InQuik
BRIDGING SYSTEMS

InQuik Bridge System Presentation

Presentation by Logan Mullaney
Co-Inventor & President

Agenda

1. History of InQuik – EST 2015 – 175+ bridges in service / in construction
2. What is The InQuik System?
3. How it reduces / eliminates
   - Risks
   - Time
   - Skills
   - Cost
4. Case Studies
5. R&D – Technical discussion – AASHTO LRFD 9th Edition
6. Natural Disasters

Nothing like this in the US before NOW!

Most Innovative ABC Bridge System Developed Outside U.S: InQuik Bridge System

History Of InQuik

2014	2015	2016	2017	2018	2019	2020	2021	2022
First Patent lodged	First design completed.	First InQuik bridge built.	3 bridges built.	First multi span Bridge built.	First Highway bridge built.	40 Bridges.	100 bridges.	**175 Bridges.**

Conventional Construction methods

What is the Patented InQuik System?

InQuik BRIDGING SYSTEMS

Factory Controlled Fabrication

Abutments & Decks

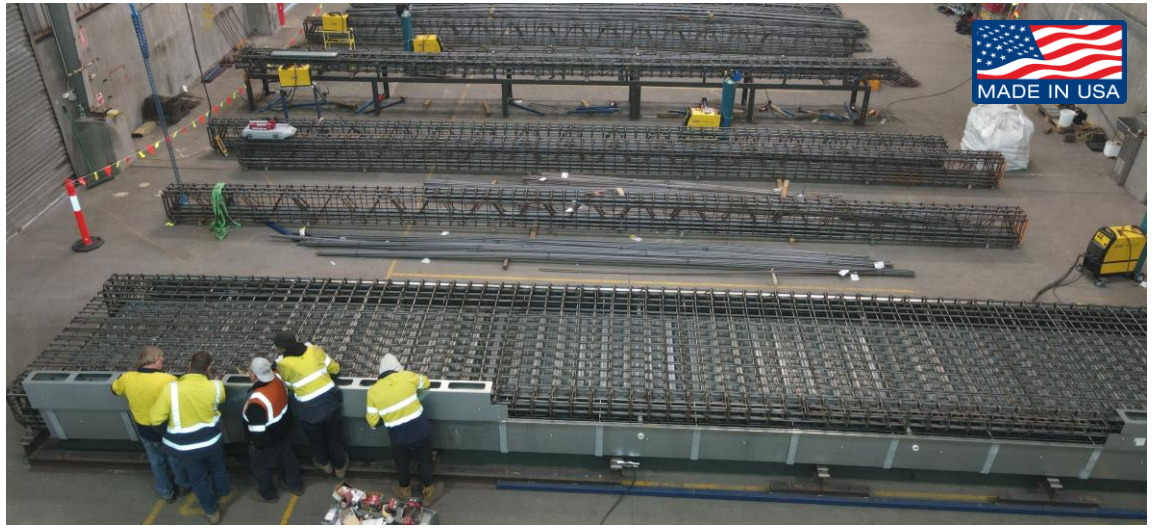
Concrete poured on-site

- ✓ Place components & pour concrete
- ✓ Fully self-supporting / no propping required
- ✓ One monolithic structure after components stitched together on-site
- ✓ Local concrete contractor

Completed Bridges

Accelerated Bridge Construction

InQuik BRIDGING SYSTEMS



Prefabricate components in a factory without concrete

Light-weight components are easily transported

Modular components lifted into place & connected

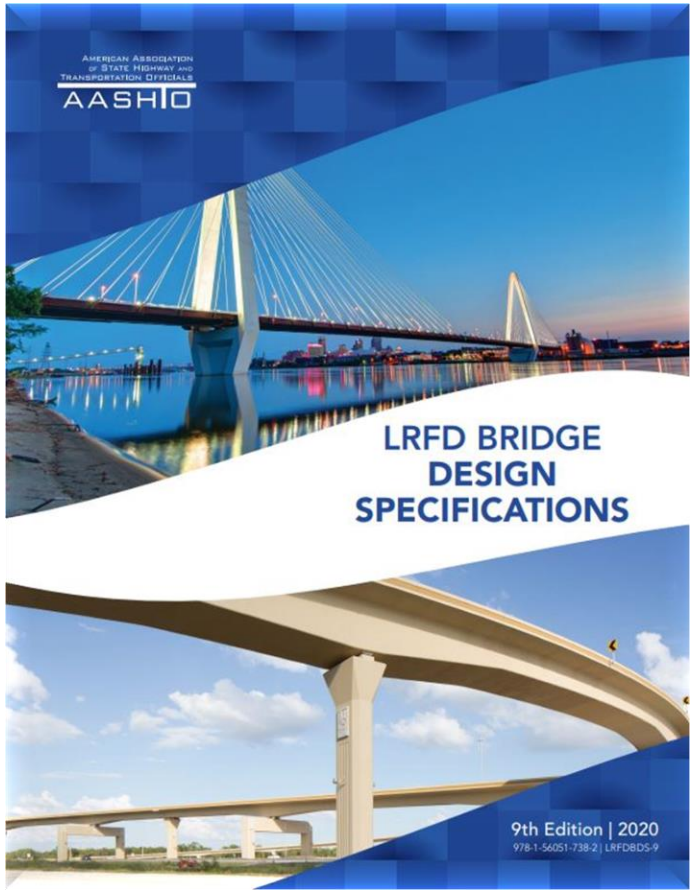
Concrete poured on-site

Performance: Advantages

InQuik Bridge	Conventional Methodology
Fast on-site construction with less trades	Longer construction time on-site
Self-supporting modular construction	Temporary supports required
Light weight bridge components (as concrete poured on-site) – small local cranage	Heavier components – larger cranage
Guaranteed concrete cover to reinforcement in factory manufacture	On-site reinforcing steel can move when fabricated on-site
Low construction risk (light weights, less construction time, reduced site labor)	Higher construction risk (longer site time, increased site labour, heavier components)
No joints in structure to allow water and salt ingress – *integral bridge*	Joints – water and salt ingress, reduced design life
No bearings or tie-downs – *integral bridge* = no long-term maintenance	Bearings and tie-downs = maintenance required
Pre-engineered, pre-certified, pre-fabricated via quality design and fabrication partners	Often fabricated and certified on-site
Ease of transportation (light weight components)	Heavier components – larger trucks, structural cracks can occur from transportation with pre-cast

All of these advantages lead to significantly reduced project costs of up to 50% - i.e. reduced program on site, reduced on site labor / hours and rate, minimal cranage on-site, reduced project construction risk, zero maintenance

Design



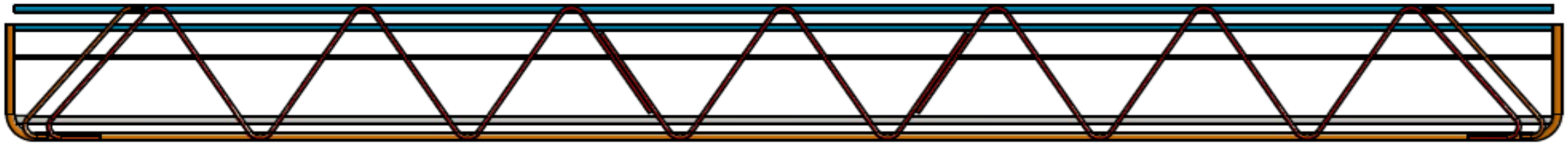
ARUP

MADE IN THE USA

InQuik components are designed to AASHTO LRFD Bridge Design Specification 9th Edition

Verification performed by ARUP

How The InQuik System Works



- Truss is added to the beam
- Pre-camber welded into the beam
- Reinforcing steel increased by 30%

- Internal reinforcing structure supports the weight of the concrete so it's in a neutral state until the live load
- And no propping is required when pouring concrete on-site

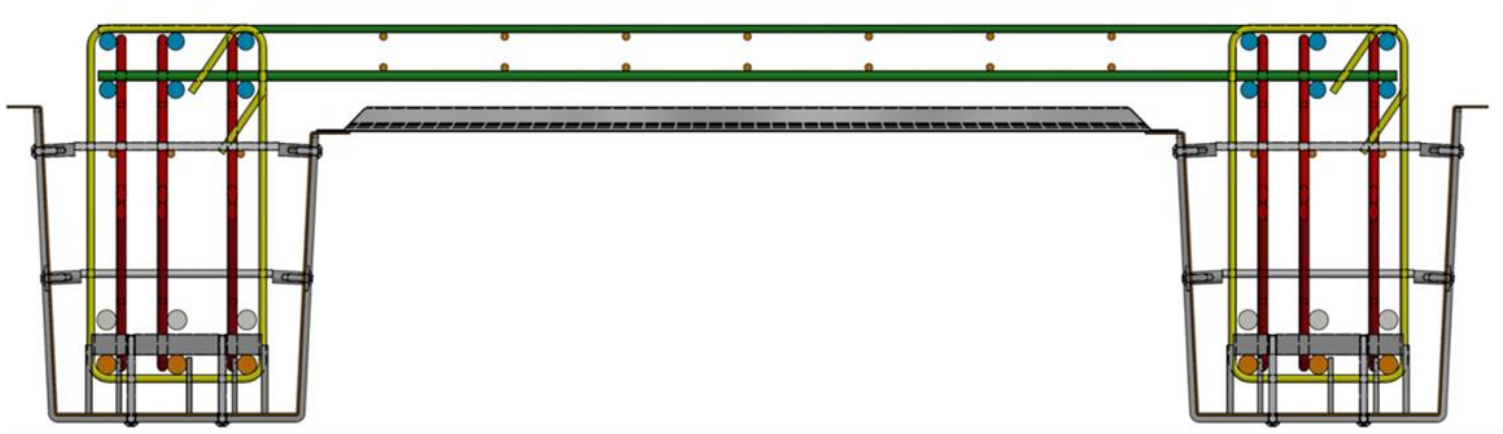
ARUP

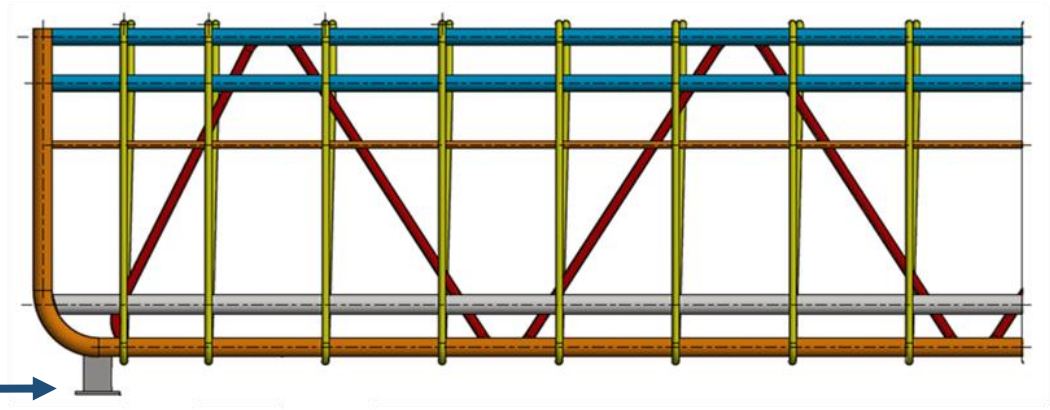
SMEC

Member of the Surbana Jurong Group

US Patent No. 11053647

How does the InQuik system work?



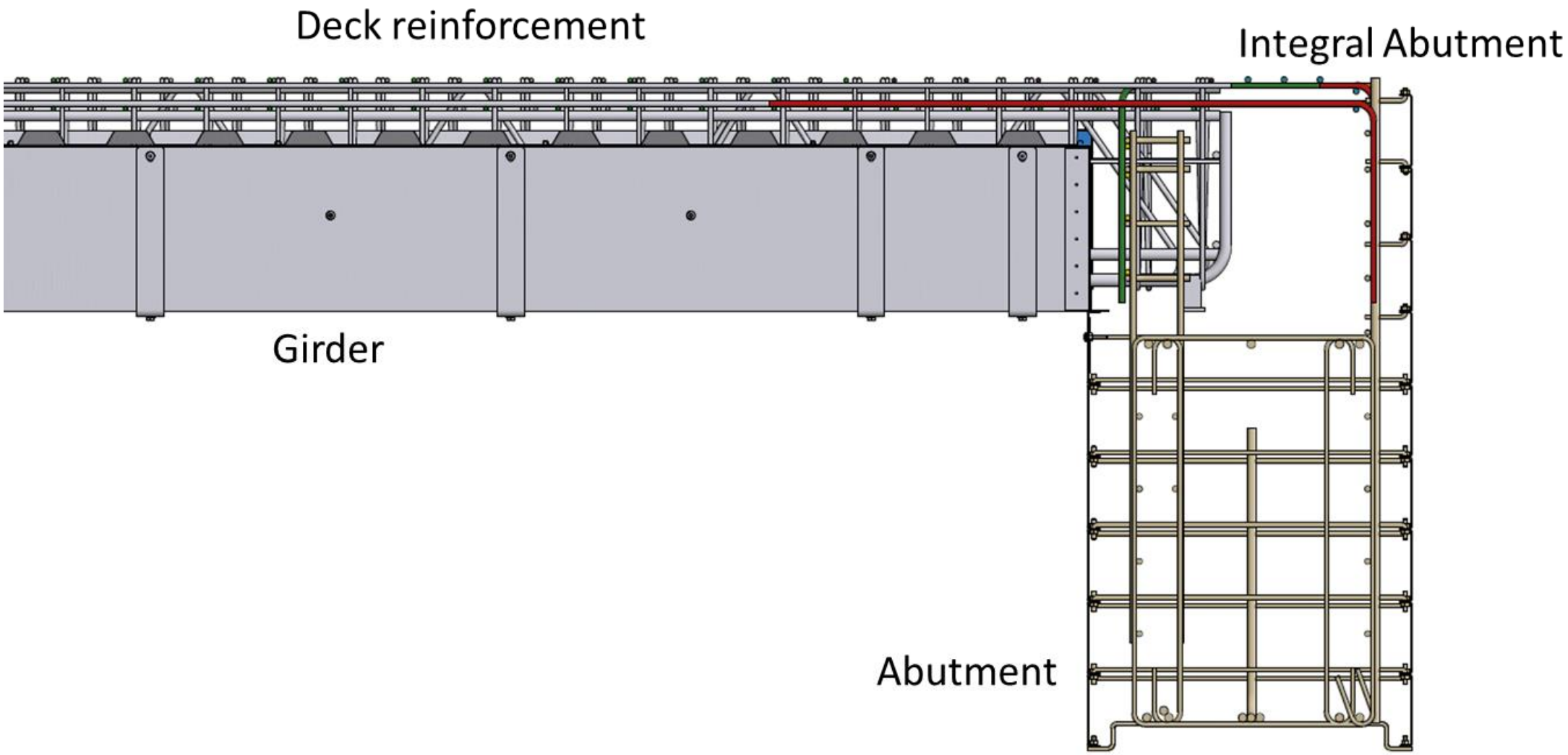


- Formwork is bolted to the reinforcing cage
- Guaranteed concrete coverage
- Truss foot sits on the abutment
- Deck weight transferred to abutment
- Self-supporting during the concrete pour
- No propping required
- Formwork is sacrificial, however remains

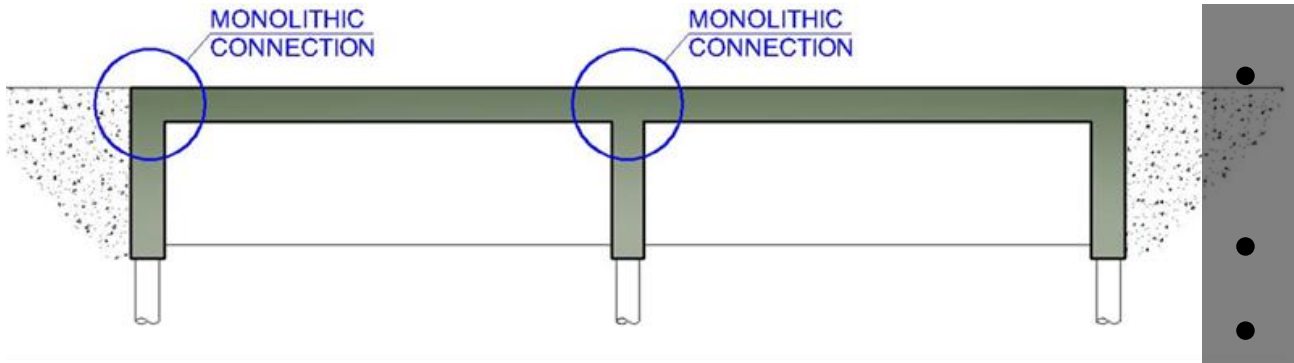
- Prevents water escaping during curing
- Prevents salt ingress
- Protects concrete

US Patent No. 11053647

Integral Structure



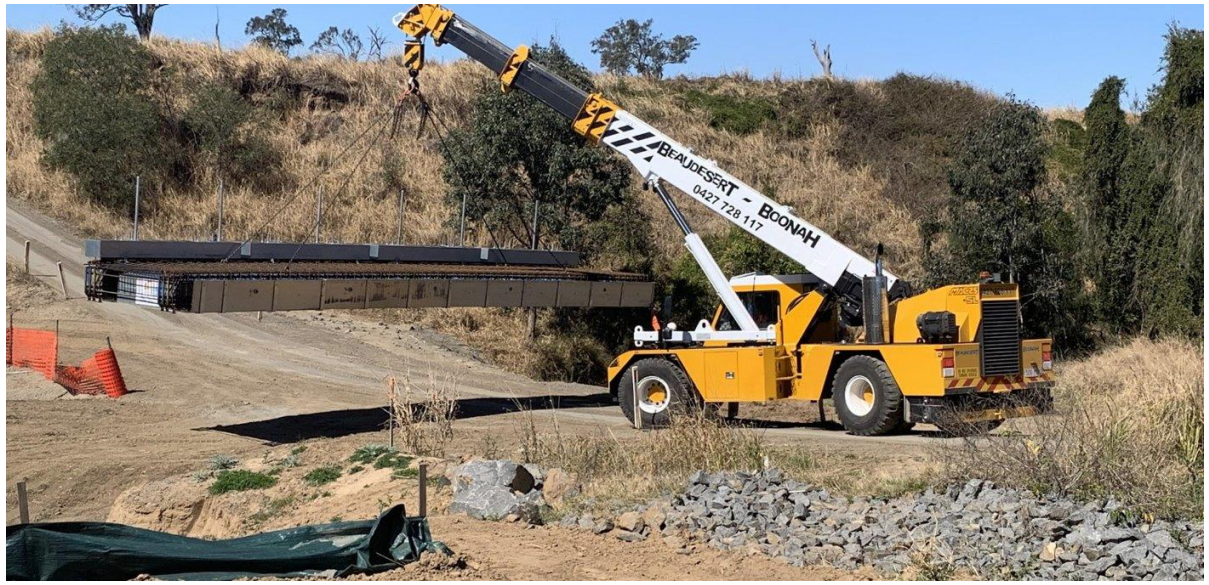
Explanation & Reasons for Use



- Integral bridges have the following advantages:
- • Lower whole-of-life cost
- • Improved operation safety
- • Improved construction safety
- • Reduced traffic disruption derived from elimination of maintenance requirement
- • Improved ride-quality and noise reduction
- • Improved structural reliability and redundancy
- • Improvement of bridge appearance through elimination of staining caused by water leakage through joints.
- • Likely Reduced initial cost

Maintenance Considerations

InQuik Process



Design Options

- 20ft – 60 ft single spans
- Multi span – beyond 300 ft.
- Single lane – Multi lane
- TL2 to TL5 Barriers MASH tested
- Abutments / Wing walls / Bent Caps / Decks / Barriers
- Services conduits
- Simply Supported or Semi / Fully Integral
- Formwork = ZAM / Weathering Steel / Stainless steel
- Rebar – Black / Galvanised / Stainless
- **Complete Solution above the foundation**

External Finish Options

Alloy coated steel

Weathering Steel

Stainless Steel

- Formwork is sacrificial
- However, it remains in place
- Protects the concrete

- *Concrete reinforced bridge*

Benefits of The InQuik System

- Design life in excess of 100 years
- Engineered to AASHTO LRFD 9th Edition by ARUP
- Up to TL5 MASH Tested Barriers as standard.
- Locally available 5ksi concrete required
- Pre-engineered, prefabricated solution
- Safer, quicker, simpler installation.
- ‘Whole of Life’ cost significantly less.
- Fabricated in existing steel fabrication shops.
- low-skilled local labor
- Proven existing technology - predictable

Major Markets

Market Sectors:

- Local Government bridges
- State bridges
- Rail bridges
- Mining
- Wharves and jetties
- Private, agricultural & pedestrian bridges
- <20 ft Span Culvert replacements

3 span bridge – 8 day install

3 Span Bridge

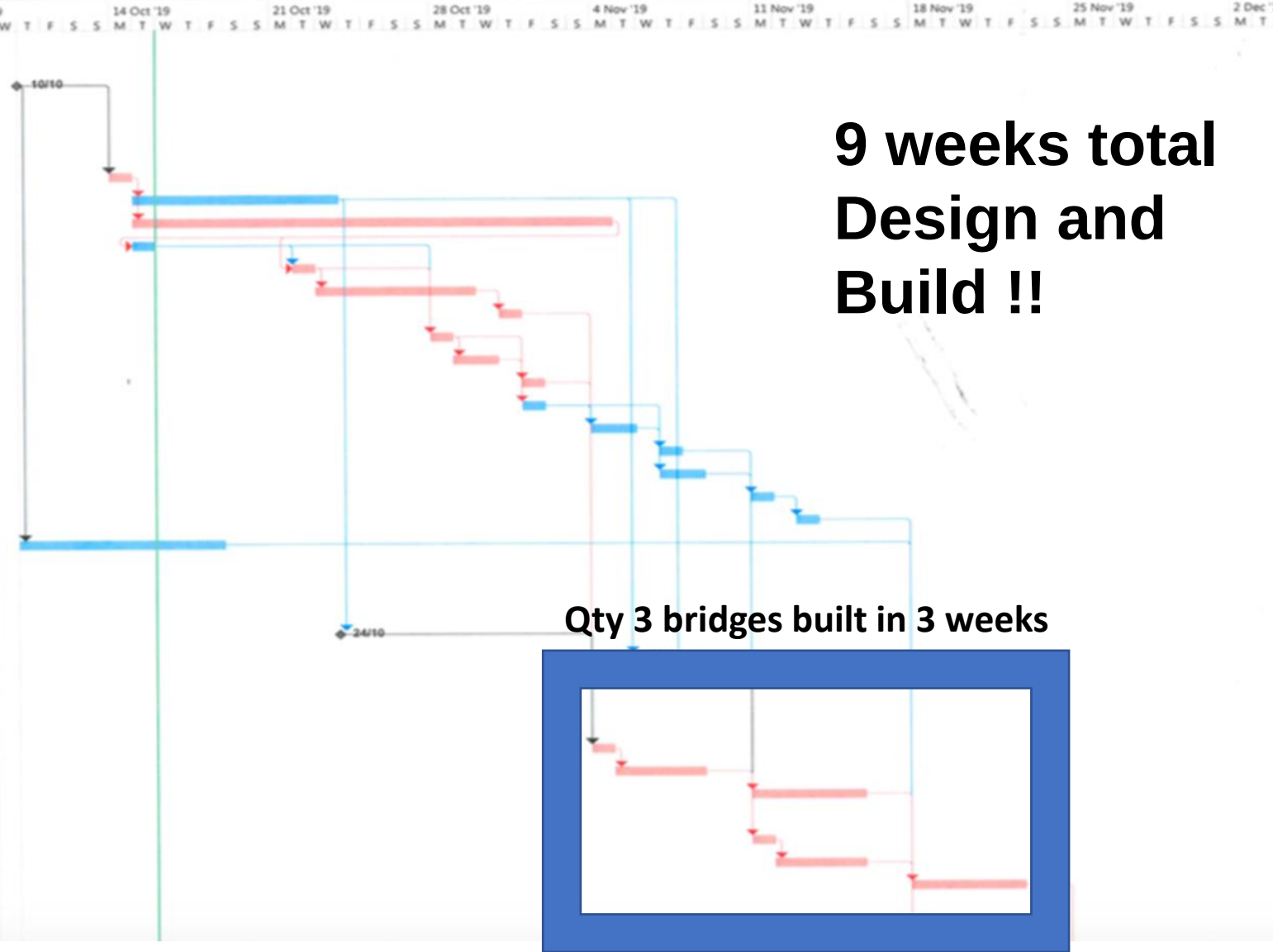
Culvert Replacement: Fish Friendly

- ✓ Developed with Department of Fisheries
- ✓ 21’ Span / 14” Girder profile
- ✓ All bridge components fit on one truck
- ✓ Easily access remote locations

Project Example

Upper Lachlan Shire Council - Willcox, Julong, Reids Flat Bridges - Construction Program Rev 1

ID	Task Name	Duration	Start	Finish	Predecessors
1					
2					
3	**Contract Awarded**	0 days	Thu 10/10/19	Thu 10/10/19	
4					
5	**Pre-Construction**				
6					
7	Subcontracts sent out	1 day?	Mon 14/10/19	Mon 14/10/19	3FS+2 days
8	Procurement of bridges	7 days	Tue 15/10/19	Wed 23/10/19	7
9	Design of bridge foundations	15 days	Tue 15/10/19	Mon 4/11/19	7
10	Site inspection of all 3 bridges	1 day?	Tue 15/10/19	Tue 15/10/19	9FS-15 days
11	Provide concept designs to ULSC	1 day?	Tue 22/10/19	Tue 22/10/19	9FS-10 days,1(
12	ULSC fishing permit application	5 days	Wed 23/10/19	Tue 29/10/19	11
13	Fisheries approval	1 day	Thu 31/10/19	Thu 31/10/19	12FS+1 day
14	Design for Willcox for review	1 day?	Mon 28/10/19	Mon 28/10/19	10,11FS+3 day
15	ULSC review and comments	2 days	Tue 29/10/19	Wed 30/10/19	14
16	Final design for Willcox	1 day?	Fri 1/11/19	Fri 1/11/19	15FS+1 day
17	Design for Julong for review	1 day	Fri 1/11/19	Fri 1/11/19	14FS+3 days
18	ULSC review and comments	2 days	Mon 4/11/19	Tue 5/11/19	17
19	Final design for Julong	1 day	Thu 7/11/19	Thu 7/11/19	18FS+1 day
20	Design for Reids Flat for review	2 days	Thu 7/11/19	Fri 8/11/19	17FS+3 days
21	ULSC review and comments	1 day	Mon 11/11/19	Mon 11/11/19	20
22	Final design for Reids Flat	1 day	Wed 13/11/19	Wed 13/11/19	21FS+1 day
23	ULSC notification to local stakeholders of works program & road closures	7 days	Thu 10/10/19	Fri 18/10/19	3
24					
25	**Delivery of Bridge Components to site**				
26	Willcox	0 days	Thu 24/10/19	Thu 24/10/19	8
27	Julong	0 days	Wed 6/11/19	Wed 6/11/19	8
28	Reids Flat	0 days	Fri 8/11/19	Fri 8/11/19	8
29					
30	**Construction**				
31	Willcox - mobilise / demolish bridge	1 day?	Mon 4/11/19	Mon 4/11/19	26,13FS+1 day
32	Foundations & Footings	4 days	Tue 5/11/19	Fri 8/11/19	31
33	Installation of abutments & decks	5 days	Mon 11/11/19	Fri 15/11/19	32
34					
35	Julong - mobilise / demolish bridge	1 day?	Mon 11/11/19	Mon 11/11/19	32,27,19
36	Foundations & Footings	4 days	Tue 12/11/19	Fri 15/11/19	35
37	Installation of abutments & decks	5 days	Mon 18/11/19	Fri 22/11/19	36,33
38					
39	Reids Flat - mobilise / demolish bridge	1 day	Mon 18/11/19	Mon 18/11/19	36,22,23

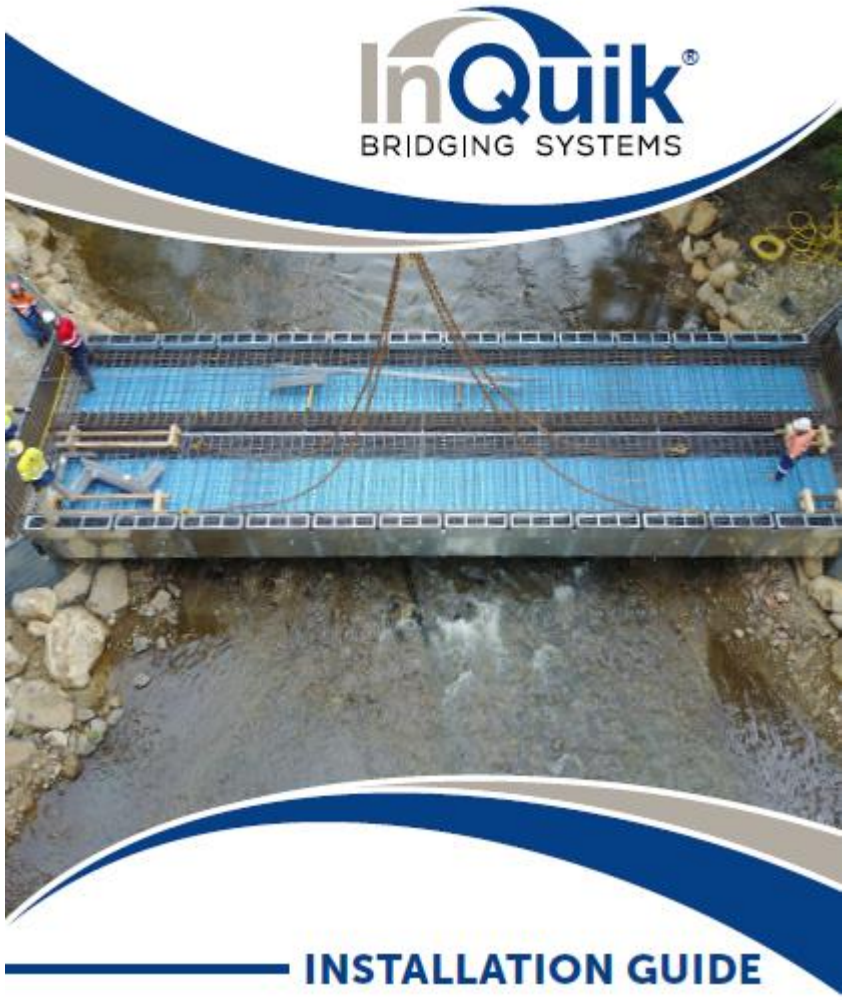


9 weeks total Design and Build !!

Qty 3 bridges built in 3 weeks

Simple Pricing

1. InQuik Bridge components
2. Environmental and Traffic controls
3. Demolition of existing bridge
4. Foundation installation
5. Crane
6. Concrete and pump
7. Labor - Set out / position / concrete



Constructed by Local County Labor

InQuik BRIDGING SYSTEMS

Pedestrian Bridges

Light weight multi use bridge + handrail

Galvanized Handrail on Vehicular + Pedestrian

Pedestrian Bridges

Collapsible Barrier

Pedestrian Bridge with Galvanized Rail.

Railing could be made from Weathering Steel or other desired options

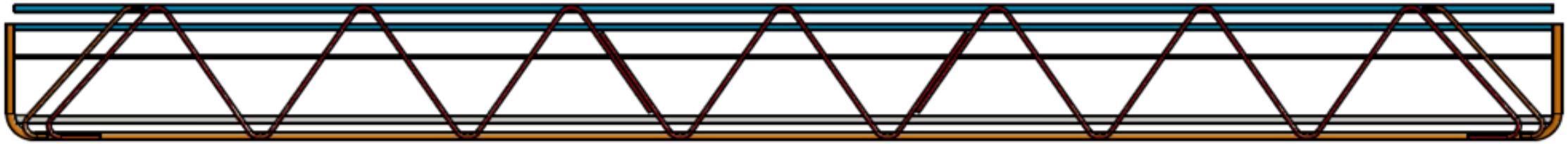
Weathering Steel finish & Excavator install

Simply place the lightweight modules and fill them with concrete.

Multi-Span Examples

Completed Bridges

R&D – Understanding InQuik



- Reinforcement Truss holds the weight of the wet concrete.
- Concrete is in a neutral state until live load. Benefits of this?

- Formwork encapsulates the concrete whilst curing. Benefits of this?
- Formwork protects concrete. What added durability is expected?.

- Integral moment connection. Load capacity / span length benefits.

R&D – Understanding InQuik

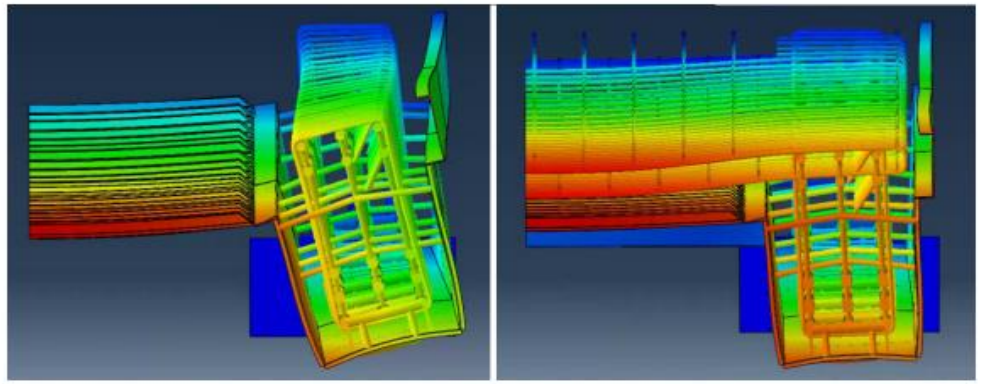


Fig. 4.11 a) Rotation of initial model, b) Rotation of final model.

It was shown that in all cases the permanent form work had a beneficial effect on the performance of the InQuik bridge system. It was shown that the permanent form work reduced the stress on the steel truss members by allowing the concrete in the troughs to cure autogenously and therefore develop a higher strength. This in turn led to a greater degree of load shedding from the trusses to the concrete when the concrete was set and thus lower stresses on the trusses. This stress transfer whilst beneficial for the trusses increased the stress in the tensile region of the concrete. This effect is negated by the higher development of strength in the concrete giving a higher value of allowable tensile stress. Taking both effects into consideration the concrete with the permanent form work in place was less likely to form cracks than the current InQuik bridge system. Aside from the concrete cracking in tensile regions the durability of the concrete deck was also improved from an abrasion resistance perspective by the lowering of the compressive stress at the upper surface of the deck. Finally the mean stress and cyclic stress on the steel trusses was reduced by roughly 10%. This can be seen as an extension of service life from a fatigue perspective over the current InQuik bridge system.

- ✓ **Assessment of Permanent Formwork**
- ✓ **Dissimilar Metals**
- ✓ **Assessment of Welds**
- ✓ **Critical 45ft span Finite Element Analysis**
- ✓ **Welding and Fatigue**
- ✓ **Failsafe Design for Rail**
- ✓ **Rail Design Optimization**
- ✓ **AASHTO Verification**

Dr. I.E.J Henderson
Prof. B. Uy
Prof W. Ariyaratne

THE UNIVERSITY OF SYDNEY

ARUP

R&D – Understanding InQuik

The autogenous shrinkage and total shrinkage over 300 days used for these models can be seen Fig: 4.25. Treating this data in the same manner as the data for Young's modulus gives the material properties in Table: 4.9.

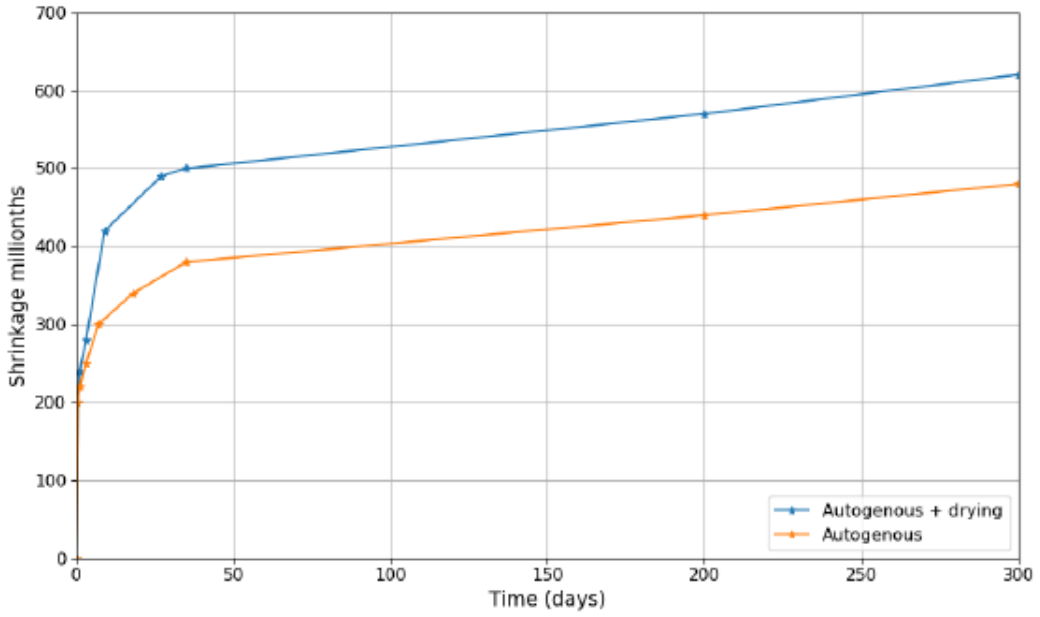


Fig. 4.25 Shrinkage composite from multiple sources.

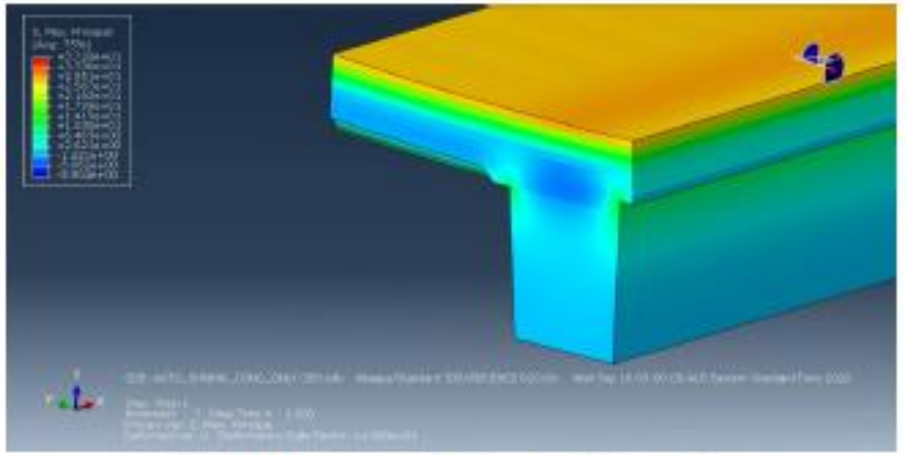
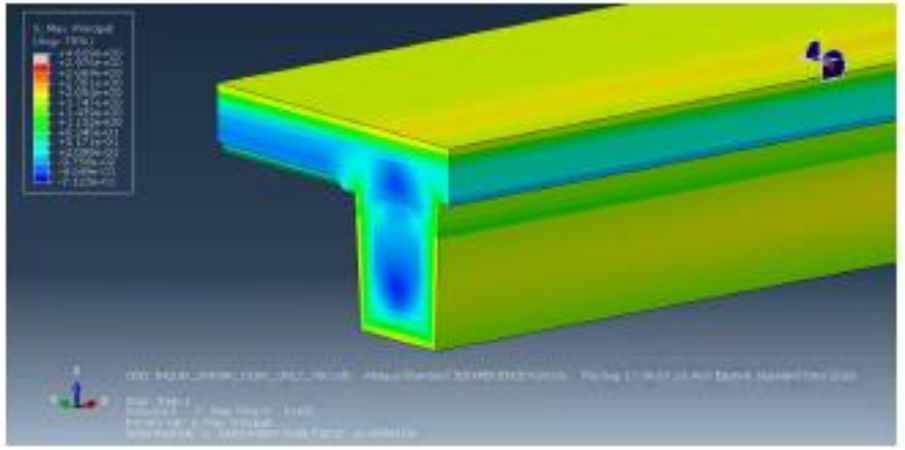
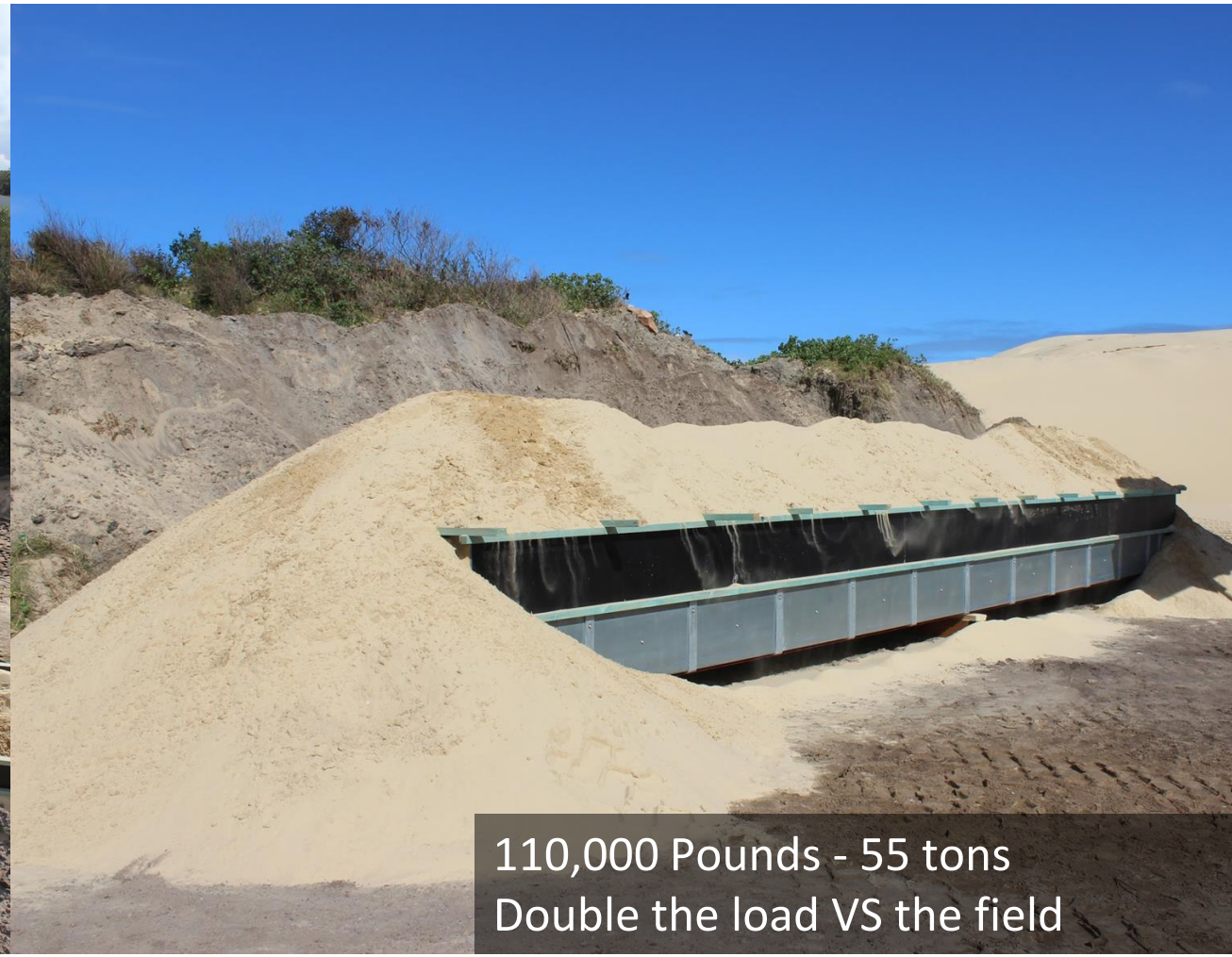


Fig. 5.10 Stress cross section, (permanent form work).



R&D – Full Scale Testing

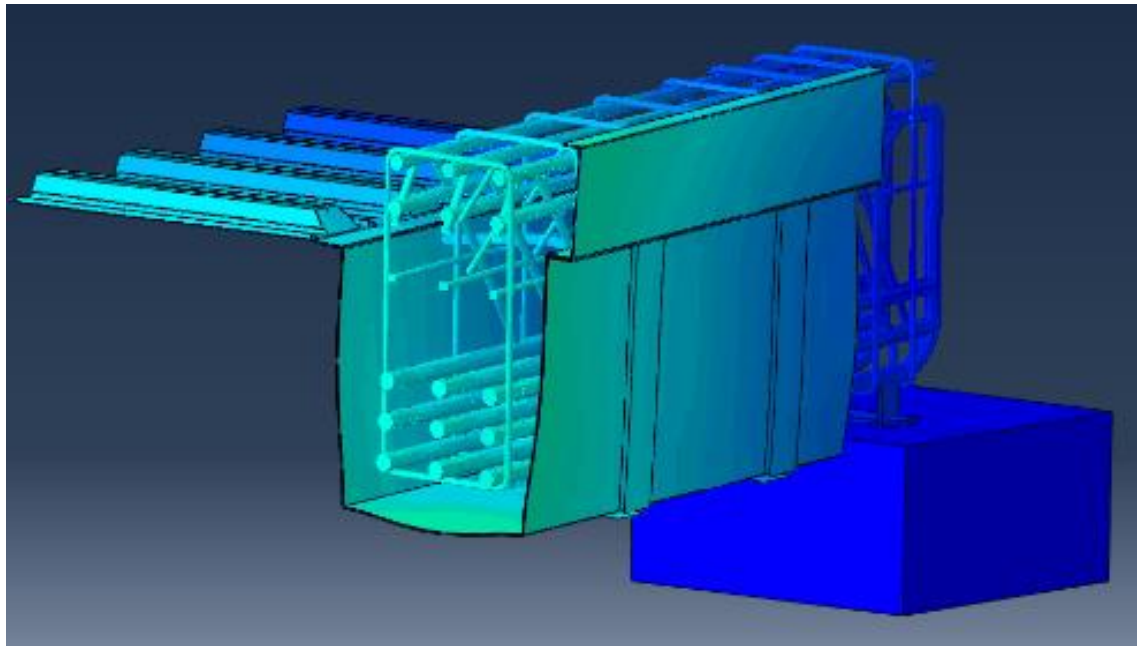


R&D – Formwork Removal

Class A finish – No voiding / honeycombing, high gloss / reflective finish

R&D – Formwork Removal

Fig. 2.14 Measured trough deformation.



1/8” Formwork bulging under weight of concrete.

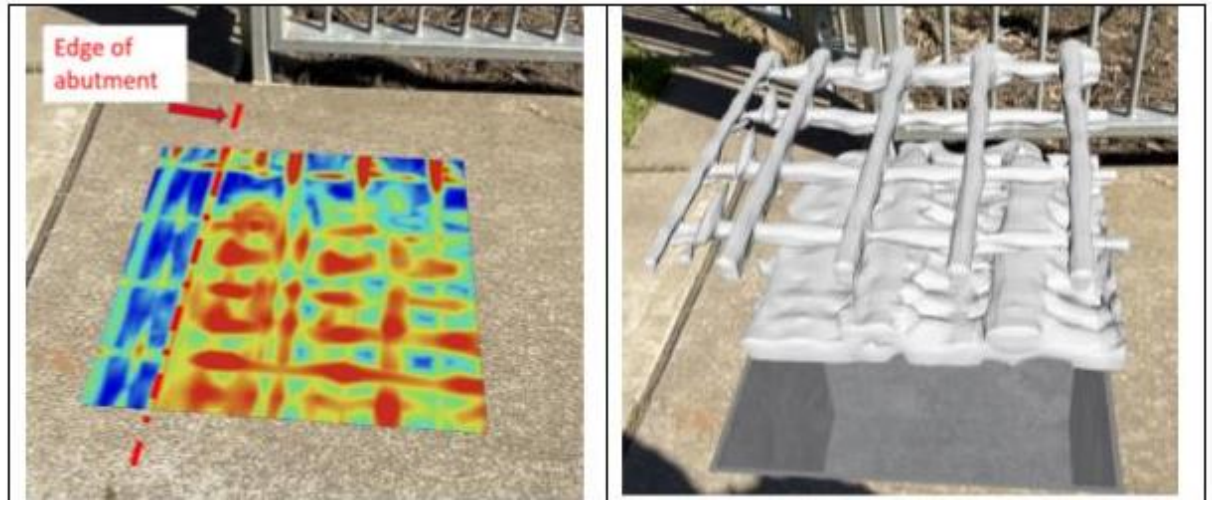
Addressing Common Issues

Issues	Causes	InQuik Bridge System
Voids	• Congested Rebar • Timber Formwork • Poor Compaction	✓ No Congested Rebar ✓ New / Steel Forms – transfer vibration ✓ Guaranteed concrete cover
Honey-combing	• Aggregate Segregation • Congested Reinforcement • Old / Reused Forms • Lack of concrete cover	✓ More Effective Vibration / Steel Form ✓ New Forms ✓ Assured cover
Cracking: Drying Shrinkage Cracking: Self-weight	• Moisture Loss • Heat of Hydration / too much cement • Dead-load / Permanent-load • Inadequate reinforcement	✓ Formwork Traps Moisture ✓ Mix Design & Cement Content ✓ Truss Takes Dead-load
Joints Spalling	• Multiple Joints / weak points	✓ Monolithic Structure / Integral abutments
Strand / Rebar Corrosion (Precast elements)	• Black Bar • Chloride ingress – concrete cover	✓ Pre-coated / Hot-dipped rebar / Stainless ✓ Assured cover
Cracking: Over-stressing	• Inadequate design / reinforcement • Over-loaded • Transportation stress	✓ Additional Capacity in Rebar ✓ Truss Disregarded in permanent design ✓ Concrete in Neutral Position ✓ Integral connection capacity

Inspecting InQuik Bridges

Inspection Types:

- Visual
- Acoustics / sound testing
- Surveys
- Chain drag
- String Lines / Camber
- GPR
- Strain Gauges
- Ultrasonic Phased Array



Fires to Floods

Resilient Infrastructure

Resilient Infrastructure

"The InQuik system has helped Lismore City Council's bridge crew deliver some great outcomes for our rural community. Culverts and causeways are not part of a resilient future."

Peter Jeuken – Engineering Director– Lismore County

Resilient Infrastructure

"The only bridges that were **not damaged**, were the ones that were built with **The InQuik System.** There is no doubt moving forward that we will be replacing all of the 30 damaged or destroyed structures with InQuik."
Dan Strazina –County Asset Engineer.

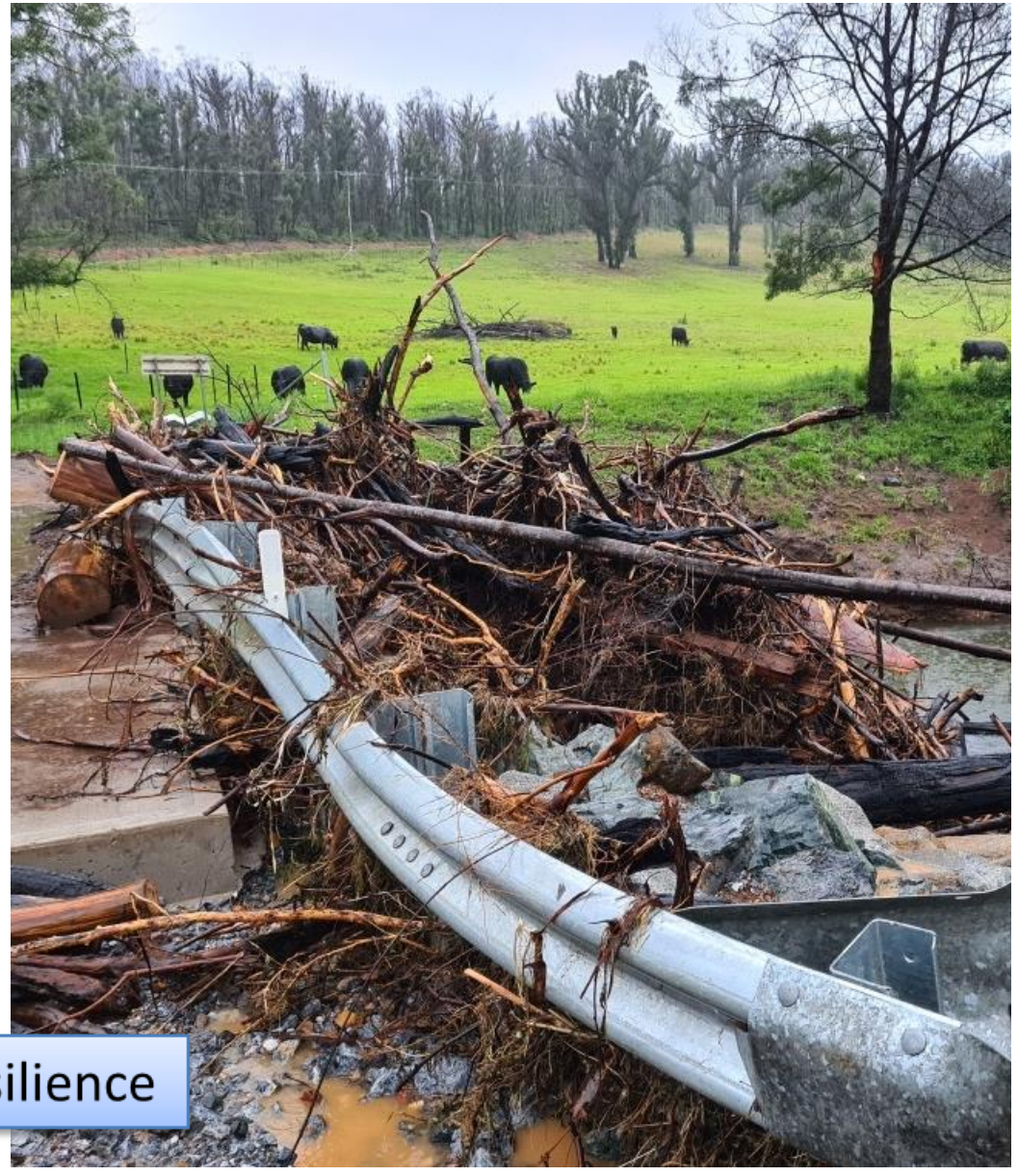
Resilient Infrastructure

Conventional Bridge Damaged during flood

Resilient Infrastructure

InQuik BRIDGING SYSTEMS

Resilient Infrastructure



InQuik Bridge Flood Resilience

5 Span – 230ft long

Rapid Replacement – 500 bridges in 24 months

InQuik BRIDGING SYSTEMS

Federal Funding → State DOT → County → Design & Bid → Not enough $ → Cannot deliver

Design & Supply → Local Labor → Delivered

- Large Program
- Skilled Labor Shortage
- Supply Chain Issues
- $$$ more than 2X

Market Analysis

7 Results

7.1 MCA ranking and scores

Refer to **Appendix A8 – MCA Results** for full details.

Table 2. MCA ranking and scores

Modular bridge option	Supplier	Score	%	Rank
InQuik modular bridge	InQuik Pty Limited	4.015	80.3%	1
Wagners CFT modular bridge	Wagners CFT Pty Limited	3.936	78.7%	2
Waeger precast modular bridge	Waeger Constructions Pty Limited	3.761	75.2%	3
Unibridge modular bridge	Unibridge Australasia Pty Limited	3.749	75.0%	4
Stahlton precast modular bridge	Fulton Hogan Limited	3.480	69.6%	5

7.2 InQuik modular bridge system (preferred solution)

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

Awards | Recognition

Most Innovative ABC Bridge System Developed Outside U.S 2021: InQuik Bridge System

InQuik take home the 2020 Australian Engineering Excellence Award for Canberra

InQuik Wins Excellence Award for Technology and Innovation at the NSW Concrete Industry of Australia Awards 2017

Winner of the Association for Iron & Steel Technology's (AIST) 2019 T.C. Graham Prize

Conclusion & Questions

Logan Mullaney
Co-Inventor & President, InQuik
Logan.Mullaney@inquikbridge.com
+1 (703) 423 9349