS

2.1 In-line Replacement Considerations

Bridges are a crucial element of a road network which require strategic planning and maintenance for safe operation. Closure or service restriction of a bridge can make significant social and economic impact, particularly in rural areas where there are no alternative routes. Most in-service timber bridges are significantly aged and have consumed most of their safe and useful life, creating many challenges in maintenance and safe operation and increasing the pressure on authorities to replace them.

Replacement of timber bridges has historically been based on several factors including asset criticality (how critical the asset's continued function is to stakeholders).

The remaining timber bridge assets in the TMR network are now usually on secondary routes. Typically, replacement occurs in-line; however, a number of site factors can significantly influence the suitability of in-line bridge replacement options, such as:

1. traffic volume
2. availability of an accessible alternative route
3. stream bed stability and accessibility (can most of the stream bed be reliably accessed during at least part of the year to facilitate in-line construction?)
4. site geometry
5. lack of environmental constraints associated with activities in and around the water course
6. predictable weather patterns
7. the capacity of associated road networks to accommodate construction traffic and heavy prefabricated elements
8. the condition of the structure to be replaced (Utilising the existing timber structure as a work platform)
9. the feasibility of extensive pre-works (prior to road shut down) and availability of suitable laydown areas to facilitate construction activities including pre-works.
10. local availability of suitable construction plant (particularly cranes) and construction materials.

A very favourable site is likely to include a short total length structure (minimises cranage and logistics issues) with simple site geometry (straight road crossing straight stream at 90 degrees) and a readily available alternate traffic route (minimum impact on service disruption) with low traffic volumes. A readily accessible stream bed with an adjacent flat laydown area during part of the year (facilitates pre-works, cranage and multiple work fronts) with locally available large cranes and construction workforce is also very beneficial. However, it is unlikely for a site to have all these favourable conditions, which imposes constraints on replacement. For example, most of the remaining TMR timber bridges are in rural areas with limited resources and therefore, large machines and skilled workforce may not be locally available.

In addition to the site factors listed above, suitable in-line replacement solutions that complement the favourable site include:

1. a competitive cost base
2. compliance with TMR bridge design criteria and specifications
3. short lead time

4. maximum use of pre-engineered components (particularly superstructure)
5. flexible integration of (3) into a tailored solution (pre-engineered design can be adapted to a range of sites)
6. extensive pre-fabrication for reduction of in situ works
7. compatibility with pre-works opportunities associated with the site
8. robust elements that are not susceptible to damage during construction
9. minimum site time and road closure requirements
10. immediate trafficability following practical completion (i.e. no cure time required for construction materials)
11. lightweight elements (minimises heavy machinery requirements).

Again, some of these desirable attributes tend to be mutually exclusive, and regardless of the above, geotechnical conditions vary for each site. Hence, solutions will require flexibility in substructure configuration, and timely geotechnical data will be required to enable design and project completion.

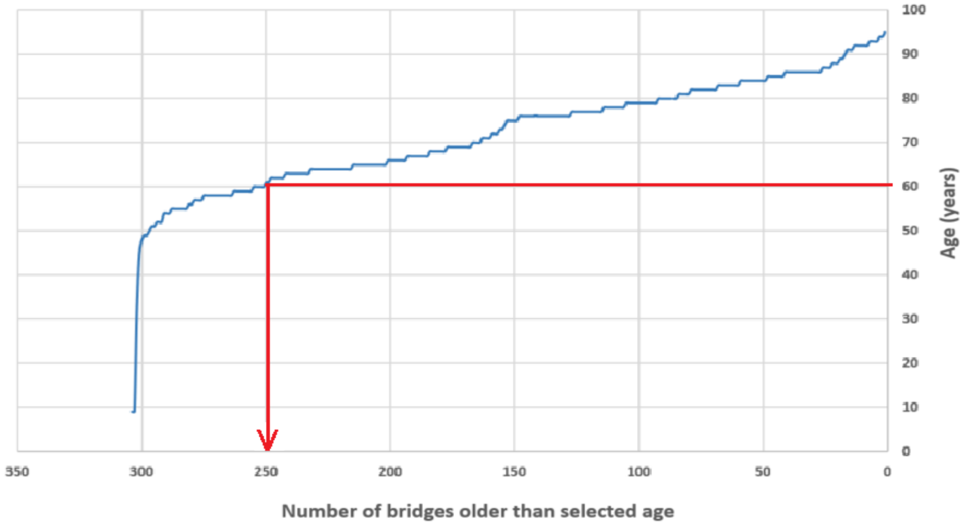
Combining a favourable site with a suitable in-line bridge replacement solution will involve compromises. Given that most sites are less than favourable, and in-line bridge replacement market solutions are often constrained by material, fabrication or construction requirements, it is essential that functional requirements and priorities for the site are clearly understood and documented. This investigation has developed tools to facilitate this process, namely:

1. site condition screening
2. replacement bridge system option selection matrix
3. bridge system data base.

2.2 TMR Bridge Stock Attributes

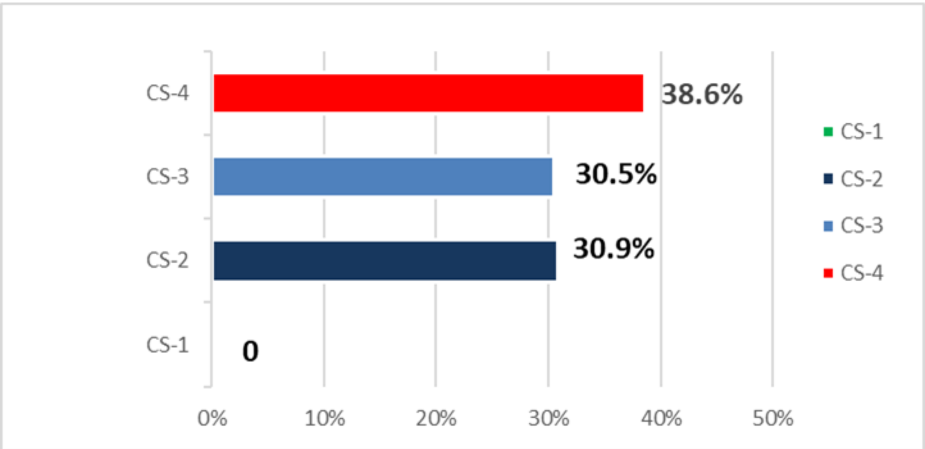
As per TMR bridge information system (BIS) data (as at October 2017), 304 timber bridges distributed over the Queensland remain in-service on TMR managed roads. As shown in Figure 2.1, approximately 250 (80%) of these bridges are more than 60 years old and were designed for a much lower traffic load than those built to current standards. Further, as shown in Figure 2.2, approximately 70% of the TMR timber bridge stock is currently in condition state 3 or 4 and approaching the high maintenance phase of their service life. Distribution of in-service timber bridges across six TMR regions and their condition rating is shown in Figure 2.3.

Figure 2.1: Age of TMR timber bridges



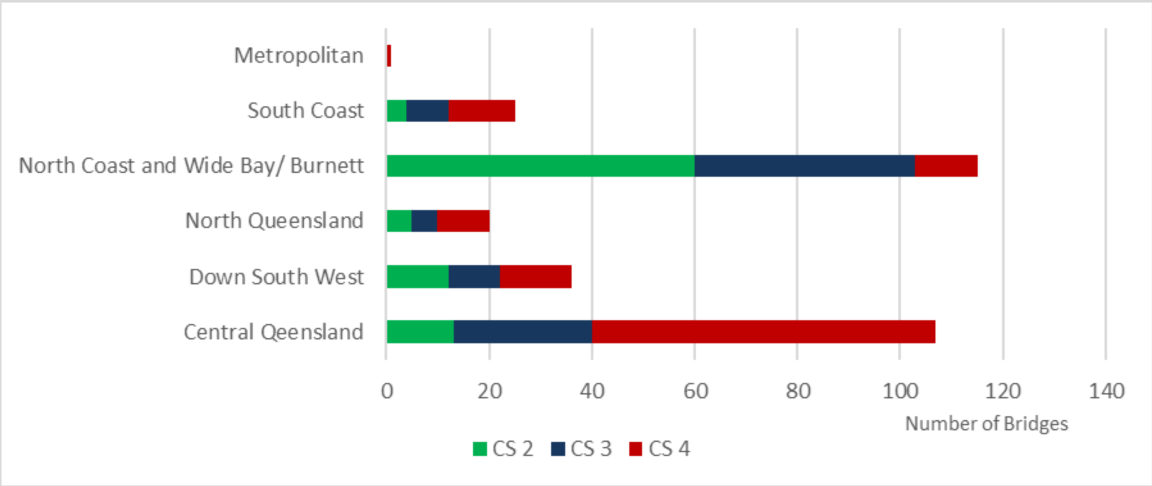
Source: TMR BIS (as per October 2017).

Figure 2.2: Overall condition rating of in-service timber bridge stock



Source: TMR BIS (as per October 2017).

Figure 2.3: Distribution and overall condition rating of timber bridges in TMR regions



Source: TMR BIS (as per October 2017).

Timber bridges are usually multi-span structures with over 90% of TMR timber bridges having individual span lengths of less than 10 m as shown in Table 2.1. Further, as shown in Figure 2.4 approximately 80% of timber bridges have an overall length of less than 40 m. Sixty per cent of the timber bridge stock accommodate two traffic lanes, and the remaining 40% of the stock have a single traffic lane only. According to bridge inventory data, carriageway width of single lane bridges varies from 2.1 m to 8.5 m with 65% of them measuring less than the current recommended minimum width of 4.9 m. Carriageway width of current two-lane timber bridges varies from 3.6 m to 9 m with 99% of them measuring less than the TMR's recommended minimum width of 8.6 m (TMR 2018). Almost all of these bridges have timber plank decks, but the substructure materials vary as shown in Figure 2.5.

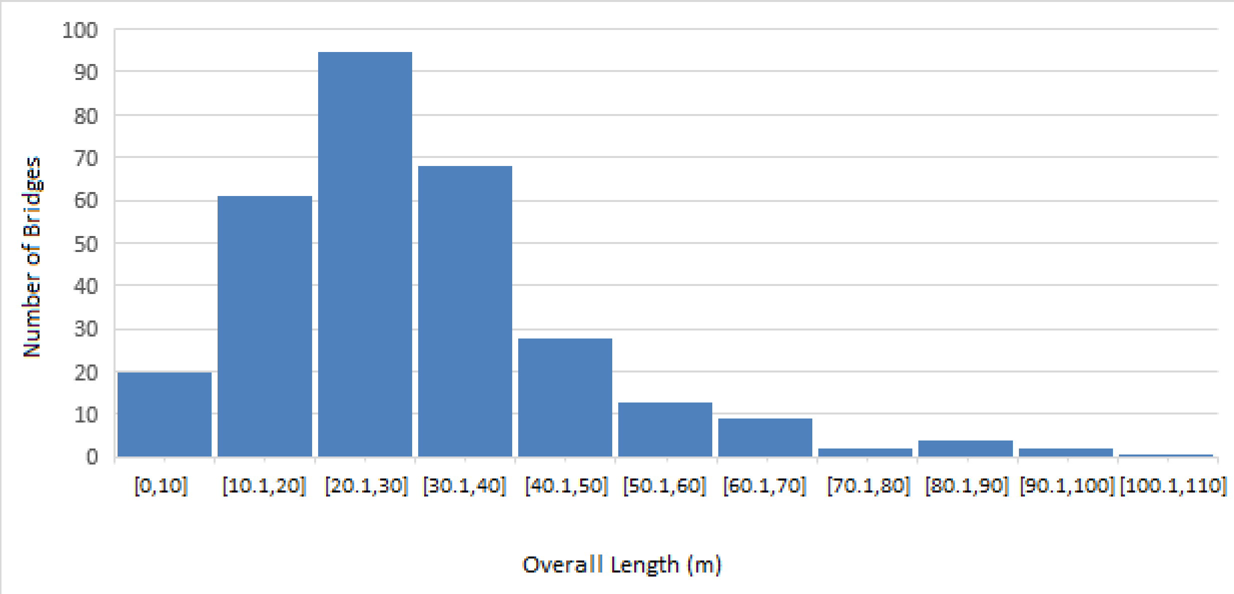
Table 2.1: Total timber bridge stock by average span length and number of spans

		Average span lengths			Total bridges
		0–5.0 m	5.01–10.0 m	10.01–15.0 m	
Number of spans	1	1	17	5	23
	2	1	46	4	51
	3	2	88	7	97
	4	14	58		72
	5		21	4	25
	6		14		14
	7		8	2	10
	8		3	1	4
	9		4		4
	10		1		1
	11		1		1
	16		1		1
Total bridges		18	262	23	303

Note: Colour code - 1 88

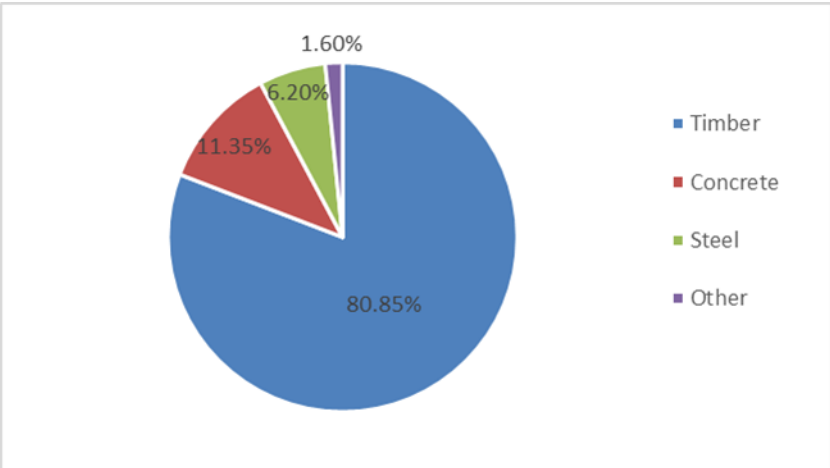
Source: TMR BIS (as per October 2017).

Figure 2.4: Overall length of TMR timber bridges



Source: TMR BIS (as per October 2017).

Figure 2.5: Substructure materials of TMR timber bridges



Source: TMR BIS (as per October 2017).

2.3 Compliance with TMR Bridge Design Criteria and Specifications

Section 2.1 discussed the constraints that may apply when conducting an in-line replacement and identified some characteristics of the ideal site. However, investigations and studies done on current market options for replacing bridges revealed possible deviations from the TMR bridge design criteria and specifications. As such, compromises may be necessary to select a replacement option, which will also consider factors such as the site condition, lead time etc. For any scenario where a departure from TMR documentation is necessary to allow a replacement option as outlined in this report, the impact of that departure must be assessed and appropriately managed/mitigated.

Commonly reported deviations in current market options which would be a departure from the *Design Criteria for Bridges and Other Structures* (DCBOS) (TMR 2018) and other relevant TMR specifications are listed below in Table 2.2.

Table 2.2: Common deviations in current market options from TMR bridge design criteria and specifications

Criteria/component	Common deviations	TMR recommendations	Reference clause
Driven piles	Reinforced concrete piles, spun piles, steel piles	Reinforced concrete piles, spun piles, Steel piles are not allowed	Clause 4.1.6 – DCBOS Clause 4.3 – DCBOS
Bored piles	Oversized pre-bored pile holes	Maximum oversize of 55 mm to a depth of 3 m	Section 6 – MRTS65
Design exposure conditions	Design for B1 exposure	Minimum B2 exposure	Clause 10.4.5 – DCBOS
Bridge barrier	Use of 'W' or 'Thrie' beams Low performance barriers	'W' or 'Thrie' beams are not allowed Minimum of regular performance barriers	Clause 4.9.1.1 – DCBOS Clause 4.9.5.1 – DCBOS
Bearing	Not provided or no provision for replacing	Required as per DCBOS	Clause 4.6.1.2 – DCBOS Clause 4.6.2 – DCBOS
Relieving slab	No provision or non-compliant detailing	Provide as per standard drawing 2255	Clause 4.11 – DCBOS Standard Drawing 2255
Narrow bridges	Narrower than minimum carriageway width	Minimum carriageway width of 4.9 m for single lane and 8.6 m for 2 lanes	Clause 3.1 – DCBOS
Expansion joints	Open joints	Open joints are not permitted	Clause 4.10.2 – DCBOS

Note:
- DCBOS – Design Criteria for Bridges and Other Structures (TMR 2018).
- MRTS- Transport and Main Roads Technical Specification (Current as of time of writing)

3 PRE-ENGINEERED SOLUTIONS

The traditional method of replacing bridges requires full bridge closure for the duration of demolition, site preparation and construction. Traffic is usually diverted through alternative roads or a temporary side track. Many timber bridges are positioned in regional roads with no suitable alternative routes. Diverting traffic through other routes may significantly increase the travel distance and time. Additionally, construction of a side track alternate route may be prohibitively expensive.

Pre-engineered bridge solutions offer the opportunity to minimise closure time at sites and, in certain circumstances, potentially remove the need for side track establishment. ARRB reviewed currently available pre-engineered solutions to evaluate their applicability to TMR's timber bridge network. The following pre-engineered solutions were reviewed:

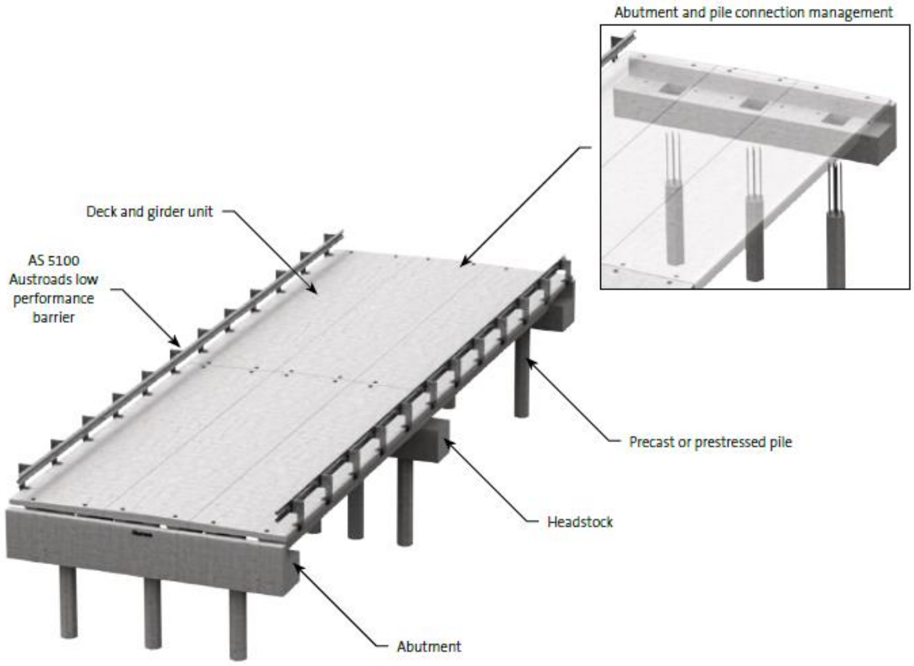
- HumeDeck Modular Bridge System (Section 3.1)
- InQuik Bridging System (Section 3.2)
- M-Lock Precast Bridge (Section 3.3)
- UniBridge (Section 3.4)
- Country Bridge Solution (Section 3.5)
- Compact 200- Mabey (Section 3.6).

Note: Refer to Section 1.4 of this report for TMR acceptance process for these bridge systems.

3.1 HumeDeck Modular Bridge System

The HumeDeck modular bridge system is a precast bridge with prestressed concrete superstructure and precast reinforced concrete substructure that has been developed by Holcim Australia. It is a complete bridge system with an assembly as shown in Figure 3.1 and structural form as shown in Table 3.1. Refer to Appendix B.1 for further details.

Figure 3.1: Complete HumeDeck system assembly



Source: Holcim Australia (2011).

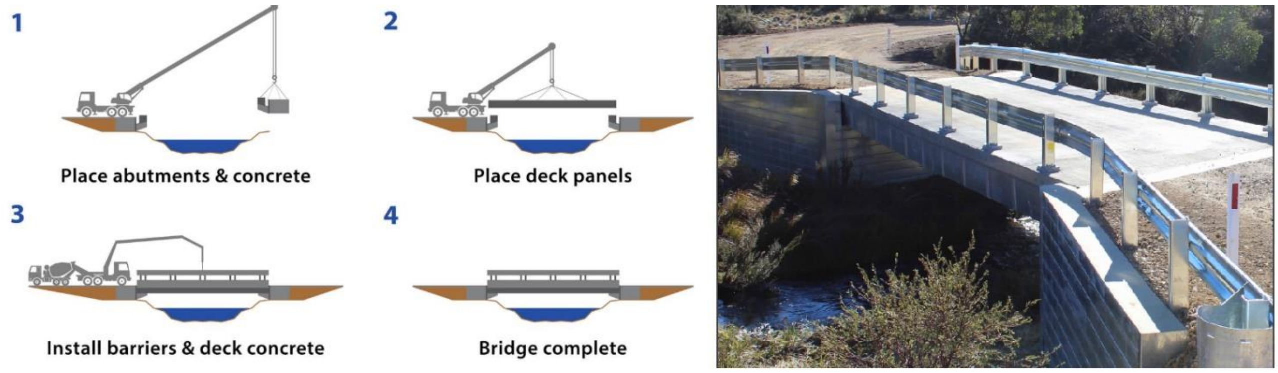
Table 3.1: Structural form of HumeDeck modular bridge

Deck	Deck panels with integral girders and grouted joints (no topping concrete)
Abutments	Custom-designed precast concrete unit
Pier	Headstock on piles
Headstock	Custom-made precast concrete unit bolted to piles/existing piers
Foundation	Precast piles (potted or driven) or use the existing foundation
Wing walls	Custom-designed precast units

3.2 InQuik Bridging System

The InQuik bridging system is a fully reinforced in situ cast concrete structure with permanent sacrificial steel formwork which allows rapid construction as shown in Figure 3.2. The bridge typically comes as a fully integrated structure (simply supported decks are also available) with the structural form shown in Table 3.2. The lightweight steel formwork with prefabricated reinforcement allows quick and easy erection of the bridge deck within a few hours. The deck concrete is usually poured the following day. Refer to Appendix B.2 for further details.

Figure 3.2: InQuik bridging system



Source: InQuik Pty Ltd (2017).

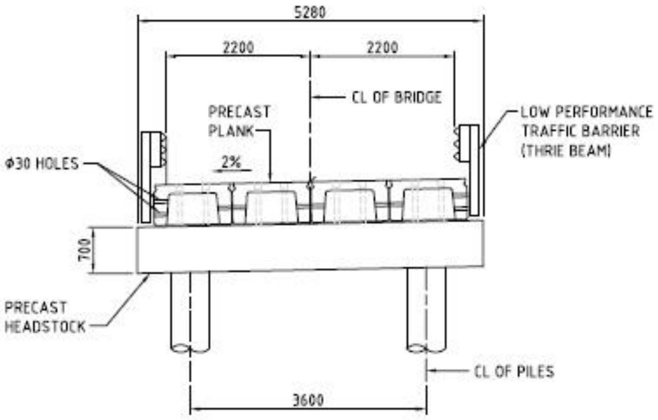
Table 3.2: Structural form of InQuik bridging system

Deck	Fully reinforced in situ cast concrete structure with permanent sacrificial steel formwork (protects concrete)
Abutments	Fully reinforced in situ cast concrete abutments with permanent sacrificial steel formwork
Pier	Fully reinforced concrete pier with the left in place sacrificial steel formwork
Headstock	Fully reinforced in situ cast concrete headstock with permanent sacrificial steel formwork
Foundation	Steel H-Piles, strip footing, poured/driven concrete piles, screw piles
Wing walls	Cantilevered wing walls off the main abutment – fully reinforced concrete structure

3.3 M-Lock Precast Bridge

M-Lock is a complete precast concrete bridge system designed by Rocla Pty Ltd, which has been used in over 250 bridges in Australia. The M-Lock bridge uses inverted U sections for the deck and reinforced concrete precast items for other bridge components in the form shown in Table 3.3. Figure 3.3 shows a typical bridge section and a completed bridge.

Figure 3.3: M-Lock precast bridge



Source: Rocla Pty Ltd (2012).

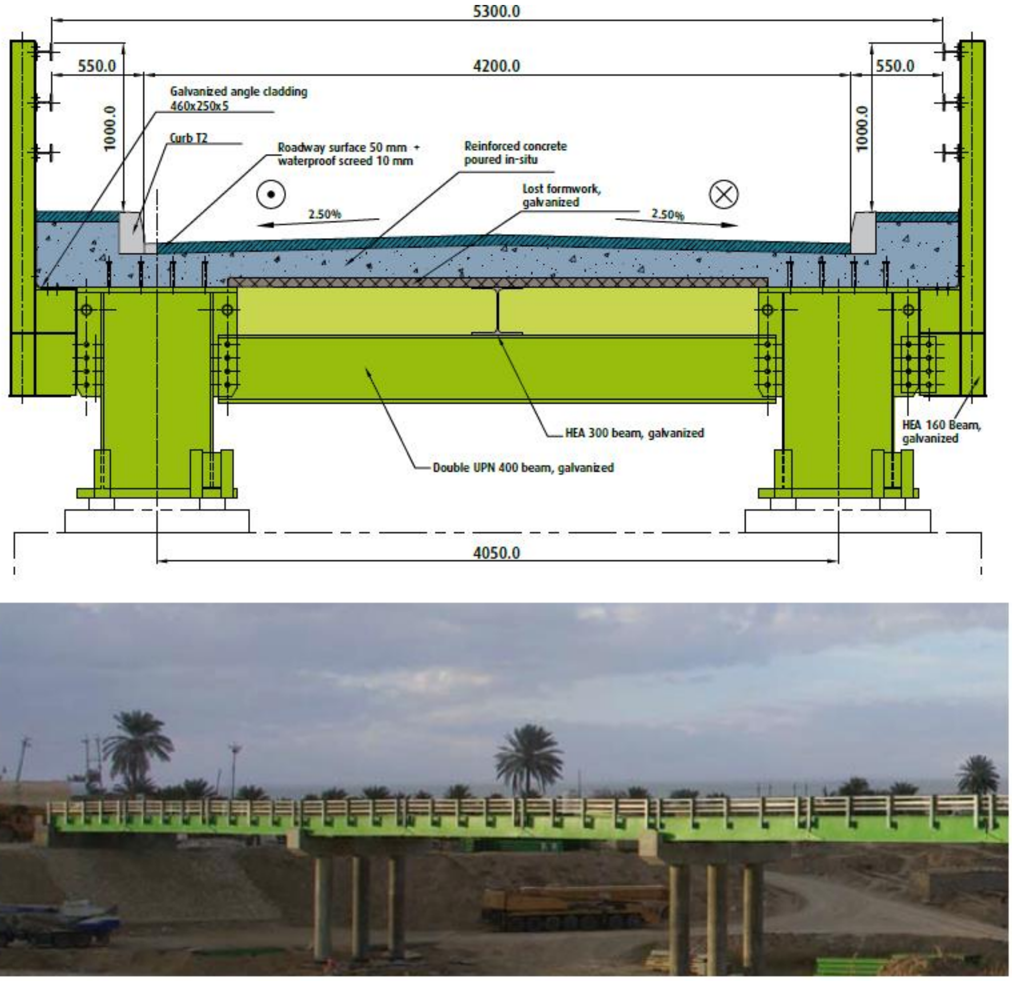
Table 3.3: Structural form of M-Lock precast bridge

Deck	Precast concrete inverted U sections fitted to headstock using bolts (no topping slab)
Abutments	Rocla MassBloc
Pier	Precast headstock on piles
Headstock	Precast concrete unit
Foundation	Socketed precast piles – hollow precast piles, square RC piles, steel UC or tubular piles
Wing walls	Rocla MassBloc

3.4 UniBridge

UniBridge is a steel pre-engineered bridge developed and supplied by UniBridge Australasia Pty Ltd. This system consists of a complete superstructure only in the form of a prefabricated steel deck or in situ poured concrete deck with steel formwork. The superstructure consists of two prefabricated steel box girders and bolted cross girders. It is compatible with all types of substructures and typical designs for substructures are available from UniBridge, if required. Figure 3.4 shows a typical cross-section of a bridge with composite deck and a completed bridge structure.

Figure 3.4: Typical bridge section with a composite deck and a completed UniBridge

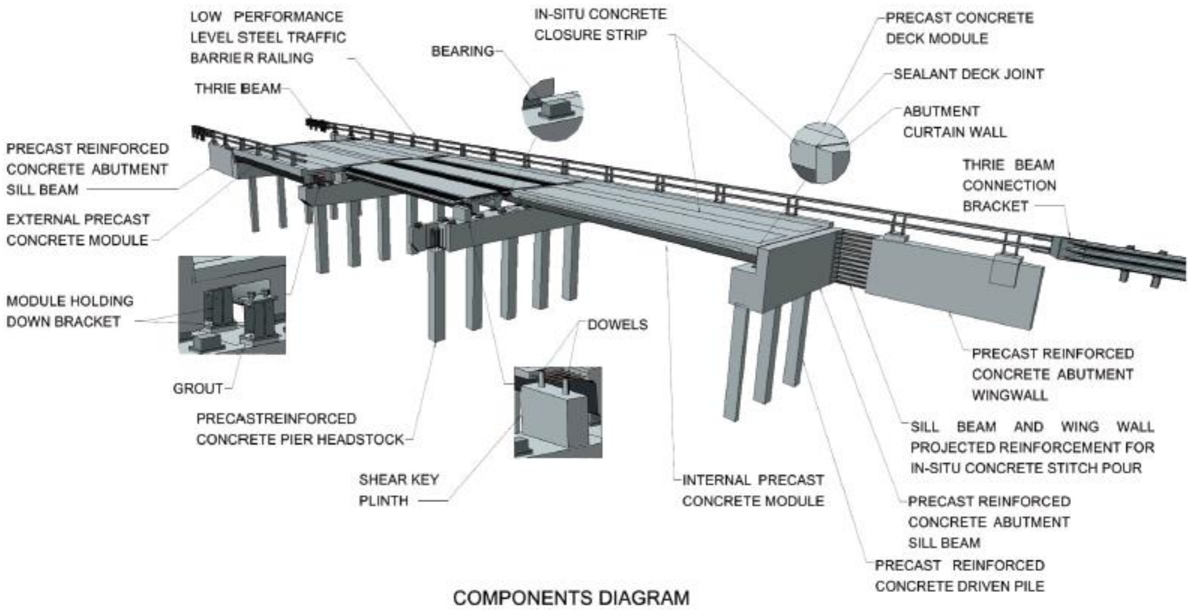


Source: UniBridge Trading (2018).

3.5 Country Bridge Solution (CBS)

Country bridge solution is a pre-engineered precast bridge system designed by Roads and Maritime Services (RMS). It consists of a precast prestressed concrete deck of inverted double T deck units with in situ closure pour and a precast concrete headstock. RMS provides the design only with a complete set of fully certified (to AS 5100-2004) drawings for the superstructure and headstock. The contractor has to design the structure below the headstock for site conditions. Typical designs are available to adopt. CBS is available for anyone to produce; however, at the time of writing, there is no current manufacturer. Figure 3.5 shows the components of CBS and Table 3.4 shows the structural form of different components of CBS.

Figure 3.5: Components of CBS



Source: RMS (2017).

Table 3.4: Structural form of CBS

Deck	Precast prestressed concrete double-T deck units and in situ closure pour
Abutments	Precast sill beam on pile/column supports
Pier	Pile/column on spread footing depending on site conditions
Headstock	Precast concrete unit on pile/column supports
Foundation	Spread footing/precast driven piles
Wing walls	Precast concrete units

3.6 Compact 200- Mabey

Compact 200 (C 200) as shown in Figure 3.6 is a truss/bailey bridge developed by Mabey Bridge Ltd for temporary and permanent applications. The bridge can be rapidly erected with minimum machinery and using unskilled labour. C 200 can span long lengths up to 60.96 m with no intermediate supports. Mabey supplies the superstructure only. However, it is compatible with any type of substructure and can be launched with incremental launching.

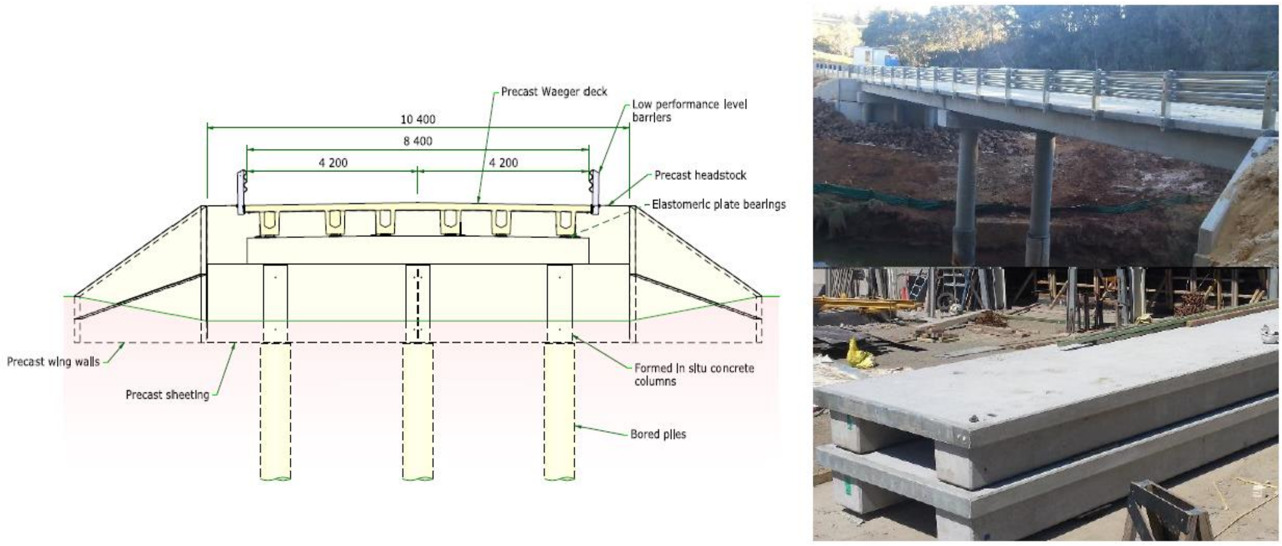
Figure 3.6: C-200 bridge superstructure

Source: Mabey Bridge Ltd (2018).

3.7 Waeger Precast Bridge

Waeger precast bridge is a complete bridge system which is designed, supplied and constructed by Waeger Constructions Pty Ltd. It is generally custom-designed to best fit each site and then precast to minimise in situ concrete work and rapid construction. Figure 3.7 shows a typical cross-section, deck units and a completed Weager bridge. Table 3.5 gives the structural form of bridge components.

Figure 3.7: Waeger precast bridges



Source: Documents supplied by Waeger Construction Pty Ltd.

Table 3.5: Structural form of Waeger bridge

Deck	Precast deck units
Abutments	Precast abutments
Pier	Cast in situ columns
Headstock	Precast unit
Foundation	Bored cast in piles, driven concrete piles or steel piles
Wing walls	Precast panels with bolted connections

3.8 Other Venders

Other than the pre-engineered bridges listed above, the vendors listed below also offer pre-engineered/rapid-built bridges. These vendors were contacted and offered an opportunity to provide further information but did not respond. Without further information, the compliance of these products with TMR bridge design criteria and specifications is unknown.

The following is a list of these vendors and their pre-engineered products:

- Hollow Core Concrete Pty Ltd – Hollow core concrete plank bridge
- Wagners – Composite fibre bridges
- Mabey Australia –Has a few pre-engineered bridge products. Except for C 200 listed in Section 3.6, other products are currently not in stock in Australia but can be ordered from UK. Mabey Australia does not wish to release product information about these bridges.
- Contech Engineered Solutions – Has few patented rapid-built precast concrete bridging systems. Their products are currently not available in Australia, but they are willing to introduce them. However, they are not currently designed to Australian standards.

4 OTHER SOLUTIONS

4.1 General Considerations

Bridge asset replacement/upgrade options generally include:

1. demolishing the bridge with no replacement (usually associated with reduced level of service requirements)
2. rehabilitating the existing bridge
3. in-line replacement including rapid construction
4. developing a conventional bespoke bridge replacement solution.

The 'do nothing' option, which is normally a consideration from an asset management perspective, is not feasible unless it is associated with a very short time limit. In general, the traditional bespoke solution (4) is the best option for replacing any structure. However, this process is normally associated with long construction times, high cost, limited availability of local materials and labour, and possibly road realignment or construction of a side track.

4.2 Rapid Construction Methods

This section summarises a range of methods to facilitate rapid construction including:

1. pre-engineered bridges
2. utilisation of the existing foundations
3. utilisation of the same superstructure for temporary and permanent bridge
4. realigning the road
5. pre-assembled bridges.

Generally, these concepts are not mutually exclusive.

4.2.1 Pre-engineered Bridges

Currently available pre-engineered bridge systems in Australia have been discussed in Section 3. The use of pre-engineered bridge systems has some advantages over bespoke solutions, typically constructability and speed of construction, as discussed in Section 2.1. Due to the nature of the pre-engineered bridges, deviation from standard solutions may result (see Section 2.3).

4.2.2 Utilisation of the Existing Foundation

As shown in Figure 2.5, 11.35% of current timber bridges have concrete substructures. Several modular deck replacement options which are mountable on any type of substructure are available to replace the superstructure. This can significantly reduce the construction time and cost but may require compromise to the design requirements depending on the substructure condition and capacity.

4.2.3 Utilisation of the Same Superstructure for Temporary and Permanent Bridge

Steel superstructures discussed in Section 3 such as Mabey bridge (C200) and UniBridge can be utilized as the temporary bridge for the side track during the construction of a replacement bridge. Once the substructure is completed, the assembled superstructure can be lifted and repositioned on the permanent structure in a matter of hours. Furthermore, these steel superstructures can span over 50 m in some instances, which may be beneficial at certain sites.

4.2.4 Realigning the Road

For some bridges, minor realignment of the road profile may be possible where the available road reserve is accommodating. In such cases, it has been a common practice to build the replacing permanent structure on the new alignment and divert the traffic at the end of construction. This can minimise the disturbance to traffic during the construction time and reduce the cost of a temporary side track while allowing the ability to deliver a better final product. Figure 4.1 shows a similar construction with CBS to replace an old timber bridge in NSW.

Figure 4.1: Bridge replacement on a new alignment

Source: RMS (2016).

4.2.5 Pre-assembled Superstructure Installation

The use of pre-assembled or prefabricated bespoke superstructures is another proven rapid construction/replacement method which uses a fully prefabricated/pre-assembled steel or composite bridge deck. This method reduces the amount of onsite work. However, large cranes may be required for lifting and placing the assembled structure in to position.

Figure 4.2: Pre-assembled superstructures

Source: BG&E (2018) (left) and Fedaral Highway Administration (2017) (right).

5 DECISION SUPPORTING TOOL

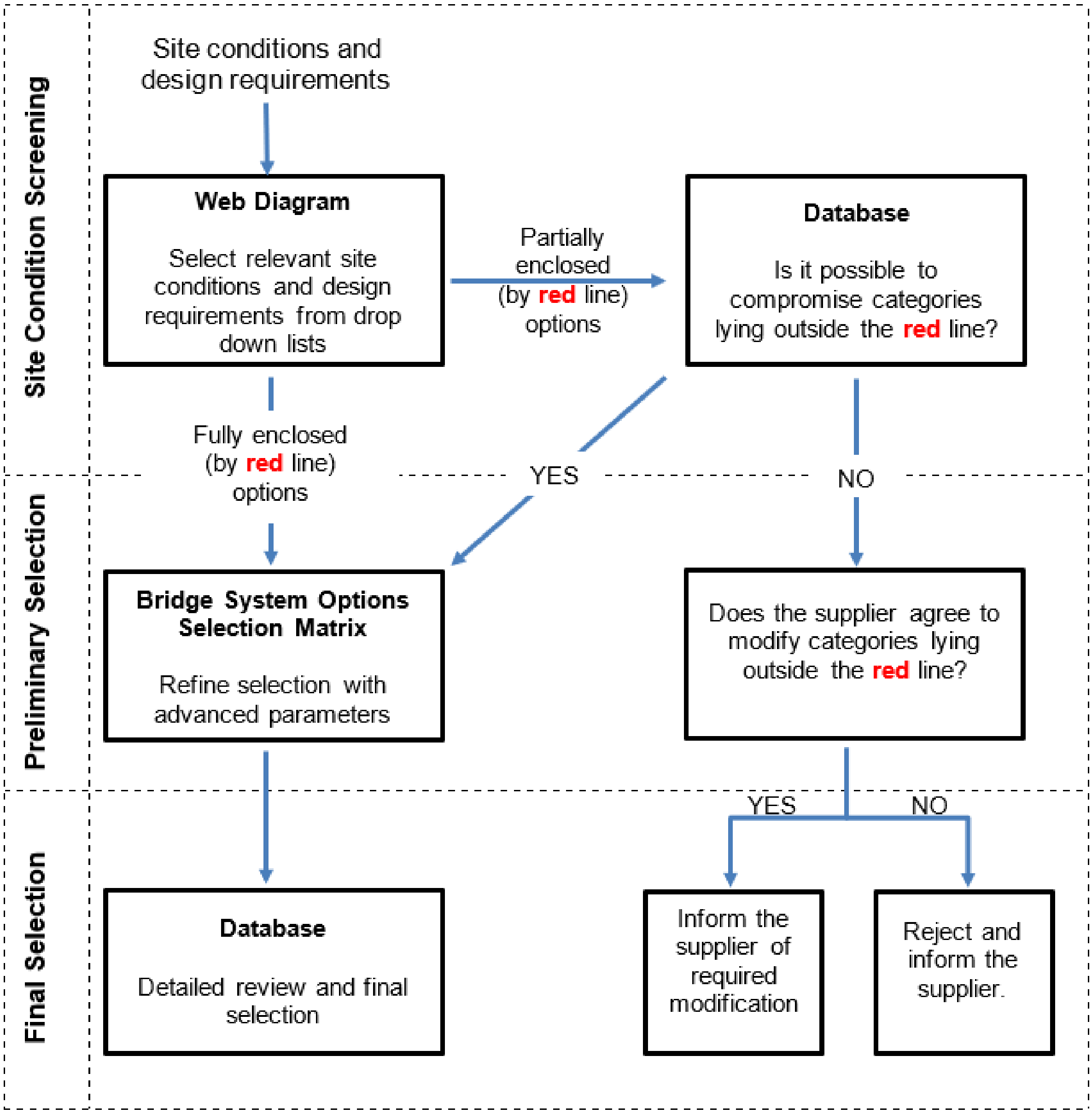
5.1 Selection Process

Outcomes of this project will facilitate TMR in the selection of available options to replace (in-line) timber bridges. The selection process proposed in this report consists of three steps as outlined below:

1. Site conditions screening – Section 5.2
2. Preliminary selection – Section 5.3
3. Final selection – Section 5.4.

The selection process should follow the sequence shown in Figure 5.1 with further explanation included in Section 5.2 – Section 5.4.

Figure 5.1: Bridge replacement option selection process – Flow chart



5.2 Site Conditions Screening

In order to simplify the selection process, an initial graphical screening has been developed in the form of a web diagram. The purpose of this step is to screen the replacement options based on a few main parameters as shown in Figure 5.2.

Figure 5.2: Site condition screening

Site Condition Screening

Category	Parameter	Site condition/ design requirement (Please select the best from the list/ Enter)
Site Accessibility	Maximum allowable GVM (tonne)	
	Long vehicle access	- Choose from the list -
	Accessibility for pre-works	- Choose from the list -
Bridge Componentry	Superstructure	- Choose from the list -
	Substructure	- Choose from the list -
	Foundation	- Choose from the list -
Geometry	Span length (m)	
	Number of traffic lanes	- Choose from the list -
	Foot path	- Choose from the list -
	Cycle lanes	- Choose from the list -
Design	Traffic Load	- Choose from the list -
	Barrier performance level (AS 5100)	- Choose from the list -
	Exposure condition (AS 3600)	- Choose from the list -
Construction	Available Lead time (**weeks**)	
	Construction duration (Deck Only) (**Days**)	- Choose from the list -
Resource availability	Concrete	- Choose from the list -
	Crane	- Choose from the list -
	Special machinery	- Choose from the list -

Column three of the table allows the selection of the best options or the ability to enter a value for the parameters listed in the second column to suit site requirements. An example of the site condition selection is shown in Figure 5.3. This will then generate a web diagram as shown in Figure 5.4 and a heatmap as shown in Figure 5.5.

Plots enclosed by the red line in the web diagram show the possible options for the replacement bridge, with the best option closest to the centre. Any point lying outside the red line indicates deviation from the site requirement. A deviating parameter can be identified from the red cells in the heat map. Some of these deviations may have only a minor effect, and it may be possible to modify the product easily to suit site conditions or adopt it with minor compromises. Hence, it is recommended to refer to the relevant section of the bridge system database for detailed information of such deviations.

Figure 5.3: Site condition screening – example

Site Condition Screening

Category	Parameter	Site condition/ design requirement (Please select the best from the list/ Enter)
Site Accessibility	Maximum allowable GVM (tonne)	60
	Long vehicle access	Standard trucks (12.5 m)
	Accessibility for pre-works	Moderately Accessible
Bridge Componentry	Superstructure	New
	Substructure	Can use exsisting
	Foundation	Can use exsisting
Geometry	Span length (m)	10
	Number of traffic lanes	Two
	Foot path	None
	Cycle lanes	None
Design	Traffic Load	SM1600
	Barrier performance level (AS 5100)	Regular
	Exposure condition (AS 3600)	B2
Construction	Available Lead time (**weeks**)	8
	Construction duration (Deck Only) (**Days**)	Urgent (< 3 days)
Resource availability	Concrete	Limited
	Crane	50 t
	Special machinery	Available

Figure 5.4: Web diagram

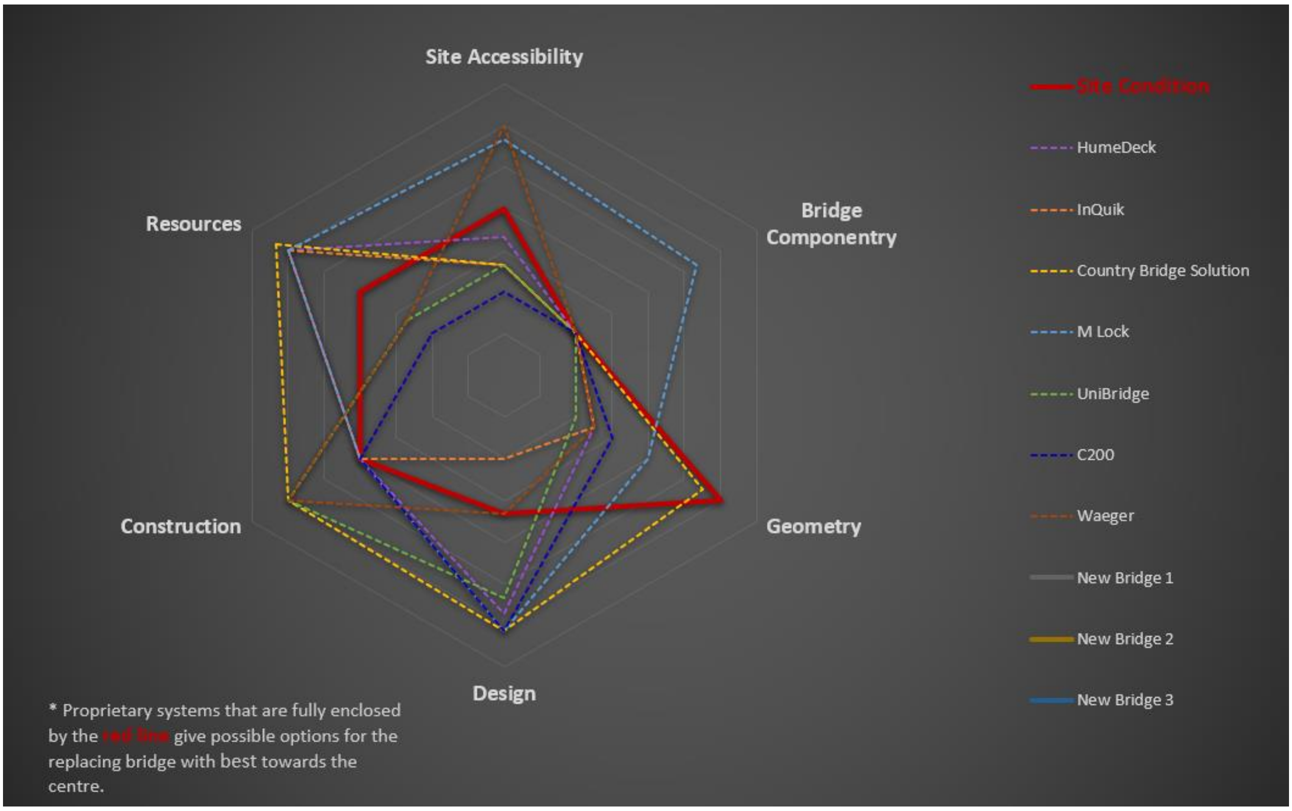


Figure 5.5: Heat map

Category	Parameter	Site Condition	HumeDeck	InQuik	CBS	M Lock	UniBridge	C200	Waeger
Site Accessibility	Heavy Vehicle access GVM (tonnes)	60	50	25	45	40	26	20	50
	Long vehicle access	Standard trucks (12.5 m)	Standard trucks (12.5m)	Standard trucks (12.5m)	Standard trucks (12.5m)	Semitrailer (19m)	Standard trucks (12.5m)	Standard trucks (12.5m)	Semitrailer (19m)
	Accessibility for pre-works	Moderately Accessible	Not required	Not required	Not required	Not required	Not required	Not required	Not required
Bridge Componentry	Superstructure	New	New	New	New	New	New	New	New
	Substructure	Can use exsisting	Can use exsisting	Can use exsisting	Can use exsisting	New	Can use exsisting	Can use exsisting	Can use exsisting
	Foundation	Can use exsisting	Can use exsisting	Can use exsisting	Can use exsisting	New	Can use exsisting	Can use exsisting	Can use exsisting
Geometry	Max Span length (m)	10	12	18.5	12	15	44.8	61	15
	Number of traffic lanes	Two	More than 3	More than 3	Two	Three	More than 3	Two	More than 3
	Foot path	None	Dedicated	Dedicated	None	Shared with cycles	Dedicated	Dedicated	Dedicated
	Cycle lanes	None	Dedicated	Dedicated	None	Shared with pedestrian	Dedicated	Dedicated	Dedicated
Design	Traffic Load	SM1600	SM1600	SM1600	SM1600	SM1600	SM1600	SM1600	SM1600
	Barrier performance level	Regular	Low	Medium	Low	Low	Low	Low	Regular
	Exposure condition	B2	B2	Marine	B1	B1	Marine	B1	B2
Construction	Available Lead time (**weeks**)	8	8	6	10	8	12	6	16
	Construction duration (Deck Only) (**Days**)	Urgent (< 3 days)	1	2	2	2	2	2	3
Resource availability	Concrete	Limited	Low	High	Moderate	Low	Low	Low	High
	Crane	50 t	150	50	125	100	50	0	50
	Skilled Labour	Available	Not required	Not required	Not required	Required	Not required	Not required	Not required

Colour Code	EXCEED	ACCEPTABLE	OUTSIDE CONDITIONS

5.3 Preliminary Selection

A matrix has been developed which lists a number of advanced parameters against bridge systems to further refine the outcomes from the first step. Parameters in the options selection matrix include:

- vendor
- componentry
- typical lengths
- width
- number of spans
- design loading
- design standard
- material
- duration of construction
- direct cost
- departures from TMR standard
- limitations.

The selection matrix is shown in Appendix A.

5.4 Final Selection

The final selection of the replacement bridge includes a detailed review of bridge system data which will help to better understand the design criteria and performance of the product. Bridge systems data sheets for bridges reviewed in this project are listed in the Appendix B.

5.5 Recommendations

The above proposed three-step selection process facilitates TMR in timber bridge replacement option selection with significant time saving. The data in decision-supporting tools are current at the time of writing. However, this tool should be updated to include improvements and developments of current products and should include any new products as they become available. Furthermore, parameters for screening have been selected to represent general site conditions. They should be updated and screened against the current network at the time of evaluation.

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APPENDIX A OPTION SELECTION MATRIX

Table A 1: Option selection matrix-part1

Product	Vendor	Completeness	Lengths 0–10 m	Lengths 10–20 m	Lengths over 20 m	Width (m)	Number of lanes	Number of spans	Design life (years)	Design traffic load	Design standard	Superstructure material	Substructure material	Duration of construction (deck only)	In-line constructability	Direct cost (deck only) (per metre[2])
HumeDeck Modular Bridge	Design and supply only – by Holcim (Australia) Pty Ltd	Foundation Substructure Superstructure Barriers	6–10	10–12	–	Any	Multilane	Multi-spans	100	SM 1600	AS 5100 (2004)	Precast reinforced concrete	Precast reinforced or prestressed concrete	1 day (decks with but joints)	Yes	Not available
InQuik Bridging System	Design and supply only – by InQuik Bridging System	Substructure (excluding foundation) Superstructure Barriers	6.1 9.1	12.1 13.7 16.1 18.5	–	4.8 – 14.4 Custom widths	Multilane	Multi-spans	100	SM 1600	AS 5100 (2017), Austroads (1992)	Reinforced concrete bridge with sacrificial galvanised steel, Magnelis or stainless steel formwork	Not included but compatible with any type of foundation	2 days + time for in situ deck to gain strength	Yes	$1100–1500
Country Bridge Solution (CBS)	Design only – Roads and Maritime Services NSW	Design only	8 10	12	–	4.2 6.5	1 or 2	Multi-spans	100	SM 1600	AS 5100 (2004)	Prestressed concrete	Reinforced concrete	2 days + time for in situ stitch joints to gain strength	Yes	$1750 (as in 2016)
M-Lock	Design and supply only– by Rocla Pty Ltd	Foundation Substructure Superstructure Barriers	7.0 9.0 10.0	12 15	–	4.8 6.0 7.2 8.4 9.6 10.8	Up to 3 lanes	Multi-spans	100	SM 1600	AS 5100 (2004)	Precast reinforced concrete	Prestressed precast concrete piles	2 days	Yes	$2500–3500
UniBridge	Design and supply of superstructure only – by UniBridge Australasia Pty Ltd	Superstructure only		11.4 17.4	22.8 28.8 34.2 40.2	Any	Multilane	Multi-spans	100	SM 1600 and HLP 320	AS 5100 (2004)	Steel girders + precast/in situ concrete deck	Not included but compatible with any type of foundation	2 days	Yes	$1200–1500
C-200-Mabey	Fabrication and supply is by Mabey Australia (Fabricated in UK)	Superstructure only		15.24 18.2	21.3 - 60.96 in 3.048 increments	3.15 4.20 7.35	1 or 2	Can span full length in single span or with intermediate supports.	100	SM 1600	AS 5100 (2004)	Steel	Not included but compatible with any type of foundation	2 days	Yes	$1800–2600
Waeger	Design, supply and construction by Waeger Constructions Pty Ltd	Superstructure Substructure Foundation Barrier	6–10	10–15	–	Any	Multilane	Multi-spans	100	SM 1600 and HLP 321or HLP 400	AS 5100 (2017)	Precast prestressed concrete	Precast concrete/in situ cast columns	3 days	Yes	$1250–2000

Table A 2: Option selection matrix-part 2

Product	Departures from TMR standards	Limitations	Comments
HumeDeck Modular Bridge	1. Open expansion joints at deck 2. No structural connection/load transfer between deck units when butt joints are used 3. Use low performance W beams for barriers 4. Barrier posts are mounted on the carriageway 5. Relieving slab connection does not follow Standard drawing 2255. No allowance for rotation 6. No provision for bearing replacement	1. In situ stich joints require on-site formwork and concreting 2. Unable to replace bearing pads. Hold down bolts are passing through elastomeric bearing pads 3. Butt joints leave a gap of 10 mm between slab units. No structural connection or lateral load distribution between panels	Allowance for expansion of deck units are made at hold down bolts. Joints at deck level are open joints.
InQuik Bridging System	1. Typically, a fully integral structure; but can be provided with simply supported deck. If integrated, special approval may be required (Section 1.2.4 and 4.7.1 (c)-*Design Criteria for Bridges and Other Structures*, TMR 2018) 2. No bearing replacement schedule (not required for integral bridges)	1. Foundation design is not included 2. Requires large volume of in situ concrete 3. For bridges longer than 12 m, deck beams need to be cast first and given time to gain sufficient strength before concreting the rest. This will increase the construction time	
Country Bridge Solution (CBS)	1. Low performance barrier 2. Designed for B1 exposure conditions only 3. Uses precast reinforced concrete driven piles 4. No approach slab 5. Narrow carriageway 6. Not designed for wearing surface except 10 mm sprayed bituminous seal (Not complying with 4.8.3 of TMR 2018)	1. Design only 2. Substructure has to be designed by contractor for site condition 3. Not suitable to use within 1 km of the shoreline of salt water 4. Maximum 2 traffic lanes and carriageway width is less than minimum recommended 5. Maximum deck height of 10 m above ground/river bed level 6. Equal spans only 7. No dedicated pedestrian or cycle paths 8. Maximum AADT of 1000	No current supplier. Design is available for anyone to use.
M-Lock	1. Typically uses spun piles which are not allowed in QLD 2. Deck units are bolted to headstock at both ends. No expansion joint or provision for rotation 3. Designed for B1 (headstocks/decks) exposure conditions 4. Uses oversized pile holes which are backfilled with sand/cement mix (Section 6 of MRTS65) 5. Low performance Thrie beam bridge barriers bolted to side of the deck 6. Uses steel, reinforced concrete piles which are restricted by TMR 7. Typically, no kerbs, no scuppers. (Available on request) 8. Uses prestressing bars to transversely prestress high traffic bridges which are left exposed (External post tension) 9. No provision for relieving slabs	1. Longer construction time for substructure (typically 15 days per span) 2. Precast bored piles require considerable amount of site work (driving steel casing, drilling, backfilling etc) 3. Unable to replace bearing pads. Hold down bolts are going through the elastomeric bearing strips	1. Bolts can be used to transversely connect deck units. However, performance of bolts for transverse load distribution may be limited 2. Bridges design for high traffic volumes use external transverse prestressing. Precast concrete barriers are sharing the same prestressing bars used to stress the deck. Damage to bridge barriers at an accident may release the tension in stressing bars
UniBridge	1. Superstructure only 2. Not designed for scour, submergence 3. Not designed for earthquake 4. No kerbs on the deck 5. Low performance barrier	Substructure is not included in the design	Earthquake design is required for bridges spanning over 20 m
C-200- Mabey	1. Narrow carriageway 2. Typically, no barriers. But can be supplied. This may further reduce the carriageway width	1. Supply superstructure only 2. Maximum 2 traffic lanes	1. Trusses are the main structural elements which are positioned at the same level as the road level but not designed for vehicle impact 2. Separate barriers can be provided but may further reduce the carriageway width
Waeger	Typically, none	1. Maximum 15 m span 2. 15 m decks are 26 t and over 3. Typically, bespoke with some cast in situ elements such as pier columns	

APPENDIX B DATA SHEETS

B.1 HumeDeck

Table B 1: HumeDeck bridge system data

	Parameter		Structure design criteria	Comments
System	Developed by	Holcim (Australia) Pty Ltd		
	Supplied by	Holcim (Australia) Pty Ltd		
	Construction			
	Key features		1. Can be installed on existing or new substructure 2. Minimal longitudinal joints leading to faster installation 3. Deck units consist of cast into galvanized channel at ends to prevent spalling 4. Option of butt joint or in situ joints for longitudinal joints	
	Advantages		1. Fully precast option 2. Fast installation 3. Can be attached to existing headstock/abutments 4. Reduced site work	
	Limitations/weaknesses		1. On-site formwork and concreting are required if in situ joints are used 2. Hold down bolts are passing through the elastomeric bearing pads 3. If butt joint for slab units is selected, a gap of 10 mm between slab units will remain. No lateral load distribution between panels 4. Low performance barrier	

	Parameter		Structure design criteria	Comments
General	Pre-engineered and standardized?		YES	
	Completeness of design (Y/N)	Superstructure	YES	
		Substructure	YES	
		Barriers	YES – Can be custom designed to meet project specific requirements	
		Drain	YES – Allowance can be made for drainage requirements	
		Kerbs	YES	
		Bearing	YES – Can be custom designed to meet project specific requirements	
		Expansion joints	YES	
		Provision for services	Can be custom designed to meet project specific requirements	
	Standardised/pre-engineered components		Deck units, headstock, piles, abutments	
	In situ cast elements		In situ horizontal joints (stitch joint), connections of pile and headstock/abutment	
	Previously used/tested in Australia?		YES – MacArthur Gardens bridge in South Sydney, Koombooloomba Dam bridge, QLD etc.	
	Availability of documentation		YES – Humes provides project-specific shop drawings for full approval and installation manual	
	Room for future expansions		YES – A completely modular system can be lengthened. Can also be widened; however, would require new abutments and headstocks	
Structural form	Deck		6 m to 12 m long and up to 2.7 m wide deck panels	
	Abutments		Reinforced concrete precast abutment on piles with in situ joint	
	Pier		Precast reinforced concrete headstock on 550 mm x 550 mm rectangular precast or 450 mm to 550 mm octagonal prestressed piles	
	Headstock		Custom-made precast reinforced concrete units in situ jointed to piles or bolted to existing piers	
	Foundation		Precast rectangular reinforced concrete or prestressed octagonal piles (potted or driven) or use existing foundation	
	Wing walls		Precast reinforced concrete units. Can be custom-designed to meet project-specific requirements	
	Relieving slab		Precast relieving slab connected to bridge with in situ stitch	Connection does not follow Standard drawing 2255. No allowance for rotation

	Parameter		Structure design criteria	Comments
Primary materials	Superstructure		Precast reinforced concrete	
	Substructure		Precast reinforced concrete or prestressed concrete piles with precast reinforced concrete headstock/abutment	
	Bearing		Typically, elastomeric sacrificial bearing pads	Hold down bolts are passing through the bearing pad hence may not to be replaced
	Barriers		Steel W beams (on concrete or kerb if required)	
	Expansion joints		Elastomeric sealant around hold down bolts. Open at the deck level	
Design	Design standards		AS 5100 (2004)	
	Design traffic load		SM1600	
	Other design forces	Earthquake	NO	
		Submergence	YES	
		Scour	YES – Flow velocity of 4 m/s	
		Barrier impact	YES – Low performance barrier	
		Other	Super imposed dead load includes – 230 mm asphalt layer over the entire bridge and 100 mm concrete topping to pedestrian walkways	
	Design life		100 years	
	Design AADT		Not specified	
	Design speed		Not specified	
	Other design assumptions		Not specified	
	Elements not covered in standard design		Geotechnical	
Compliance	Compliance to *Design Criteria for Bridges and Other Structures*		Typical deviations are listed below	
	Compliance to TMR specifications		Typical deviations are listed below	
	Departures from TMR specifications		1. Relieving slab connection does not follow Standard drawing 2255. No allowance for rotation	Clause 4.11 – DCBOS Standard drawing 2255
			2. No provision for bearing replacement	Clause 4.6.2 – DCBOS
			3. Use low performance barriers with W beams	Clause 4.9.5.1, Clause 4.9.5.1 – DCBOS
			4. Bridge rails are mounted on the carriageway	Clause 4.9.4 – DCBOS
			5. Open expansion joints	Clause 4.10.2 – DCBOS
Geometry	Typical widths		Any width with panel widths up to 2.7 m	
	Typical span length		6 m – 12 m	
	Number of spans		Multiple	
	Number of traffic lanes		Multilane	
	Pedestrian/cycle lanes		As required – Can be custom designed to meet project-specific requirements	

	Parameter		Structure design criteria	Comments
Site considerations	Adaptability for various site conditions	Skew	YES. Up to 20º	
		Grade	YES	
		Horizontal curve	NO	
		Vertical curve	NO	
	Required site investigations		Geotechnical	
	Resistance for corrosive environments (design exposure condition)		B2 Exposure	
Constructability	In-line construction		YES	
	Shut down option (full shut/lane shut)		Usually shut down existing bridge	
	Deployment lead time		8 weeks on average	
	Availability of prefabricated/precast items		Australia-wide	
	Special machinery		Pile driving machines	
	Special skills/techniques required at site		None	
	Transportability of precast components		Standard vehicles	
	Weight of heaviest part		29.03 t (for 12 m span)	
	Size of largest part		12 m x 2.7 m x 0.9 m	
	Time to complete deck		24 hours for deck	Installing deck with butt joints only. Time for in situ joints has to be considered for other type
Cost	Approximate construction cost per sqrm		Information not available	
	Approximate annual maintenance cost		Not specified	
Maintenance	Recommended inspection frequency		Annual	
	Recommended routine maintenance		As required	
	Durability		100 years design life/B2 exposure	
Considerations			1. If butt joint for slab units is selected, a gap of 10 mm between slab units will remain 2. No lateral load distribution between panels 3. Typically, bridge rails are mounted on the carriageway	
References	Humes modular Bridge system website		https://www.holcim.com.au/humes/precast-concrete-solutions/bridge-and-platform/modular-bridge-system	
	Hume deck system -Brochure		https://www.holcim.com.au/sites/australia/files/atoms/files/hu-humedeck-modular-bridge-system-iss1.pdf	

B.2 InQuik

Table B 2: InQuik bridge system data

	Parameter		Structure design criteria	Comments
System	Developed by	InQuik and SMEC Australia		Fabricated by Australian Reinforcing Company (ARC)
	Supplied by	InQuik Bridging Systems		
	Construction			
	Key features		1. A semi-modular system integrated with prefabricated sacrificial steel formwork and reinforcing components 2. InQuik abutments, wing walls, headstocks and blade piers are constructed using a similar semi-modular method as the deck 3. Greater adoptability to site conditions with several options for major components 4. Certified by SMEC Australia Pty Ltd (SMEC) to the Australian Standards, AS 5100 (2017) Bridge Design requirements 5. Option of integral or simply supported deck	
	Advantages		1. No temporary formwork/supports needed 2. Can integrate with all major foundation types 3. Lightweight prefabricated items 4. No special machinery and skill required 5. Permanent steel formwork provides additional protection and durability to concrete	No exposed concrete surfaces. Visual inspection may not detect concrete defects
	Limitations/weaknesses		1. Prior approval may require for fully integral structure (Section 1.2.4 – *Design Criteria for Bridges and Other Structures*, TMR 2017) 2. Foundation design is not included 3. Requires large volume of in situ concrete 4. Deck needs concreting in 2 states for over 12 m long deck panels. (Beams to be cast first and wait for gaining strength before concreting rest) 5. Max abutment height – 2.4 m in a single pour	

	Parameter		Structure design criteria	Comments
General	Pre-engineered and standardized? (Y/N)		YES	
		Superstructure	YES	
		Substructure	Abutments, wing walls, blade piers and headstocks are provided by InQuik. Foundation to be designed by the contractor	All foundation types can be used with the InQuik system
	Completeness of design (Y/N)	Deck	YES	Standard deck panel width is 2.4 m wide, lay panels side by side for wider deck. Can also increase deck width using extension spacers between deck panels, up to 550 mm each. Also offer 3.2 m-wide panels for narrow bridges (e.g. for farms, service roads, etc).
		Barriers	YES	Low (side/top-mounted), regular and medium performance
		Drain	YES	Deck can have cross-fall, and if necessary castellated kerbs/scuppers can be provided
		Kerbs	YES	Castellated or continuous with drainage scuppers
		Bearing	YES – if required	The standard InQuik single span bridge is fully integral, removing bearings and tiedowns
		Expansion joints	YES – if required	
		Provision for services	YES – if required	Provision for 3 x 165 mm service holes can be incorporated into each panel
	Standardised/pre-engineered components		Deck panels, abutments, headstocks, wing walls, blade piers or fully integral bridge structure	
	In situ cast elements		All components are FULLY cast in situ	This means there is one mass of concrete on the deck, and thus there are no deck joints, grout, tie bolts, and no surface treatment is required
	Previously used/tested in Australia?		YES – previous projects in NSW: Snowy Mountains (Murrumbidgee River, 12 m single lane with 15 degree skew), Boxers Creek (12 m single lane), Bellingen Council (Reids Creek, 12 m double lane), Hills Shire Council (Caddies Creek, 12 m single lane with service holes), Chivers Bridge (13.7 m single lane, fully integral), James Bridge (9 m single lane, fully integral), Byron Council (Durrumbal Causeway, 16.1 m single lane, fully integral), Snowy Monaro Council (Merima Rd, 12 m single lane, fully integral)	

	Parameter		Structure design criteria	Comments
	Availability of documentation		Case studies, product catalogue, technical documentation, certifications, install guides, etc. all available	
	Room for future expansions		YES – If required.	
Structural form	Deck		Fully reinforced in situ cast concrete structure with permanent sacrificial steel formwork (protects concrete)	
	Abutments		Fully reinforced in situ cast concrete abutments with permanent sacrificial steel formwork (protects concrete)	
	Pier		Fully reinforced concrete pier with left in place sacrificial steel formwork	
	Headstock		Fully reinforced in situ cast concrete headstock with permanent sacrificial steel formwork (protects concrete)	
	Foundation		Compatible with any type of foundation	To be designed by contractor
	Wing walls		Cantilevered wing walls off main abutment – fully reinforced concrete structure	
	Bearing		Elastomeric strip bearing if designed for it – Usually fully integral structure requiring no bearings	
Primary material	Superstructure		Reinforced concrete bridge with sacrificial galvanised steel, Magnelis or stainless steel permanent formwork	Magnelis- is an exceptional metallic coating with very high corrosion resistance
	Substructure		Abutments, headstocks and blade piers are reinforced concrete with sacrificial Magnelis/stainless steel permanent formwork with any type of foundation	
	Bearing		Elastomeric strip bearing if designed for it (fully integral structure requires no bearings)	
	Barriers		Steel or concrete	
	Expansion joints		Optional	
Design	Design standards		AS 5100 (2017), Austroads (1992)	
	Design traffic load		SM1600, T44/62 t B-double	
	Other design forces	Earthquake	No	
		Submergence	No	Deck panels can include anti-buoyancy air vents
		Scour	Flow velocity 2 m/s	
		Barrier impact	Low, regular and medium	
		Other	–	
	Design life		100 Years	
	Design AADT		No limitation	
	Design speed		As required	
	Other design assumptions		Not specified	
	Elements not covered in standard design		Foundation	

	Parameter		Structure design criteria	Comments
Compliance	Compliance to *Design Criteria for Bridges and Other Structures*		Typical deviations are listed below	
	Compliance to TMR specifications		Typical deviations are listed below	
	Departures from TMR specifications		1. Normally a fully integral structure. Special approval may be required (Section 1.2.4 – *Design Criteria for Bridges and Other Structures*, TMR 2017)	Clause 1.2.4 – DCBOS
			2. Bearing replacement schedule to be determined (not required for integral bridges)	Clause 4.6.2 – DCBOS
Geometry	Typical widths		4.8 m – 14.4 m or custom widths	
	Typical span length		6.1 m to 18.5 m (6.1, 9.1, 12.1, 13.7, 16.1, 18.5)	
	Number of span		Multi-spans	
	Number of traffic lanes		Multilane	
	Pedestrian/cycle lanes		Can provide if required	
Site considerations	Adaptability for various site conditions	Skew	YES. Up to 15º	
		Grade	YES	
		Horizontal curve	YES	
		Vertical curve	YES	
	Required site investigations		Geotechnical, site survey and flood data	
	Resistance for corrosive environments (design exposure condition)		40 MPa for B1 Classification, 50 MPa for B2, and marine concrete + thicker cover for C classification	The formwork protects the concrete from corrosion for the life of the forms – If Magnelis is used, the formwork coating alone will last over 100 years

	Parameter	Structure design criteria	Comments
Constructability	In-line replacement	Requires side track or full road closure (steam curing or high early strength concrete can be used to shorten closure time)	
	Shut down option (full shut/lane shut)	Full shut during full construction period	
	Deployment lead time	Typically, 4–6 weeks	
	Availability of prefabricated/precast items	Components are sometimes available ex stock, but short lead times can be met	
	Special machinery	No special machinery to install	
	Special skills/techniques required at site	No	
	Transportability of precast components	No precast parts	
	Weight of heaviest part	Depends on the length of the unit – 12 m x 2.4 m deck weighs ~4.5 tonne. Single lane abutment is typically ~1.2 tonne	
	Size of largest part	18.5 m x 2.4 m deck weighs ~9.5 tonne	
	Time to complete deck	2 days to install and concrete deck panels. Time required for gaining strength	*Abutments typically take 1 day to install and concrete, then the decks take a few hours to install, and concrete is usually poured the following day. *Deck needs concreting in 2 stages for over 12 m long deck panels. (Beams to be cast first and wait for gaining strength before concreting rest). This will increase construction time
Cost	Approximate construction cost per sqrm	Whole-of-job construction cost can typically be $2000 to $3500 per sqrm, depending on the foundation type, site conditions, barrier designs etc. Approximately $1100 – $1500 per sqrm for slab only	
	Approximate annual maintenance cost	Minimum maintenance if integral structure is used	No bearing, no exposed concrete. Only barrier and surfacing maintenance
Maintenance	Recommended inspection frequency	Not specified	
	Recommended routine maintenance	Not specified	
	Durability	100 years of design life	
Considerations		Requires a large volume of concrete No exposed concrete surfaces. Visual inspection may not detect any concrete defects	
References	InQuik website	http://inquik.com.au/	
	InQuik Bridging” Brochure	http://inquik.com.au/wp-content/uploads/2017/08/Trifold-v2.3.5.pdf	
	InQuik Catalog	http://inquik.com.au/wp-content/uploads/2016/10/Inquik-Catalogue-v1.0.5.pdf	

B.3 Country Bridge Solution

Table B 3: CBS bridge system data

	Parameter		Structure design criteria	Comments
System	Developed by	Road and Maritime Services, NSW		Design is available for anyone to use
	Supplied by	No current supplier		
	Construction			
	Key features		1. Designed to Australian standard- AS 5100 (2017) 2. A fully certified bridge deck system, incorporating prestressed concrete double-T deck modules 3. Standardised substructure components can be easily adapted to suit a range of site conditions 4. Three standard bridge configurations to suit different future traffic demands and site constraints 5. A suite of standard bridge drawings for a modular bridge solution	
	Advantages		1. Available for anyone to manufacture 2. Transportability of precast components on standard trucks 3. Minimised on-site concrete required 4. Reduced maintenance requirements resulting from a 100 years design life	
	Limitations/weaknesses		1. Design only; Available for anyone to construction 2. Substructure has to be designed by the contractor for site condition 3. Designed for exposure condition B1 only. Not suitable to use within 1 km of the shoreline of salt water 4. Design for equal spans only 5. Maximum 2 traffic lanes and AADT of 1000 6. Maximum deck height of 10 m above the ground (limited column height) 7. No dedicated pedestrian or cycleway 8. No relieving slab	

	Parameter		Structure design criteria	Comments
General	Pre-engineered and standardized? (Y/N)		YES	
		Superstructure	YES	
		Substructure	NO	The contractor design foundation for site conditions. Standard options are available to adopt
	Completeness of design (Y/N)	Barriers	YES – Low performance barrier	
		Drain	Scuppers can be included in deck modules	
		Kerbs	Included in the external deck module	
		Bearing	YES	
		Expansion joints	YES – Pour in place seal joint	
		Provision for services	NO	
	Standardised/pre-engineered components		Deck module, traffic barriers, bearing, holding downs and restrain brackets, pier headstock, abutment sill beam, wing walls	
	In situ cast elements		Deck closure strips, pile-headstock connections	
	Previously used/tested in Australia?		Trial bridge at Bookookoorara Creek, NSW	
	Availability of documentation		Full documentation available for entire assets life cycle	
	Room for future expansions		Not considered	
Structural form	Deck		Precast prestressed concrete double-T deck units + in situ closure pour	
	Abutments		Precast sill beam on pile/column supports	
	Pier		Pile/column on spread footing depending on site conditions	
	Headstock		Precast concrete unit on pile/column supports with in situ connection	
	Foundation		Spread footing/precast driven piles	
	Wing walls		Precast concrete units	
Primary material	Superstructure		Prestressed precast concrete	
	Substructure		Precast reinforced concrete	
	Bearing		Laminated elastomeric bearings – replaceable	
	Barriers		Steel low performance barriers	
	Expansion joints		Pore in place sealant	

	Parameter		Structure design criteria	Comments
Design	Design standards		AS 5100 (2004), Austroads bridge design code (1992)	
	Design traffic load		SM1600, T44 (single-lane bridge)	
	Other design forces	Earthquake	YES	
		Submergence	YES – 5 m overtopping	
		Scour	Water flow scour (flow velocity 4 m/s)	
		Barrier impact	YES – Low performance barrier	
		Other	Vehicle braking forces	
	Design life		100 Years	
	Design AADT		Max AADT 1000 vehicles per day	
	Design speed		Not specified	
	Other design assumptions		Equal spans only, no wearing surface except 10 mm sprayed bituminous seal	
	Elements not covered in standard design		Everything below the headstock has not been included in standard documents and has to be designed for site conditions. E.g. piles, pile caps, columns, footings, temporary supports, connections	
Compliance	Compliance to *Design Criteria for Bridges and Other Structures*		Typical deviations are listed below	
	Compliance to TMR specifications		Typical deviations are listed below	
	Departures from TMR specifications		1. Low performance barrier	Clause 4.9.1.1 – DCBOS
			2. B1 exposure conditions	Clause 10.4.5 – DCBOS
			3. Use precast reinforced concrete driven piles	Clause 4.1.1 – DCBOS
			4. No relieving slab	Clause 4.11 – DCBOS
			5. Narrow carriageway	Clause 3.1 – DCBOS
			6. Not designed for wearing surface except 10 mm sprayed bituminous seal (Not complying with 4.8.3 of DCBOS)	Clause 4.8.3 – DCBOS
Geometry	Typical widths		Min 4.2 m for single lane, 6.5 m for 2 lanes	
	Typical span length		8 m, 10 m, 12 m	
	Number of spans		Multi-spans (equal spans only)	
	Number of traffic lanes		Maximum 2 lanes	
	Pedestrian/cycle lanes		No	
Site considerations	Adaptability for various site conditions	Skew	No	
		Grade	Yes. Constant grades only	
		Horizontal curve	No	
		Vertical Curve	No	
	Required site investigations		Geotechnical	
	Resistance for corrosive environments (design exposure condition)		Designed for B1 exposure category	

	Parameter	Structure design criteria	Comments
Constructability	In-line construction	YES	Side track or full bridge closure is required
	Shut down option (full shut/lane shut)	Full shut	
	Deployment lead time	No current supplier	
	Availability of prefabricated/precast items	No current supplier. Open for anyone to use	
	Special machinery	One large crane, machine for driving piles	
	Special skills/techniques required at site	None	
	Transportability of precast components	Can be transported in a standard truck	
	Weight of heaviest part	23.2 tonnes	
	Size of largest part	2.06 m x 9.97 m x 0.755 m	
	Time to complete deck	2 days. Time required for stitch joints to gain strength	
Cost	Approximate construction cost of deck per sqrm	$1750 per sqm	
	Approximate Annual Maintenance cost	Not specified	
Maintenance	Recommended inspection frequency	Level 1 inspections at every 6 months, Level 2 inspection at every 2 years	
	Recommended routine maintenance	As required	
	Durability	Designed for B1 exposure category and 100 years of design life	
References	All documents and drawings are available to download from	http://www.rms.nsw.gov.au/business-industry/partners-suppliers/lgr/country-brige-solutions.html	

B.4 M Lock

Table B 4: M Lock bridge system data

	Parameter		Structure design criteria	Comments
System	Developed by	Rocla Pty Ltd		Rocla temporarily ceased the sale of M-Lock on 01/05/2018 until further notice
	Supplied by	Rocla Pty Ltd		
	Construction			
	Key features		1. A complete bridge system 2. Designed in accordance with AS 5100 (2004), for SM1600 traffic loadings, with a design life of major components of 100 years 3. Cardno design certification of precast components and system design 4. Design Options – Cost effective 'Bolted' assembly for < 1000 AADT bridges, 'Post-Tensioned' system for > 1000 AADT	
	Advantages		1. No large in situ concretes. (No ready-mix concrete is required) 2. Span over span construction (can be constructed by reaching out) 3. Minimal construction impact on waterways 4. Less on-site skilled labour requirement	
	Limitations/weaknesses		1. Longer construction time for substructure (typically 15 days per span) 2. Restricted use of available pile types in QLD 3. Precast bored piles require considerable amount of site work (driving steel casing, drilling, backfilling etc.) 4. Deck units are fitted to headstock using bolts. No provision of expansion joints may results limitations in use 5. Designed to B1 (headstocks/decks) exposure conditions 6. Performance of bolts for transverse load distribution and durability may be limited 7. Standard design does not consider scour or submergence	

	Parameter		Structure design criteria	Comments
General	Pre-engineered and standardized? (Y/N)		YES	
		Superstructure	YES	
		Substructure	YES	
		Barriers	YES	Low traffic bridges – Low performance steel thrie beam barriers bolted to side of the deck panels High Traffic bridges – precast medium performance barriers fixed through prestressing bars on side of deck
	Completeness of design (Y/N)	Drain	NO	Drainage through decks. Can supply scupper holes in kerbing if required
		Kerbs	Optional	Typically, no kerb
		Bearing	Elastomeric strip	
		Expansion joints	NO	
		Provision for services	Optional	
	Standardised/pre-engineered components		Piles, headstock, plank, end protection beams	
	In situ cast elements		No in situ concrete	
	Previously used/tested in Australia?		Yes – first bridge – over Ohio Creek at Walcha, NSW (1995) + over 230 bridges in Australia	
	Availability of documentation		Technical guides, installation guides, Cardno design certification	
	Room for future expansions		Dependant on applications	
Structural Form	Deck		Precast concrete inverted U sections fitted to headstock using bolts	Deck units are transversely connected using M20 bolts. A high tensioned prestress bar is used for transverse connection for bridges with high volume of traffic (Over 1000 AADT)
	Abutments		Precast headstock on piles+ Rocla MassBloc wall to retain soil	
	Pier		Precast headstock on piles	
	Headstock		In situ jointed precast concrete unit	
	Foundation		Socketed hollow precast piles, square RC piles, steel UC or tubular piles	Typically, bored hollow piles, backfilled with cement/sand mix and pile void filled with stabilized sand
	Wing walls		Rocla MassBloc	

	Parameter		Structure design criteria	Comments
Primary material	Superstructure		Precast reinforced concrete	Transversely prestressed deck for high traffic bridges
	Substructure		Precast reinforced concrete	
	Bearing		Elastomeric strip	Sacrificial bearings. Unable to lift for bearing replacement due to grouted hold down bolts
	Barriers		Thrie beam bolted on barrier rail or precast concrete crash barrier	
	Expansion joints		No	
Design	Design standards		AS 5100 (2004)	
	Design traffic load		SM1600	
	Other design forces	Earthquake	No	
		Submergence	No	
		Scour	No	
		Barrier Impact	Low or medium performance barriers	
	Design life		100 years	
	Design AADT		Options of less than 1000 or more than 1000	
	Design speed		As required	
	Other design assumptions		–	
	Elements not covered in standard design		–	
Compliance	Compliance to *Design Criteria for Bridges and Other Structures*		Typical deviations are listed below	
	Compliance to TMR specifications		Typical deviations are listed below	
	Departures from TMR specifications		1. Typically, uses spun piles, steel or RC piles which are not allowed in QLD	Clause 4.1.6, Clause 4.3 – DCBOS
			2. B1 (headstocks/decks) exposure conditions	Clause 10.4.5 – DCBOS
			3. Uses oversized piles holes which are backfilled later with sand/cement mix (Violates MRTS65 section 6)	Section 6 – MRTS65
			4. Low performance Thrie beam bridge barriers bolted to side of the deck (low traffic bridges)	Clause 4.9.1.1, Clause 4.9.5.1 – DCBOS
			5. Hold down bolts are going through the bearing strip. May not be replaceable	Clause 4.6.2 – DCBOS
			6. Uses external prestressing bars to transversely prestress high traffic bridges	Clause 4.7.2 – DCBOS
			7. No provision for relieving slabs	Clause 4.11 – DCBOS Standard Drawing 2255

	Parameter		Structure design criteria	Comments
Geometry	Typical widths		4.8 m, 6.0 m, 7.2 m, 8.4 m, 9.6 m, 10.8 m	
	Typical span length		7 m – 15 m	
	Number of spans		Single/multi-spans	
	Number of traffic lanes		Up to 3 lanes	
	Pedestrian/cycle lanes		Optional	
Site considerations	Adaptability for various site conditions	Skew	30º skew angles are available	
		Grade	up to 5% longitudinally, 7% cross-fall	
		Horizontal curve	No	
		Vertical curve	No	
	Required site investigations		Geotechnical	
	Resistance for corrosive environments (design exposure condition)		Headstocks/decks- B1, piles B2 exposure	
Constructability	In-line construction		YES	
	Shut down option (full shut/lane shut)		Full shut	
	Deployment lead time		6–8 weeks lead time typically	
	Availability of prefabricated/precast items		6–8 weeks lead time typically	
	Special machinery		Drilling rig for piles	
	Special skills/techniques required at site		Transverse post tensioning if required	
	Transportability of precast components		Standard length or extended length semi-truck	
	Weight of heaviest part		15 m long post-tensioned deck plank – 20 tonnes	
	Size of largest part		15 m long deck plank – 15 m long x 1.2 m wide x 0.8 m deep	
	Time to complete deck		2 days	
Cost	Approximate construction cost per sqrm (deck only)		$1000–1400	
	Approximate annual maintenance cost		Not specified	
Maintenance	Recommended inspection frequency		Not specified	
	Recommended routine maintenance		Not specified	
	Durability		100 years design life/ B1 exposure	
Special requirements/considerations			1. Temporary steel casing may be required for piles 2. Deck panels are fixed to the abutment/pier headstock at both ends. No allowance for expansion or rotation 3. No expansion joints. Gap between spans to be filled with non-shrinking mortar 4. Performance of bolts for transverse connection need to be assessed (e.g. durability, fatigue capacity) 5. No provision for relieving slab 6. Unbale to lift for bearing replacement due to grouted hold down bolts which are also passing through bearing strip 7. External prestressing bars for transverse prestressing 8. Typically, no kerb or scuppers. (Available on request)	

	Parameter	Structure design criteria	Comments
References	Rocla website	http://www.rocla.com.au/M-Lock-Precast-Bridge.php	

B.5 UniBridge

Table B 5: UniBridge system data

	Parameter		Structure design criteria	Comments
System	Developed by:	UniBridge Australasia Pty Ltd		
	Supplied by:	UniBridge Australasia Pty Ltd		
	Construction			
	Key features		1. All steel or composite options 2. Options of modular steel deck with anti-skid system, in situ cast or precast concrete deck 3. Structural members are underneath the deck level with no chance of vehicle collision or damage 4. Longer span up to 44.8 m 5. All connections are made with either pins or bolts for easy connection	
	Advantages		1. Can be completed without sophisticated equipment 2. Easy to expand 3. Can be launched using launching nose or a crane. Temporary supports are not required 4. Can be used as temporary or permanent structure 5. Specialist tools or on-site welding is not required	
	Limitations/weaknesses		1. UniBridge provides superstructure only 2. Not designed for scour, submergence 3. Not designed for earthquake 4. No kerbs 5. Low performance barrier	
General	Pre-engineered and standardized? (Y/N)		YES	
	Completeness of design (Y/N)	Superstructure	YES	
		Substructure	NO	Supply typical design
		Barriers	YES	
		Drain	YES	
		Kerbs	NO	
		Bearing	YES	
		Expansion joints	No intermediate joints	
		Provision for services	NO	
	Standardised/pre-engineered components		Main box girders, deck – also barriers, barrier posts, bearings	
	In situ cast elements		Reinforced concrete poured in situ deck on permanent steel formwork	Steel or precast options are also available

	Parameter	Structure design criteria	Comments
	Previously used/tested in Australia?	YES – Gold Coast city council currently using as temporary bridge in bridge replacement projects. At the end of programme, same bridge will be installed as a permanent bridge. Temporary bridge on Kilcoy – Toogoolawah road	
	Availability of documentation/drawings	Supplies general layout drawings for each and every bridge with all measurements true and correct	
	Room for future expansions	Steel bridges can easily be expanded in width or moved and reconfigured as needed. The cast in situ or precast can also be expanded in width but this is more difficult to do because of the type of deck	
Structural form	Superstructure/deck	Basic module – 2 fabricated steel box girders + concrete-steel composite deck	
	Abutments	Supplies typical abutment designs (formwork and reinforcement) which the contractor can then adapt to the specific site and pile design based on the geotechnical reports	
	Pier	Supplies pier typical designs	
	Headstock	Supplies headstock typical designs	
	Foundation	Compatible with any type of foundation	Site-specific design by the contractor
	Wing walls		Site-specific design by the contractor
Primary material	Superstructure	Steel + reinforced concrete	
	Substructure	Site-specific designed by the contractor	
	Bearing	Typically, neoprene bearings. However, steel pot or slide bearings can be provided	
	Barriers	Galvanised steel	
	Expansion joints	Not required	No intermediate joints. Freyssinet joints are used for the expansion joint between abutment and deck

	Parameter		Structure design criteria	Comments
Design	Design standards		AS 5100 (2004)	
	Design traffic load		T44, SM 1600, HLP320	
	Other design forces	Earthquake	No	Earthquake design may be required for over 20 m long bridges
		Submergence	No	
		Scour	No	
		Barrier impact	Low performance barriers	
		Other	Fatigue life of 1 000 000 (one million) cycles (AS 5100)	
	Design life		100 years	
	Design AADT		Not specified	
	Design speed		Not specified	
	Other design assumptions		Not specified	
	Elements not covered in standard design		Substructure	
Compliance	Compliance to *Design Criteria for Bridges and Other Structures*		Generally, complies	
	Compliance to TMR specifications		Generally, complies	
	Departures from TMR specifications		Low performance barriers	Clause 4.9.1.1, Clause 4.9.5.1 – DCBOS
Geometry	Typical widths		Cast in situ or precast concrete decks can be anything. All steel: one lane: 4 m, two lanes: 7 m, three lanes: 10 m, four lanes: 13 m etc	
	Typical span length		Single lane 11.4 m – 50.8 m, Double lanes 11.4 m – 44.8 m (clear spans)	
	Number of spans		Multi-spans	
	Number of traffic lanes		Multilane	
	Pedestrian/cycle lanes		Can provide if required	
Site considerations	Adaptability for various site conditions	Skew	NO	
		Grade	YES	
		Horizontal curve	NO	
		Vertical curve	NO	
	Required site investigations		Geotechnical	
	Resistance for corrosive environments (design exposure condition)		Unless in a marine environment, use C4 level of paint protection. In a marine environment C5 marine level coating is used	

	Parameter	Structure design criteria	Comments
Constructability	In-line construction	YES	
	Shut down option (full shut/lane shut)	Full shut	
	Deployment lead time	90 days from order to reach nearest port (Brisbane)	Imports from France
	Availability of prefabricated/precast items	Not available in stock. Imported from France	
	Special machinery	No	
	Special skills/techniques required at site	No	
	Transportability of precast components	Can be transported by semi-trailers	
	Weight of heaviest part	Varies with bridge size	
	Size of largest part	Varies with bridge size	
	Time to complete (single span, 2 lane bridge)	2 days (superstructure with steel deck)	
Cost	Approximate construction cost per sqrm (deck only)	$1100 – $1500	
Maintenance	Recommended inspection frequency	Annually	
	Recommended routine maintenance	Annually	
	Durability	100 years design life/C4 exposure	
Considerations			
References	UniBridge website	http://www.unibridge.net.au/	

B.6 C200

Table B 6: C200 Bridge system data

	Parameter		Structure design criteria	Comments
System	Developed by:	Mabey Bridge Limited		
	Supplied by:	Mabey Australia		
	Construction			
	Key features		1. Modular and pre-engineered 2. Separate pedestrian walkways can be mounted 3. Can be assembled by hand or light plant 4. Various deck options are available 5. Transportable in a standard container 6. Optional ramps, piers, foot walks, parapets and barriers	
	Advantages		1. Easy to transport 2. Can be used as temporary, permanent or emergency bridge 3. Rapidly assembled and installed 4. Longer unsupported spans (Up to 60.96 m) 5. Crane installation or cantilever launch	
	Limitations/weaknesses		1. Maximum 2 traffic lanes 2. Superstructure only. Contractor designs the substructure 3. Narrow carriageway 4. Typically, no barriers. But can be attached if required	C 200 trusses are not designed to act as a traffic barrier. Separate barriers can be attached
General	Pre-engineered and standardized? (Y/N)		Yes – The compact bridge system uses standard, interchangeable steel components	
	Completeness of design (Y/N)	Superstructure	YES	
		Substructure	NO	
		Deck	YES	
		Drain	YES	
		Kerbs	YES	The kerb is a formed fabricated plate, which is bolted to the side of the deck units, which form the edge of the roadway and are located close to the bridge trusses
		Bearing	YES	The bearing baseplate supports the bridge bearings under each truss

	Parameter	Structure design criteria	Comments
			line, at each end of the bridge
	Expansion joints	Not required	
	Provision for services	Yes, if required	
	Standardised/pre-engineered components	All superstructure	
	In situ cast elements	NO	
	Previously used/tested in Australia?	Yes – recent projects include ToneBridge Bridge Replacement in WA used for Main Roads Western Australia. Blade Bridge for Wollondilly Shire Council. Colongra Power Station NSW – supplied under Ertech. More can be provided if required	
	Availability of documentation/drawings	Technical Brochures, case studies, installation guides, product description etc	
	Room for future expansions	Permanent structures have the ability to be expanded if necessary, subjected to Engineering approval	
Structural form	Superstructure/deck	Steel truss/panel (Bailey) bridge with steel decking	The deck is a steel fabricated unit, which is 3.042 m long x 1.050 m wide x 135 mm deep and spans between the top flanges of the bridge transoms
	Abutments	Designed by the contractor	
	Pier	Not required	
	Headstock	Designed by the contractor	
	Foundation	Designed by the contractor	
	Wing walls	Designed by the contractor	
Primary material	Superstructure	Galvanised high-strength steel with a polyurethane based anti-skid deck surface	
	Substructure	N/A	
	Bearing	Galvanised high-strength steel	
	Barriers	Galvanised high-strength steel	
	Expansion joints	Galvanised high-strength steel	

	Parameter		Structure design criteria	Comments
Design	Design standards		AS 5100 (2004), AASHTO	
	Design traffic load		AS 5100 (2004)/SM1600	
	Other design forces	Earthquake	AS 5100 (2004)	
		Submergence	AS 5100 (2004)	
		Scour	N/A	
		Barrier impact	Not specified	Typical design does not include barriers
		Fatigue	100 000 cycles of stress due to AASHTO HS25-44 truck or lane loading applied to both lanes of the bridge simultaneously	AS5100 recommends a higher fatigue load than AASHTO
	Design life		100 years design life	
	Design AADT		Not specified	
	Design speed		Not specified	
	Other design assumptions		N/A	
	Elements not covered in standard design		Substructure	
Compliance	Compliance to *Design Criteria for Bridges and Other Structures*		Generally, Yes	
	Compliance to TMR specifications		Generally, Yes	
	Departures from TMR specifications		1.Narrow road way	Clause 3.1 – DCBOS
			2. Trusses are not designed to act as a traffic barrier, but can be attached if required	Clause 4.9.1.1 – DCBOS
Geometry	Typical widths		3.15 m, 4.20 m, and 7.35 m	
	Typical span length		15.24 m (50 ft) to 60.96 m (200 ft) in modular increments of 3.048 m (10 ft)	
	Number of spans		Multiple spans available if needed	
	Number of traffic lanes		Dual lane traffic	
	Pedestrian/cycle lanes		These are available as a Cantilever walkway – 1.5 m wide and can be located on either side or both sides of the bridge	
Site considerations	Adaptability for various site conditions	Skew	NO	
		Grade	YES	
		Horizontal curve	NO	
		Vertical curve	YES	
	Required site investigations		Not required for superstructure	
	Resistance for corrosive environments (design exposure condition)		All steel components on all Mabey's bridge products come galvanised as standard. Additional coating/protection properties would be considered on a case-by-case basis	

	Parameter	Structure design criteria	Comments
Constructability	In-line construction	YES	
	Shut down option (full shut/lane shut)	Quick assembly methodology for rapid bridge build and time/cost efficiencies on site	
	Deployment lead time	If current stock available 1 week, otherwise lead time is dependent on the project	
	Availability of prefabricated/precast items	Items are usually held in stock in locations around Australia, dependant on the project and the availability of parts – these could be ex stock	Import from UK
	Special machinery	Crane or launching equipment	
	Special skills/techniques required at site	No special skills needed	
	Transportability of precast components	Stock is transported on semi-trailers from Mabey Depot, all stock is flat packed	
	Weight of heaviest part	Dependant on the size of the bridge	
	Size of largest part	Dependant on the size of the bridge	
	Time to complete	Quick assembly typical for a 5-bay bridge (15 m) to be built in 2 working days with unskilled crews and minimal plant hire	
Cost	Approximate Construction cost Per sqrm (DECK ONLY)	15 m span – $1800	Supply cost only. Need to add erecting cost. Hire option is also available
	Approximate Annual Maintenance cost	Not specified	
Maintenance	Recommended inspection frequency	Initial visual inspection to be carried out one month after bridge has opened to traffic. All bridges to be inspected at least once every 12 months and as soon as possible after a known flood event	
	Recommended routine maintenance	All bridges to be inspected at least once every 12 months and as soon as possible after a known flood event	
	Durability	Galvanized high strength steel is guaranteed for life of asset – expected to be 100 years in applications of low traffic volume and dry climate conditions	Extra protective coatings can be considered depending on the requirement, budget etc.
Considerations		1.Fatigue design is done for AASHTO design guidelines which uses lower fatigue load than the AS 5100 2.Trusses are the main load bearing elements. They are vulnerable to impact but not designed to act as a traffic barrier	
References	Mabey website	https://www.mabey.com/au/products/bridging/mabey-compact-200	

B.7 Waeger Precast Bridges

Table B 7: Waeger bridge system data

	Parameter		Structure design criteria	Comments
System	Developed by	Waeger Constructions Pty Ltd		
	Supplied by	Waeger Constructions Pty Ltd		
	Construction	Waeger Constructions Pty Ltd		Client can construct themselves if they wish
	Key features		1. Designs custom to each site location to ensure best fit bridge for each application 2. Adaptable in width and length 3. Multiple or single span construction 4. Simple precast solutions with minimal in situ concrete works	
	Advantages		1. Simple precast solutions with minimal in situ concrete works 2. Fast construction time on site	
	Limitations/weaknesses		1. Maximum 15 m span 2. 15 m decks are 26 t and over 3. Typically bespoke with some cast in situ elements such as pier columns	
General	Pre-engineered and standardized? (Y/N)		To some extent, each bridge is designed specifically for the loading and site conditions for each specific application	
	Completeness of design (Y/N)	Superstructure	YES	Precast Waeger deck units
		Substructure	YES	Typically, precast abutment and pier headstock beams. Precast sheeting panels for walled abutments and wing wall as required
		Barriers	YES	Low-protection level Thrie beam or custom concrete/steel barrier combination for higher protection level
		Drain	YES	Scuppers can be incorporated if required. Typically, longitudinal and cross-fall is sufficient for drainage purposes
		Kerbs	YES	Precast kerb, cast-in situ kerbs. Can accommodate castellated or continuous kerbs
		Bearing	YES	Typical laminated elastomeric bearing pads

	Parameter	Structure design criteria	Comments
	Expansion joints	YES	Joint sealant at transverse joints
	Provision for services	YES	Can be accommodated between beams or on outer edge of beams
	Standardised/pre-engineered components	To some extent, each bridge is designed specifically for the loading and site conditions for each specific application	
	In situ cast elements	Piling/foundations depending on site conditions. Columns for piers and abutments are typically cast in situ (Ø600 round columns) as required	
	Previously used/tested in Australia?	Mow Creek bridge – Binnaway, 5 Bridges in Walcha Council etc	Extensively used throughout NSW
	Availability of documentation	Concept designs for a range of bridge widths and span configurations can be provided	
	Room for future expansions	Simple headstock extensions can be completed, plus additional Waeger deck units can be installed to provide additional bridge width as required	
Structural form	Deck	Precast Waeger deck (double T unit)	
	Abutments	Precast abutments	
	Pier	Typically cast-in situ columns with precast headstock beams	
	Headstock	Precast unit	
	Foundation	Bored cast in piles, driven concrete piles, driven steel piles	Typically, compatible with all types of foundations
	Wing walls	Precast panels with bolted connections	
	Relieving slab	Can be precast or cast-in situ depending on site preferences	
Primary material	Superstructure	Concrete (prestressed)	
	Substructure	Concrete	
	Bearing	Laminated elastomeric bearing	
	Barriers	Steel/concrete	
	Expansion joints	Polyurethane joint sealants	

	Parameter		Structure design criteria	Comments
Design	Design standards		AS 5100:2017	
	Design traffic load		T44 or SM1600 loading and HLP320 or HLP400 if required	
	Other design forces	Earthquake	Site dependent	
		Submergence	YES	
		Scour	Site dependent	
		Barrier impact	No/low/regular options available	Low-protection level Thrie beam or custom concrete/steel barrier combination for higher protection level
	Design life		100 years	
	Design AADT		Not specified	
	Design speed		Not specified	
	Other design assumptions		Not specified	
	Elements not covered in standard design		Each design is customised to the specific site application	
Compliance	Compliance to *Design Criteria for Bridges and Other Structures*		Can be compliant where required	
	Compliance to TMR specifications		Can be compliant where required	
	Departures from TMR specifications		Typically, none	
Geometry	Typical widths		2.3 to 3.5 m per Waeger deck unit. Bridge widths from 4.2 m and up	
	Typical span length		6 m to 15 m	
	Number of spans		Single or multiple	
	Number of traffic lanes		Single or multiple	
	Pedestrian/cycle lanes		Can be incorporated easily with additional deck width	Can be simply raised from road level with kerb type barrier separation, or other separation barrier as required by the site/client
Site considerations	Adaptability for various site conditions	Skew	Up to 45°	
		Grade	Longitudinal and transvers grades easily accommodated. Single or dual cross-fall	
		Horizontal curve	Easily accommodated with additional within short bridges, or staggered skew arrangement for long bridges	
		Vertical curve	Can be incorporated into substructure elements with little additional work	
	Required site investigations		Geotechnical, detailed survey, service locations	
	Resistance for corrosive environments (design exposure condition)		All concrete elements can be designed to various exposure classifications in accordance with AS 5100 and AS3600	

	Parameter	Structure design criteria	Comments
Constructability	In-line construction	YES	Depends on road alignment and construction of existing bridge. Superstructure system is easily split for staged construction. Substructure can also be designed for staged construction if required
	Shut down option (full shut/lane shut)	Either can be accommodated depending on existing bridge construction and road alignments	
	Deployment lead time	Typically, 8 to 10 weeks for design development	
	Availability of prefabricated/precast items	Typically, 3 to 6 weeks from issue of design drawings	
	Special machinery	Mobile cranes for lifting and installation, plus piling equipment to suit site conditions	
	Special skills/techniques required at site	Experience in installation of precast/prefabricated items is recommended	
	Transportability of precast components	Typically, on flatbed semi-trailers. Larger/heavier deck units may be on extendable semi-trailers or extendable low loaders or jinkers	
	Weight of heaviest part	15 m decks are 26 t and over	
	Size of largest part	15 m long x 2.5 m wide x 0.7 m high	Width can be increased to suit desired bridge width/arrangement
	Time to complete deck	Typically, trafficable 2 to 3 days after installation of precast deck	Time to allow for grouting of shear key joints and joint sealants. Products used for this will determine actual trafficable time required
Cost	Approximate construction cost per sqrm	Typically, \$1250 to \$2,000/m^2 (ex GST)	Includes design of entire bridge, plus supply of abutment/pier headstocks, bridge deck and traffic barriers. Based on single span, dual lane bridges
	Approximate annual maintenance cost	Not specified	Designed for minimal maintenance. Typically, replacement of bearings at 40 to 60 years design lift. General maintenance on steel components (if used)
Maintenance	Recommended inspection frequency	Typical bi-annual inspections recommended	
	Recommended routine maintenance	Cleaning of headstock sills. Checking of bolts/connections	
	Durability	100 years design life	
Considerations			

	Parameter	Structure design criteria	Comments
References	Waeger website	http://www.waeger.com.au/	